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Fridrik M. Baldursson and Jon Thor Sturluson

Reykjavik University Institute for Research in Finance and Economics

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by

Fridrik Mar Baldursson

School of Business

Reykjavik University

and

Jon Thor Sturluson

School of Business

Reykjavik University

Corresponding author:

Fridrik Mar Baldursson

School of Business

Reykjavik University

Ofanleiti 2

Reykjavik 103

Iceland

fmb@ru.is

Tel. +354 599 6396. Fax +354 599 6201

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Abstract

The paper presents the results of an economic experiment in which the effects of fees on allocative efficiency of tradable utilization permits (e.g. pollution permits) are explored. Laboratory subjects (university students) play the roles of firms whose generic product requires a specific input or permits. Scarcity is exogenously introduced by a fixed supply of tradable production permits. Three treatments are compared: A) no fee imposed; B) a fixed tax per permit; C) partial retraction of permits which are reissued by auction. We regard B and C as two ways of imposing fees. Our results indicate that, after controlling for deviation of permit prices from a prediction based on fundamentals, fees have an impact on distribution of permits. Interestingly, a fixed tax enhances efficiency compared to the case of no fees, while retraction and reallocation by auction reduces efficiency compared to both alternative treatments. Apparently, subjects' decision making is affected by the imposition of fees, but it matters how such costs are presented or framed.

Key words: Tradable permits, taxation, auctions, efficiency, experimental economics

JEL classification codes: C92, Q22, Q25

1 Introduction

In his seminal article, Montgomery (1972) established that a system of tradable pollution permits minimizes the costs of achieving a set abatement target. How licenses or permits are initially distributed is irrelevant to this result. In particular, it does not matter whether licenses are auctioned off or allocated free of charge. Furthermore, the imposition of (non-distortionary) fees should not affect efficiency. The end result in all cases is the same: trade will take place until marginal costs of abatement are equal across firms and aggregate abatement costs are minimized. This result, *mutatis mutandis*, not only applies to tradable pollution permits, but to any activity regulated by tradable quantity instruments, be they licenses, permits or quotas. In the last few years, such regulation has increasingly been used by governments in many countries. Examples are markets with permits for pollution release, fishing quotas, quotas for agricultural production, radio spectra and transport franchises.

Little, if any, research has been conducted using data from real markets to test for the impact of fees on efficiency of allocation of pollution permits. This is no wonder, since it is difficult to find reliable data where the effects of taxation or auctions of permits on different market results can be isolated. Experimental testing therefore lends itself well to this situation. In the laboratory, it is possible to compare behavior in markets which are identical in all other aspects than those regarding initial endowment and fee imposition.

In this paper we use experimental methods to study the question whether taxation or auctioning of permits affects allocative efficiency. More specifically, we investigate whether the imposition of fees – where we use the term ‘fees’ to include

both taxation and revenues from permit auctions – influences the distribution of permits between firms with different production costs. The setup also allows us to test whether the initial allocation of permits affects allocation in the long-run. Our study is rooted in a long tradition of experiments on market behavior, particularly asset markets, and is *inter alia* based on the work of Smith, Suchanek and Williams (1988).

Previous experiments have focused on the effect of initial endowment,[2] but to our knowledge the effect of fees has not been tested before. Recently, in a study of compliance in emissions trading programs with imperfect monitoring, Murphy and Stranlund (2006) found that firms with higher initial allowances tended to retain more permits and be more compliant than those with a lower initial allocation; a similar effect was not observed in a perfect monitoring and compliance treatment indicating that some sort of transaction costs – in a broad sense – are created by the introduction of imperfect monitoring and the related uncertainty. Interestingly, such an effect was not found in a study of imperfect enforcement and banking by Cason and Gangadharan (2006). Closest to our setup is an experimental study of tradable fishing allowance markets by Anderson and Sutinen (2006). None of these papers, however, focus on the effect of permit fees on allocative efficiency as we do here.

In practice, when tradable permit or quota systems have been introduced for an existing activity, such as fishing or emissions of CO_2 from electricity generation, this has usually been done by grandfathering, i.e. by allocating permits without recompense in accordance with historical use. Grandfathering is often criticized on equity grounds with concomitant calls for taxation or auctioning of quotas; the reason for the prevalence of this practice, however, is most likely the need to acquire political

[2] See e.g. Kahneman et al. (1991).

support from the affected industry.[3] However, the view that this entails no efficiency losses has traditionally been the prevailing one in economics literature. Yet, dissenting views have been gaining ground in recent years and claims that free allocation of permits will indeed lead to efficiency losses seem to be gaining momentum. Such claims go beyond the critical assumptions of Montgomery's static, friction-free, full-information model. Most often deviations from these assumptions have implications for dynamic, rather than allocative, efficiency and should not matter in a static setting.[4]

It has also been argued that allocative efficiency is improved by imposing resource fees. For example, Stavins (1995) shows that transaction costs can inhibit trading so that an inefficient initial allocation of permits is, at least partially, maintained and abatement costs are not minimized.[5] Auctioning permits, on the other hand, should lead to an efficient initial allocation as firms with the highest valuations of permits will bid highest.[6] It should be noted that, in contrast to auctioning, imposing a fixed tax on permits would not have any effect on an inefficient initial distribution of permits in Stavins's setup. However, taxation could still 'push' inefficient firms to sell their permits if the tax results in a loss from operating inefficient units and firms make

[3] See Oates and Portney (2003) for an overview of the political economy of environmental policy.

[4] For example, Hahn and McGartland (1989) show that permit auctions create incentives to develop new options in production or pollution reduction technology. Kling and Zhao (2000) analyze a model where auctions affect entry and exit of firms; see also Pezzey (2003) for a comparison of views on the long-run efficiency of emission taxes and auctioned permits. Taking a general-equilibrium perspective rather than the partial-equilibrium perspective of Montgomery's theorem, the double-dividend literature (e.g. Bovenberg and Goulder, 1996) points out that revenues from auctioned quotas can be used for reducing distortionary taxes. The aforementioned literature is not directly relevant to our experiment.

[5] The results of Montgomery and Stavins are of course intimately related to the Coase (1960) theorem, i.e. that in the absence of transaction costs well-defined property rights and free trade lead to an efficient allocation of rights.

[6] On a related note Baldursson and von der Fehr (2004) show that when up-front investment in abatement is required and agents are risk averse, efficiency is achieved by partial auctioning of allowances.

a distinction between paid costs and non-realized opportunity costs of holding allowances.

We do not look at fee imposition as an administrative tool to achieve a given target utilization, but focus on a system where the collective utilization of a resource is determined in advance. Hence, our approach is meant to capture, in a stylized manner, a situation where a tradable permit system for regulating production is already in place with a predetermined maximum aggregate quantity; permits are long-lived and production takes place over a number of periods. Examples of such situations are given by the U.S. Sulfur Trading Program, the European Union Greenhouse Gas Emission Trading Scheme (EU ETS), and the Icelandic fishing quota system; it should be noted that grandfathering was used for initial allocation in all these systems.[7] Two particular ways of collecting fees in such a system are compared: a fixed tax on permits and partial retraction and reallocation of permits by auction.[8] Parameters are chosen such that the amount of fees collected is equivalent, *ex ante,* in both cases. The latter method of collecting fees – partial retraction and subsequent auction of permits – may also be regarded as a politically feasible way of phasing out a grandfathering regime: in the end all permits will have been retracted and reallocated by auction.

The examples given above of particular permit systems did influence our experimental setup. However, the experiments were run with neutral terminology. Also, our approach is rather general and should therefore be applicable to any market

[7] Our approach was initially motivated by local debate – sometimes quite heated – in Iceland on the effects of fishing fees and whether they should be imposed and, if so, how; for some aspects of this debate, see the papers in Arnason and Gissurarson (1999), and Matthiasson (2001). Some features of our experimental design reflect the Icelandic system of tradable fishing quotas as well as policy options that were suggested in the debate on fishing fees. A similar debate has of course come up in other contexts than the Icelandic one. See, e.g., Hepburn et al. (2006), who call for allocating EU ETS permits by auction rather than grandfathering.

[8] Both these methods were suggested in the Icelandic debate. Starting in 2004, a (modest) tax was imposed on allocated fishing quotas each year.

where an essential input is available in limited quantity and is allocated to producers by tradable permits.

Our experiment is set up so that dynamic issues such as entry and exit of firms or general-equilibrium issues such as the double-dividend effect are not relevant. The level and methods of collecting fees are such that, in the absence of transaction costs and with perfect information, the equilibrium distribution of permits should be the same, irrespective of whether and how resource fees are collected. Yet, our results indicate that – controlling for deviation of permit prices from fundamentals – collecting resource fees does have an impact on efficiency and the distribution of permits. In particular, taxes appear to enhance efficiency compared to the grandfathering case. However, in contradiction to the transactions cost theory of Stavins, retraction and reallocation of permits by auction reduces efficiency compared to the case of no resource fee.[9]

As has been established in economic experiments, individuals' and firms' behaviors are not always rational in the traditional interpretation of economic theory. In this context, we maintain that two primary factors are potentially important in relation to our subject matter. On one hand, fee imposition can be important if companies react in different ways to real and paid cost, such as taxation, and the opportunity cost of holding a utilization permit, in this case the market price of a permit. Experiments on auction markets indicate that this could be the case (Phillips, Battalio and Kogut, 1991). On the other hand, the original permit allocation could influence individuals' valuation (Thaler, 1980) so that there is a tendency for those who receive a generous initial allocation to retain their permits in excess of what can

[9] Stavins's model is static with full auctioning of quotas while our experimental setup is dynamic with partial retraction of quotas in each time period. However, Stavins's argument should still apply: given that there are transactions costs that inhibit trade, partial retraction of quotas in each period with subsequent allocation by auction should enhance efficiency.

be expected on the basis of expected present value income from the permits and their market price. Initial allocation, however, appears not to be an important driver of our results and it seems that it is the former explanation – i.e. different reactions to paid and opportunity costs – which is the most likely one. Furthermore, it appears that presentation of fee imposition is important, since taxation, on the one hand, and retraction and auctions, on the other, had opposite effects.

The remainder of the paper is organized as follows. Section 2 describes the experimental structure and procedures. Section 3 contains the main results, which are discussed further in the fourth and last section; in particular we consider possible explanations of the aforementioned counterintuitive results. Section 4 concludes.

2 A simple utilization permit market

2.1 The structure of the experiment

In order to study the effect of fee imposition on efficiency in resource utilization, we designed an experimental market, described below.[10] Participants were given the role of firms, producing and selling an unspecified product. Possession of tradable permits was required for production. Eighteen six-person groups made up of students from the business, economics, engineering and science programs of the University of Iceland participated in the experiment, which was conducted in several sessions in May and October 2004.[11] Thirty-six of these 108 students participated twice so that the effect of acquired experience on the results could be assessed. Participants were paid for their contribution in direct proportion to the profit they made, with a

[10] The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007)

[11] In addition, 20 students participated in a preparatory experiment conducted at the Bifrost School of Business in Iceland.

minimum of ISK 800. The highest payment was ISK 4,097, and the average payment was ISK 2,252.[12]

Six subjects participated in each session. The task was to run a business which was endowed with a number of production permits and an initial fund which could be used to purchase additional permits.[13] Each game ran for 15 periods, in addition to two practice periods which did not count for payoff and are not included in the analysis below. Each period consisted of a market phase and a production phase. In the market phase, subjects participated in a double auction market for production permits (for a minimum of three minutes) where all participants could buy or sell individual permits. The market institution as such is not the subject of the analysis and hence the double auction market form, which has proven to be a particularly efficient institution in numerous experiments (Sunder, 1995), was chosen.

In the production phase, participants chose a quantity of the output to produce and sell for the current period, an integer smaller than or equal to the number of permits they owned. To simplify, perfect competition in the product market was imposed, so that every company received a fixed price of 75 experimental dollars (e$) for all produced units. At the end of each period, participants could see how much profit they had made and the state of their funds and production permit holdings. One version (treatment) of the experiment included an additional phase, where at the start of each period 20% of the production permits (i.e. three permits) were retracted and an equal number of permits reallocated by auction.

Three subject pairs (firms) had the same unit production costs but different initial allocation of permits. As can be seen in Table 1, Firms 1 and 2 had *low cost* per unit,

[12] Corresponding to approximately $13/€10, $69/€50, and $38/€28, respectively.

[13] Most similar experiments use larger markets (i.e. with more participants). However, preliminary testing showed that there was little difference between results based on whether the group consisted of six or eight people.

or e$ 35 for the first three units and e$ 45 and e$ 55 for the fourth and fifth units, respectively. Firms 3 and 4 had, relatively, *intermediate cost* per unit, and firms 5 and 6 had *high unit cost*. Firms could not own more than five permits or produce more than five units.

Had it not been for the production limit imposed by the ownership of permits, the firms could have manufactured 30 units in total without suffering a loss at the margin. However, there were only 15 production permits in total. The initial allocation of permits was intentionally neutral with respect to the cost structures. Odd-numbered companies were not allocated any permits, while the even-numbered ones received five permits, which was the maximum number allowed for one company. The allocation of funds compensated for the unequal initial permit allocation, permitting each and every company to acquire up to five permits.

Table 1: Cost per unit for companies and allocation of production permits

	Unit cost					*Permit allocation*	
Firm	*1. unit*	*2. unit*	*3. unit*	*4. unit*	*5. unit*	*Initial*	*Efficient*
1	35	35	35	45	55	0	4-5
2	35	35	35	45	55	5	4-5
3	35	45	55	65	65	0	2-3
4	35	45	55	65	65	5	2-3
5	55	65	65	75	75	0	0-1
6	55	65	65	75	75	5	0-1

Each group of six participated in one of three experimental treatments. In Treatment A, the baseline treatment, there was no fee imposed on production licenses. In Treatment B, the tax treatment, the companies paid a tax in every period for each permit held at the end of the period. The tax was fixed at e$ 15 per permit. In Treatment C, the auction treatment, three permits were retracted at the beginning of each period. Since the intention was to simulate a uniform 20% reduction in permit

holdings, but permits were indivisible and only traded in integers, the following random procedure was used to determine which firms had to hand in a permit: a firm owning one permit had a 20% probability of losing its (single) permit, a firm owning two licenses had a 40% chance of losing a permit, and so on. A firm with five permits lost one permit with probability one. [14] Irregular loss (or profit) at a particular firm caused by relatively large (or small) retraction was compensated with a money transfer so that the overall effect would be equivalent to everyone losing 20% of their permits in monetary terms. The three permits were then sold in a sealed-bid auction of the Vickrey type. All companies were obligated to bid for one and only one permit. The three highest bidders received one permit each and paid for it the amount of the fourth highest bid. The treatments were identical in all other respects. As explained in detail below, assuming permit prices follow predicted prices, the two methods of imposing fees in treatments B and C are *ex ante* equivalent in terms of income effects. They are also non-distortionary, i.e. they do not affect the competitive equilibrium allocation of permits.

Subjects in each treatment were given information about the overall structure and the rules of the game in the treatment in which they participated. They also knew the price of output and the number of periods. Firm specific information – costs, profits, holdings of permits, cash position, taxes paid (Treatment B) and permits lost (Treatment C) – was private to each firm. In the interactive auction market, subjects saw all posted buy and sell offers and permit transactions as they occurred. In

[14] Note that this rule does *not* make Treatment C equivalent to a system where a maximum of four, rather than five, permits per firm is imposed: firms that began a period with five permits and therefore lost one permit with certainty could nevertheless buy back a permit – either in the subsequent sealed bid auction or in the double auction market – and produce five units of the output.

Treatment C the results of the sealed-bid auction vis-à-vis each firm (i.e. whether the firm received a permit and what price was paid) were revealed.[15]

Subjects' payoff prospects, measured in experimental dollars, varied considerably depending on their assigned role and treatment. For instance, high cost firms were disadvantaged and rents available were higher in Treatment A than in the other treatments. The paid-out payoff difference based on role and treatment was minimized by determining a separate exchange rate for each role in each treatment. All participants had *a priori* similar expected payoffs based on predicted behavior (see details below).

When the experiment was repeated with experienced participants, the structure was altered slightly in order to speed up the learning process and facilitate a convergence to equilibrium. The main change was that instead of having 15 periods, each game included four rounds of four periods each; i.e. a four-period game was repeated four times (following Anderson and Sutinen, 2006). Some parameters were also changed slightly. The product price was raised to e$ 80 and production cost was lowered somewhat. The tax was lowered to e$ 11 to take into account the effect of fewer rounds on auction revenues. These changes do not qualitatively affect the theoretical prediction of behavior which is described below. To simplify the exposition, we only refer to the parameters of the former experiment with inexperienced participants below, except where the difference is crucial.

2.2 Predicted behavior

A single profit maximizer, running all six firms and facing a 15-unit production limit, would choose the 15 least expensive units for production, i.e. those with unit

[15] For details, see the experiment instructions in the Appendix.

cost up to e$ 55. In competitive equilibrium, where all firms base their decisions on profit maximization and take prices as given, the result should be the same.[16] The 15 permits are held by firms holding the least expensive production units. This means that none of the 12 units costing more than e$ 55 to make, displayed with a shaded background in Table 1, should be used in production.

As mentioned above, participants were paid for their contribution in direct relation to the profit they made on behalf of their company. Thus, the participants had a clear incentive to maximize profit. However, it cannot be assumed that everyone behaves according to profit maximization in an experiment like this one, although there is a strong tendency in that direction.[17] In order to reduce the effect of deviations from profit maximization on market equilibrium, the cost structure is such that all firms are able to produce at e$ 55 a unit. Still, due to the scarcity of permits, at most three firms will use these marginal units at any given time in equilibrium.

Fees do not have an impact on the competitive equilibrium permit allocations and production choices: the merit order of production units is unchanged by the fees. Furthermore, parameters were chosen such that even after the imposition of fees, the marginal units – i.e. with costs of e$ 55– will still return a positive operating surplus. Therefore, the production limit will still be binding after the imposition of fees; on units with higher costs (those in the shaded areas of Table 1) there is an operating loss after the imposition of fees.

As a result, competitive equilibrium does not provide a unique prediction of the division of permits and thus each firm's production volume. The low cost firms (number 1 and 2) hold four or five, the intermediate cost firms (number 3 and 4) have

[16] It is not necessary to assume that all six firms maximize profit. A sufficient condition is that three firms maximize profit and the rest either choose profit maximizing quantities or one unit less.

[17] See Camerer and Hogarth (1999), who, *inter alia*, deal with the effects of different amounts on incentives in economics experiments.

two to three, and the high cost firms (number 5 and 6) zero to one unit. There is, however, a unique solution for the price of production permits, given by surplus from the marginal unit, less fees, summed over remaining periods (see details below).

There are at least two reasons for why convergence to competitive equilibrium could be delayed or even hindered. First, individual firms do not have sufficient information to calculate equilibrium market price. Each firm only knows its product price, the development in the quota market, and its own cost structure. The firms can nevertheless calculate their profit and assess the differential profit of an increase or decrease in license holding by one permit. By following the simple rule to buy a permit when the benefit of owning an additional one exceeds its market price, and, conversely to sell a license when the benefit of owning the last permit falls short of its market price, it should not be long before all business opportunities are taken advantage of and competitive equilibrium is reached. All the same, the process of adapting to equilibrium can be slow (Smith, 1962).

Second, when firms make their decisions they must also take into consideration that production permits are assets which are transferred between periods. Economics experiments have demonstrated that there is a strong tendency for asset prices not to follow fundamentals, at least temporarily, as in the case of price bubbles.[18] The concept of a 'price bubble' refers to a development where prices rise far more than underlying returns suggest (e.g. net operating profit). Our experiment is different from traditional experiments on asset prices insofar that in our experiment operating profits – corresponding to dividends in asset market experiments – are not stochastic. But random dividend payments are not necessary for price bubbles to occur (Porter and Smith, 1995). Unpredictable expectations, lack of common knowledge and

[18] See Porter and Smith (2003) for an overview of such experiments.

speculation are also likely culprits.[19] We can therefore expect bubbles to appear in this experiment. Permit prices can take on a life of their own, so to speak, and thus create trade with production permits independent of efficiency concerns. These two factors, i.e. fragmented information and speculation, can hinder the market from converging to competitive equilibrium and efficient distribution of production licenses. Since both factors are also likely to appear in real-world markets of this type they are a crucial part of the experimental design.

2.3 Predictions

As mentioned above, our primarily concern is whether fees imposed on utilization permits have an effect on efficiency. It is therefore necessary to define an efficiency measure. Let R_{ijt}, C_{ijt} and $\Pi_{ijt} = R_{ijt} - C_{ijt}$ stand for income, cost and operating surplus of company $i \in I_j$ in Treatment $j \in \{A,B,C\}$ at time t, respectively.[20] Therefore the total surplus of firms $j \in \{A,B,C\}$ at time t is $\Pi_{jt} = \sum_{i \in I_j} \Pi_{ijt}$. Maximum possible surplus is denoted by $\Pi^*_{jt} > 0$. Note that this surplus can only be made when production is at full capacity, i.e. 15 units. We will now define the efficiency measure E as the ratio of realized and optimal aggregate surplus.

$$E_{jt} = \frac{\Pi_{jt}}{\Pi^*_{jt}}. \tag{1}$$

Clearly $E_{jt} \leq 1$ with equality only if production is efficient, i.e. $\Pi_{jt} = \Pi^*_{jt}$.

[19] According to Smith et al. (1988), speculation on a market such as this one is not a result of irrationality. Although everyone trading in a particular stock has exactly the same distribution of future returns and full and mutual information is accessible, this is not enough to create unity in market participants' expectations. In their opinion, the main reason for bubble formation is individuals' uncertainty regarding the behavior of other market participants.

[20] Note that profits from trading in permits are not included in the operating surplus.

As pointed out above, we are mainly interested in testing whether efficiency differs significantly between treatments. Permit prices are not directly comparable between experiments, since fee imposition has a direct impact on price formation. Yet, we are interested in comparing relative price deviations from the theoretical forecast of permit price and its effects on behavior. In all cases, the price prediction is based on the assumption that firms maximize expected profit, taking fees into consideration. Recall that the fundamental price of production permits in a given period is given by surplus from the marginal unit, less fees, summed over remaining periods. The prediction for permit price in the basic treatment (A) is thus:

$$\hat{P}_{A,t} = \sum_{i=t}^{T} s = s \times (T - t + 1), \tag{2}$$

where s is per-unit marginal surplus, T is the total number of rounds and t represents the decision period. In the first implementation (inexperienced subjects), the hypothetical marginal unit surplus in each round was e$ 20 and the number of rounds was 15. In that case, the price prediction was e$ 300 in the first round, decreasing by e$ 20 in each round. In the second implementation (experienced subjects), the marginal profit in each period was e$ 27 and there were only four rounds. The price forecast was therefore initially e$ 108, decreasing by e$ 27 in each round.

In the tax treatment (B), the tax τ was subtracted from participants' income for each permit they owned at the end of each round. The price prediction is thus:

$$\hat{P}_{B,t} = \sum_{i=t}^{T} (s - \tau) = (s - \tau) \times (T - t + 1). \tag{3}$$

The tax, τ, was e$ 15 in the first implementation and e$ 11 in the second one. The post-tax profit was e$ 5 at the margin in the first implementation, which means that the price prediction starts at e$ 75 in the first round and decreases linearly to e$ 5 in

the 15th round. In the second implementation, the after-tax marginal surplus was e$ 16; the price prediction started at e$ 64 and decreased by e$ 16 in each round.

The price prediction in the auction treatment (C) is a bit more complicated since the production permit value is partly determined by the retraction ratio *f*. In period *t*, current and future per-unit surplus $t+j$, must be discounted by $(1-f)^j$, where $j = 0,1,...,T-t$. The predicted price is the sum over the discounted per-period surpluses:

$$\hat{P}_{C,t} = s\sum_{i=t}^{T}(1-f)^{T-i} = s\frac{1-(1-f)^{T-t+1}}{f}. \qquad (4)$$

The retraction rate f was always set equal to 0.2, which means that the price forecast started at just over e$ 96 and ended at e$ 20 in the first implementation, and in the second one, it started at e$ 80 and was e$ 27 in the end. Figures 1 to 4 below illustrate price forecasts in the three treatments, and also give examples of real outcomes.

Note that expected fees levied on each permit are almost equal in treatments B and C: taxes collected on each permit in Treatment B are e$ 15 in each period or e$ 225 in total; expected auction revenues in Treatment C are 20% of predicted price in each period, easily calculated from (4) to be e$ 223 in total.

3 Results

3.1 Production permit prices

Before we turn to the main research question in detail, we briefly describe how trade was conducted and how prices and volumes in the experimental markets developed. As it turned out, the outcomes were fairly diverse from one session to another. Individual sessions can be roughly grouped in three categories according to price development.

Of the twenty-four sessions, an evident *price bubble* followed by a crash appeared on five occasions. The development of bids and prices in experiment 3A, illustrated in Figure 1, is typical for this category. Price was originally quite low, i.e. only one-third of the price predicted from fundamentals using equation (2). The price then increased substantially in the first four rounds, and peaked at e$ 500, by which time it was double the fundamental price. Subsequently the price remained high compared to the price prediction (see the horizontal lines in the figure) until it plunged quickly in the thirteenth round.

Session 4B is characteristic for the second type of market behavior which can be referred to as *stable excess prices*, see Figure 2. Prices started above the predicted price based on equation (3), and stayed above it for most periods. The price then dropped drastically in the final round and came close to the fundamental price. A similar development was noticeable in five other sessions.

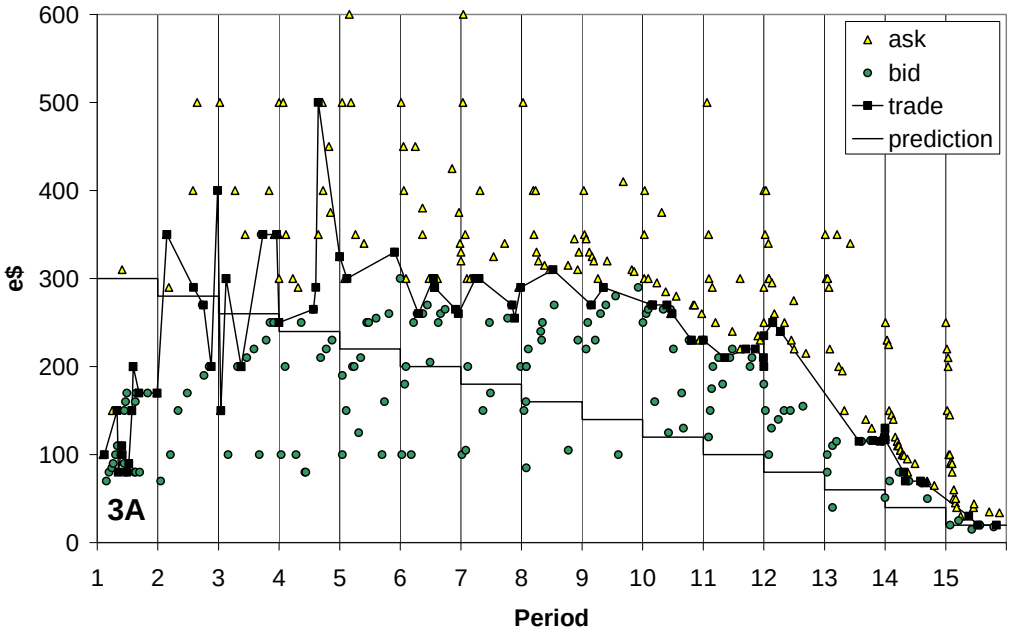


Figure 1: Outcome of asks, bids and transaction prices compared to predicted price path in session 3A (no-fee treatment).

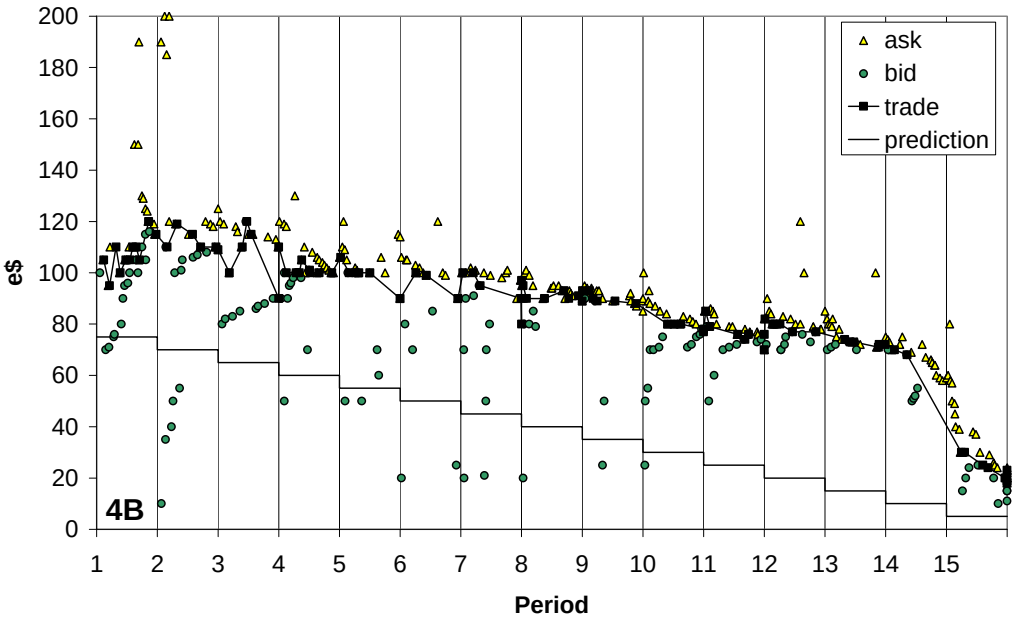


Figure 2: Outcome of asks, bids and transaction prices compared to predicted price path in session 4B (tax treatment)

In seven instances price development was comparable to the data from experiment 6C, shown in Figure 3. What is characteristic of this development is a relatively *stable price*, apart from the first and last periods. Moreover, the price starts out below the price forecasted from (4), but in the end it is substantially above it, as the forecast price decreases during the experiment.

Finally, market behavior was very close to *predicted behavior* in six instances. An example, session 8A, is shown in Figure 4. Here, participants were taking part in the experiment for the second time and can therefore be considered relatively experienced in the game. In the sessions with experienced subjects, the structure was changed so that the number of rounds was reduced to four, and instead, the game was repeated several times. These are the last six experiments (7A to 8C). As is clear from Figure 4, the market price development was relatively close to the predicted price in the last two rounds.

The examples are too few and the behavior categorization too rough for any generalizations to be made regarding the likelihood of one behavior or another. In almost all treatments, there are examples of a particular behavior. The exception is Treatment A which at no time shows a stable excess price. On the other hand, there are more examples of price bubbles in Treatment A than in other treatments. However, the difference between these two categories of behavior is not great between treatments and therefore it is possible to hypothesize that the treatment as such – i.e. whether and how fees are imposed on utilization rights – does not have a substantial effect on what sort of price behavior is to be expected.

In addition to price development and price forecasts, Figures 1 to 4 depict selling and buying bids made in each session in chronological order (read from left to right). Figure 3, which shows examples of Treatment C, also shows the price paid for redistributed permits in auction. As is clear in the figure, the auction price was always slightly lower than the market price, which is characteristic for this treatment in the experiment.

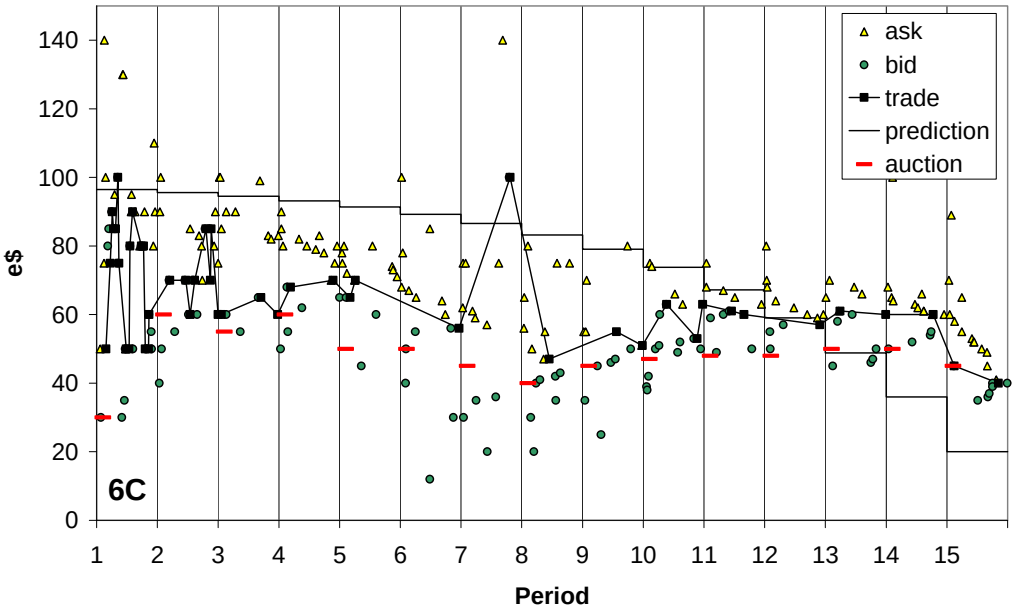


Figure 3: Outcome of asks, bids and transaction prices compared to predicted price path in session 6C (auction treatment)

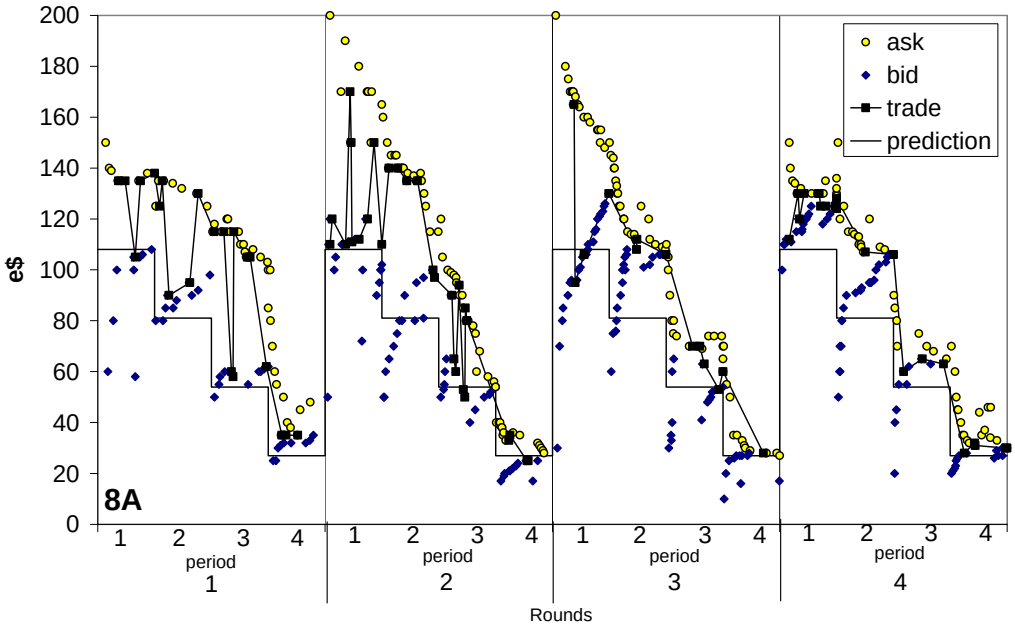
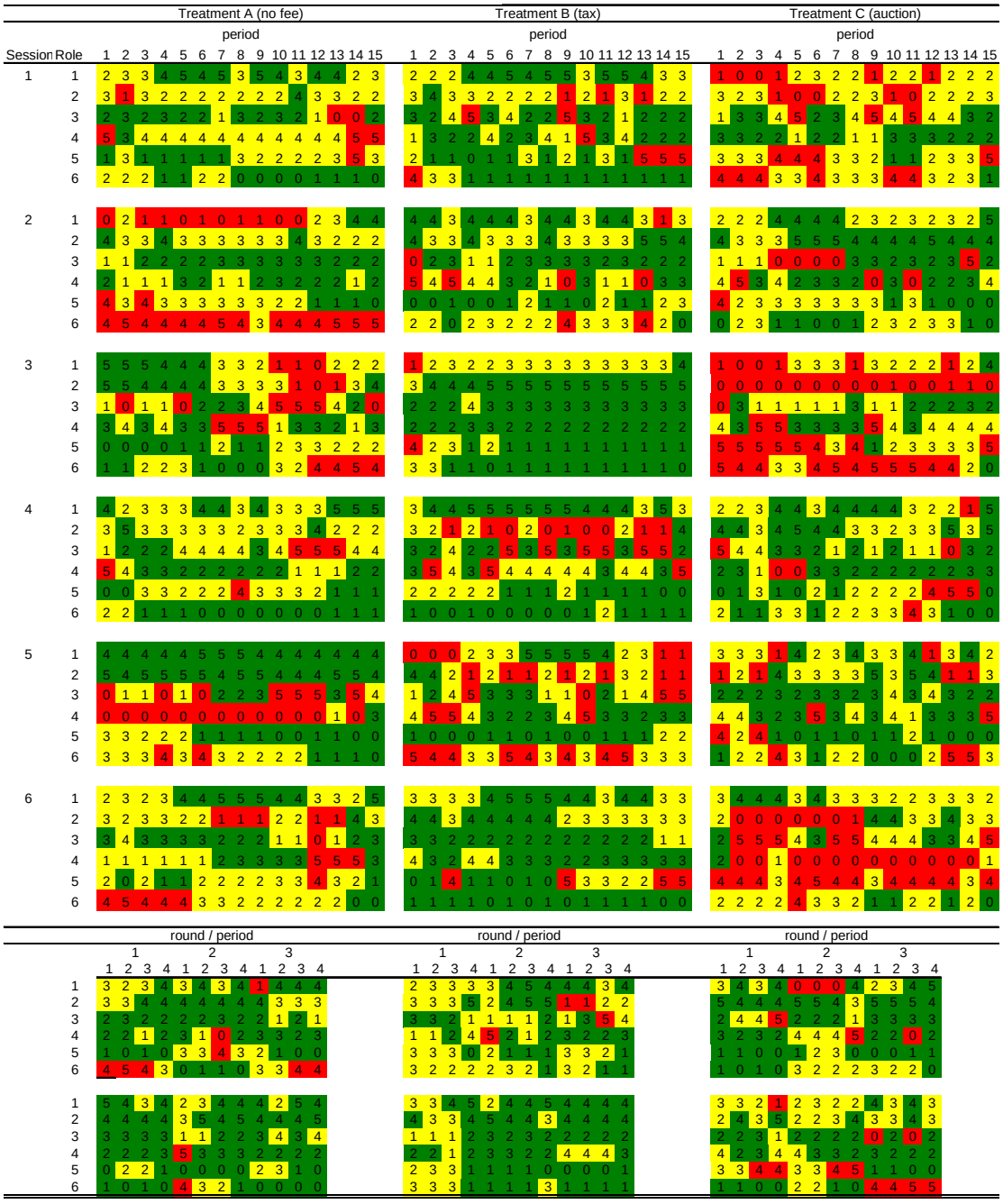


Figure 4: Outcome of asks, bids and transaction prices compared to predicted price path in session 8A (no-fee treatment, experienced subjects)

Table 2: Allocation of permits in the production phase in each period

Color indications: green: efficient level; yellow: a deviation of 1-2 units from efficient level; red: a deviation of 3 or more units from efficient level



3.2 Distribution of permits

As discussed above, price development was rather varied from one session to another. The same applies to trade and allocation of production permits. Table 2, illustrates the

development of ownership of production permits in all the sessions. Recall that in order to reach the most efficient position, the participants running firms of type 1 and 2 had to possess four to five permits, firms of type 3 and 4 needed to have two to three permits, and firms of type 5 and 6 zero to one permit. In order to clarify the picture to some extent, green background indicates an efficient position, yellow represents a one or two unit deviation and red depicts even greater deviations.

Table 2 does not invite easy conclusions. For example, there seems to be no systematic difference between the three treatments of the experiment. Behavior seems to be fairly variable in all instances. Whether efficiency increases with time or not is also non-discernable. If we consider every experiment in each treatment and calculate average efficiency according to (1), it is clear, however, that there is a considerable difference, both between experimental treatments as well as temporal development. Figure 5 depicts the average efficiency in the first 18 experiments (inexperienced subjects).[21] During all the periods, the auction treatment (C) seems to produce the lowest efficiency, but the tax treatment (B) is on average the most efficient. However, efficiency rises steadily in the auction treatment and becomes similar to that of other treatments in rounds 14 and 15. The increase in efficiency over time is much less pronounced in the other two experimental treatments. Figure 6 shows the development of average efficiency for each treatment with experienced participants. Evidently, experience is important and valuable. Efficiency is in general much higher than in Figure 5, and its increase over time is fairly clear. We cannot draw conclusions from the difference between individual experimental treatments in this instance, as there are only two sessions behind each average.

[21] Recall that perfect efficiency corresponds to E=1.

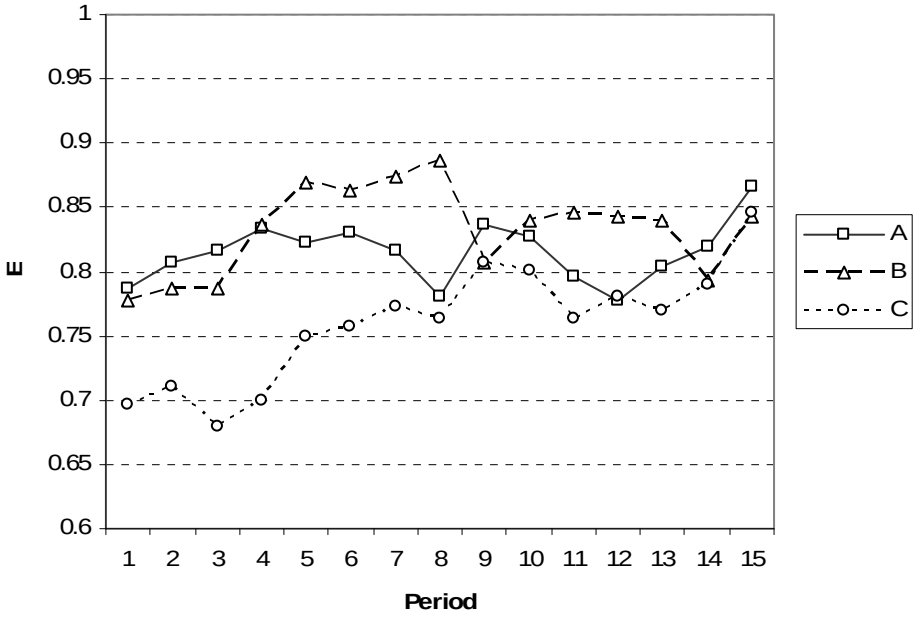


Figure 5: Mean efficiency in each treatment (inexperienced subjects)

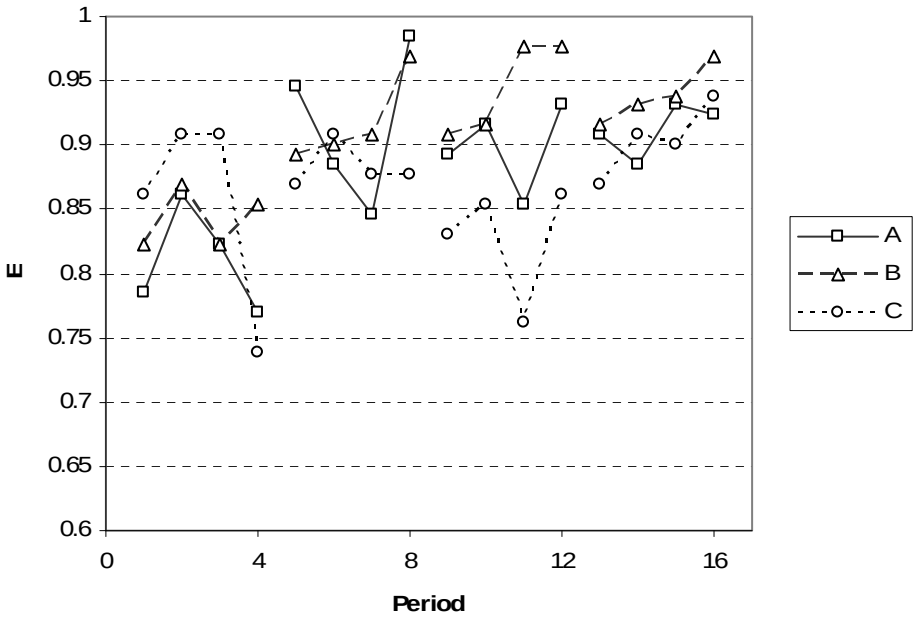


Figure 6: Mean efficiency in each treatment (experienced subjects)

More formally, we may investigate whether there is a significant difference in efficiency between treatments by comparing the distribution of results with a

nonparametric test. The results from such tests, on the one hand the Wilcoxon/Mann-Whitney test for the same probability distribution in two treatments at a time, and on the other hand the Kruskal-Wallis test for the same probability distribution in all three treatments at the same time, are shown in Table 3. For inexperienced participants, the measurements are divided into three groups of five periods each, but for experienced participants, we test each round separately. It is evident from Table 3 that the null hypothesis (H_0) of a common distribution is rarely rejected with traditional significance levels (p-value less than 5% or 10%). Treatment C – the auction treatment – differs significantly in the first group of experiments with inexperienced participants and in the third round with experienced participants.

The above comparisons do not allow us to draw conclusions on the superiority of one arrangement over another in terms of efficiency, even though there are weak indications that the auction treatment is less efficient than both the tax treatment and the baseline (no fee). This effect, however, appears to fade with added experience of subjects.

Table 3: Significance levels (p-values) in non-parametric tests of equal medians in all treatments

Inexperienced subjects	***Period***		
Hypothesis	***1-5***	***6-10***	***11-15***
Equal medians in A and B	0.98	0.15	0.66
Equal medians in A and C	0.00	0.76	0.29
Equal medians in B and C	0.01	0.10	0.19
Equal medians in all treatments *)	0.00	0.19	0.36

Experienced subjects	***Round***		
Hypothesis	***2***	***3***	***4***
Equal medians in A and B	0.96	0.12	0.32
Equal medians in A and C	0.29	0.03	0.49
Equal medians in B and C	0.16	0.00	0.32
Equal medians in all treatments *)	0.32	0.00	0.31

*) The Kruskal-Wallis test is used here, in other instances the Wilcoxon/Mann-Whitney test is used

3.3 The interaction between price and efficiency

Although aggregate efficiency in the three treatments is (statistically) similar when participants have gained experience, one must not jump to the conclusion that fee imposition does not have an effect on efficiency. Other aspects than efficiency are variable between individual experiments and can create 'noise' which makes comparison with relatively few measurements potentially difficult. Price development is one of the components which is worthy of special attention in this context.

Price and price expectations can have a significant influence on the development of trade with production permits. As in other asset markets, participants can profit from trade with production permits, either by retaining a certain number of permits and produce and sell in the market, or by buying permits at a low price and sell when the price is high. Although a price forecast predicts a steady decrease in production

permit prices as their remaining utilization period becomes shorter, realized price can equally well go up, at least temporarily. Expected price increases create profit opportunities and incite participants to focus on speculation so that price becomes disconnected from fundamentals.

It is likely that deviations from fundamental (predicted) prices affect permit ownership, especially if subjects have heterogeneous expectations. Consider for example a participant who has high production costs (roles 5 and 6) and expects prices to rise, at least temporarily. If other participants in the same experiment, particularly those with low production costs (roles 1 and 2) do not foresee higher prices, a situation can easily arise in which the former retains more permits than is efficient, without a counterweighing response from the latter. A similar state of inefficiency can also be brought about if the price is too low. Thus, our hypothesis is that deviation from predicted prices has a negative effect on efficiency. Further to that, if such effects are significant, the efficiency difference between treatments could turn out to be more profound, taking this additional effect into account.

In order to analyze the effect of price deviation and the method of fee imposition jointly, it is necessary to use multiple regression analysis. The main regression results, using a linear mixed-effects model, are displayed in Table 4.[22]

[22] Note that the definition of efficiency is solely in terms of production surplus. Therefore, even if the price deviation is an endogenous variable in the experiment it does not affect the calculation of efficiency.

Table 4: Regression results for efficiency in markets with inexperienced and experienced subjects (linear mixed-effects model)

	Model 1 (Inexperienced)	***Model 2 (Inexperienced)***	***Model 3 (Experienced)***
Constant	0.783***	0.185***	0.879***
	(0.04)	(0.04)	(0.03)
Period	0.005***	0.002	0.013**
	(0.001)	(0.001)	(0.008)
Round			0.003
			(0.01)
Price deviation	- 0.023***	- 0.019***	- 0.052**
	(0.006)	(0.005)	(0.022)
Efficiency (-1)		0.723***	
		(0.04)	
Tax	0.042	0.027**	0.038**
	(0.05)	(0.01)	(0.02)
Auction	- 0.054	- 0.01	- 0.032**
	(0.05)	(0.01)	(0.02)
R^2	0.10	0.61	0.29
R^2 *(adj.)*	0.09	0.60	0.24
1º autocorr., ρ	0.73***	-0.016	-
No. obs.	270	252	72
Cross sections	18	18	6

Cross sectional parameters not shown. *) Significant at the 10% level; **) significant at the 5% level; ***) significant at the 1% level. Standard errors shown in parentheses.

In Model 1 of Table 4, we endeavor to explain efficiency in the first 18 experiments, when all participants were new to the project, by conditioning variables as well as the absolute value of price deviation from the price forecast. For the sake of parsimony, we assume that the time effect is linear.[23] It appears that price deviation has a markedly negative effect on efficiency, but neither the tax treatment nor the auction treatment seem to have a significant effect. This result should be interpreted with caution since there is considerable autocorrelation in the equation's residuals. This problem is addressed in Model 2, which is the same as Model 1 except that

[23] A more general definition of time effect does not significantly affect the results.

lagged values of efficiency have been added to the equation. With this change, autocorrelation is no longer significant and explanatory power increases. Furthermore, the tax treatment has significantly (at the 5% level) higher efficiency than the baseline treatment; as in Model 1 the auction treatment has lower efficiency than the baseline, but the difference is not statistically significant.

Model 3 is comparable to Model 1, but it uses data from sessions with experienced subjects. The only difference between the estimated equations as such is the addition of the variable *round*, which along with *period*, captures the effect of repetition. In this case, there are relatively few available observations (72). With that proviso, all coefficients of the equation come out as significant apart from the *round* effect. Treatment effects have the same sign as in Models 1 and 2 and are significant at the 5% level.

These results indicate that, as conjectured, price deviation from forecast price has a significant negative effect on efficiency of allocation of permits. Furthermore, after controlling for the effects of price deviation, an effect of fee imposition on efficiency of allocation is detectable. In particular, the tax treatment has significantly higher efficiency than the baseline, as opposed to the auction treatment, which has significantly lower efficiency. It is probable that the less pronounced results in Models 1 and 2 result from the participants' inexperience of the game, leading to irregular behavior that is difficult to interpret. When participants are more experienced, the effects of the fee imposition are more clear. Thus, it seems safe to reject the null hypothesis that fee imposition or its implementation does not affect efficiency. This result is, however, conditional on controlling for price effects.

3.4 Underlying reasons for the effects of fee imposition

The theory that fee imposition or its implementation does not matter to allocative efficiency builds on neo-classical principles concerning the maximization of present value of profit as well as an assumption of rational expectations. There are several possible reasons why the theory might fail in an experiment. One possibility is that of endowment effects, i.e. that participants might consider their original allocation as an important point of reference, independent of financial incentives, and are ready to sacrifice money in order to maintain an allocation which they think is normal or right. Such tendencies could clearly reduce efficiency, as maximization of profit no longer dominates. The combined results of endowment effects and fee imposition on trade with production permits are complex and not easily predictable, and different methods of fee imposition may matter.

Another possible explanation is that participants will not equate paid cost and opportunity cost. In this context, the opportunity cost of production permit ownership rests in the market price of permits. Individuals' attitudes to opportunity cost can vary, especially considering that participants may have different expectations of permit price development and that they have very different production possibilities.

A permit fee is a direct cost and thus reduces profits, but simultaneously, opportunity cost is lowered through the subsequent reduction in production permit price. These influences are manifested in different ways in the tax and auction treatments. In the former, the tax has the effect that inefficient units (the shaded cells in Table 1) are no longer profitable. A large part of the opportunity cost of retaining permits is thus changed to paid cost with taxation. In each round of the auction treatment, some participants lose a permit and in order to reach their former position, they need to buy the permits back, either in the sealed-bid auction or in the secondary

market. The tax and the retraction ratio are arranged so that expected fee imposition is equal in Treatments B and C. Hence, there should not be a great difference between the two methods (i.e. Treatments B and C) with regards to income effects, even if the method of fee imposition is different. The method with which this shift from opportunity to paid costs is presented may, however, make a difference. The framing of information (Tversky and Kahneman, 1981) is often a critical determinant for the outcome of experiments and may play a part here. The chief difference in implementation between tax and auction treatments – i.e. in presentation of fees – is that in the tax treatment, participants that had some permits needed to make a decision about whether they were going to sell one or more permit or not, while in the auction treatment, the participants needed to decide how much they were ready to spend in order to acquire more permits or reclaim permits which they had lost before.

There is also a possibility that participants' uncertainty regarding permit loss because of retraction in auction sessions had an effect. Recall, however, from Section 2.1 that irregular income effects due to randomized retraction were evened out by transfers, so that the financial implications for each participant were close to 20% reduction of the value of individual ownership of production permits. Of course the possibility cannot be excluded that some participants did not fully realize the total implications of permit depreciation and transfers. Yet, informal interviews with participants at the end of auction sessions did not indicate an appreciable lack of comprehension of this mechanism.

In order to study the importance of such effects for individual behavior in our experiment, an ordered probit model was estimated, in which the dependent variable is the number of permits that the participant in question owned at the end of a particular round. As stated above, each participant could have from zero to five

permits. The model estimates the likelihood that a certain number of permits is chosen using particular exogenous variables.

In Model 4 in Table 5, the initial allocation (the variable *initial*), that is to say the number of permits allocated at the beginning of each session, and the production opportunities of participants are used as explanatory variables. Production opportunities are described by two dummy variables: the variable *efficient* takes the value 1 when the participant has the role of running a firm of type 1 or 2, i.e. has relatively low production costs, but otherwise the value 0; and the variable *inefficient* takes the value 1 when the participant has the role of running a firm of type 5 or 6, i.e. has relatively high costs; otherwise the variable takes the value 0. So as to be able to assume that initial adaptation has taken place only the last five periods are used for inexperienced participants and the last two periods from all rounds except the first one for experienced ones.[24]

Production opportunities appear to have a significant effect on the number of production permits in Model 4, especially among experienced participants. In particular, participants that have efficient production opportunities – have low production costs – are likelier to retain more permits (the coefficient at *efficient* is positive) while those that have less efficient production opportunities – high production costs – are likelier to retain fewer permits (the coefficient at *inefficient* is negative) in comparison to those that have average costs. Thus relative efficiency certainly pushes participants in the 'right' direction.

[24] The effect of adding periods and rounds to the regressions as independent variables was negligible.

Table 5: Ordered probit models for individual permit holdings

	Model 4		*Model 5*	
	Inexperienced	***Experienced***	***Inexperienced***	***Experienced***
Initial	- 0.031	0.034	- 0.032	0.034
	(0.02)	(0.03)	(0.02)	(0.03)
Efficient	0.033	1.119**	- 0.003	1.406**
	(0.14)	(0.19)	(0.23)	(0.31)
Inefficient	- 0.515***	- 1.870**	- 0.355	- 2.215**
	(0.14)	(0.20)	(0.23)	(0.33)
Tax			0.010	0.062
			(0.23)	(0.30)
Auction			0.166	0.224
			(0.25)	(0.30)
Efficient and Tax			0.475	- 0.082
			(0.33)	(0.43)
Efficient and Auction			- 0.485	- 0.716*
			(0.35)	(0.43)
Inefficient and Tax			- 0.463	0.141
			(0.33)	(0.43)
Inefficient and Auction			- 0.018	0.821*
			(0.35)	(0.44)
LR index (pseudo R^2)	0.02	0.13	0.03	0.13

*) Significant at the 10% level, **) significant at the 5% level,
***) significant at the 1% level.

Endowment effects, however, appear not to be important (the parameter at the variable *initial* is not significantly different from zero). This agrees with recent studies (e.g. List, 2004), which demonstrate that endowment effects are only significant when participants are relatively inexperienced and that indications of such an effect usually disappear when participants have gained experience and competence.

Model 5 in Table 5 has added dummy variables for Treatments B (*tax*) and C (*auction*) and cross-variables between treatments and production possibility dummies. This has the purpose of analyzing if the treatment has an effect on the number of permits that participants in different roles choose. The production possibilities (*efficient* and *inefficient*) are still key explanatory variables and the only ones that turn

out to be significant at a 5% significance level. In the case of experienced participants, there also turns out to be a weakly significant difference (at the 10% level) in participants' behavior according to the roles in the auction treatment compared to the basic treatment. The effects indicate that participants with efficient production possibilities retain fewer permits in the auction treatment than in other treatments. Conversely, participants with inefficient production possibilities appear to retain more permits in the auction treatment than in other treatments. The behavior of those that have average costs is not significantly different across treatments. There are no indications of similar effects in the tax treatment. These results must be considered inconclusive regarding possible treatment effects. It should be kept in mind that such effects only materialized in the efficiency regressions (Table 4) after controlling for price deviations, so it is perhaps not surprising that they do not materialize here.

We conclude that there is a clear tendency for more efficient firms to retain more permits and for those that are less efficient to retain fewer permits. Endowment effects appear not to be important. Testing for the impact of different methods of fee imposition is inconclusive.

4 Conclusion

This article has sought to answer the question whether the imposition of fees on previously allocated utilization permits and the way such fees are implemented can have an effect on efficiency. The underlying idea is that fee imposition may accelerate the process of inefficiently run companies reducing production, thus giving more efficient companies room to expand. According to neoclassical principles, fee imposition should affect neither the final allocation of utilization permits nor efficiency: companies which have more efficient operations should be prepared to pay

more for the utilization permits than ones that are run less efficiently. Inefficient companies should not profit as much from keeping all their permits as opposed to selling them. Thus, there should be a strong tendency towards an efficient distribution of the utilization permits, whether or not there is any tax imposed on them.

The experiment described here is intended to explore whether the neoclassical prediction is upheld in the laboratory. A simple statistical analysis of the experimental results does not indicate a significant impact of fees on efficiency. However, after controlling for deviation of realized permit prices from theoretical predictions based on fundamentals, results indicate that fee imposition does matter from an efficiency perspective. Furthermore, the method of collecting fees seems to matter considerably. While taxation on utilization permits seems to increase efficiency, the results indicate that partial retraction and re-allocation by auction reduces efficiency rather than enhancing it.

The experiment is designed so that the outcome cannot be explained by explicit transaction costs, demand effects or uncertainty.[25] An analysis of individual behavior also demonstrates that the effects of initial allocation (endowment effects) are not significant. Insufficient experience does not seem to be a likely explanation either, since the above results are even clearer when the experiment was repeated with experienced subjects.

The explanation which remains and must be considered the most probable one is that participants differentiate between paid cost and opportunity cost, contrary to what neoclassical theories maintain. In addition, the presentation of fee imposition seems to

[25] Here, we refer to the result that price fluctuations in markets for utilization permits can have an effect on technical development by reducing the demand for permits, e.g. by better pollution prevention equipment. It has also been argued that uncertainty in property rights is created by retraction and that has negative effects, e.g. on incentives for innovation and investment and on how the resources in question are treated.

matter in this context. When a tax is imposed on permits, the choices of inefficient firms are quite important: their decisions primarily involve the question of whether to retain a particular quantity of permits or reduce their numbers. In the auction treatment where permits are retracted and resold to the highest bidder, all participants must actively consider trade in quotas, especially those that have the most efficient production possibilities. In addition, the decision relies on different principles, as it mainly revolves around whether or not the company wishes to acquire more permits. Such presentation effects can matter dramatically in experiments as well as in real situations.

It cannot be determined with certainty to what extent these results can be applied to real markets. The possibility cannot be ruled out that participants in the experiment had not gained enough experience in the short time at their disposal such that their decisions can be compared to the decisions of real firms. However, the fact that results were more pronounced with increased experience of participants would seem to weaken the force of this argument and strengthen our conclusions.

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Appendix. Experiment instructions

Instructions (A)

Thank you for participating in this experiment, which is being conducted at the University of Iceland with the support of the Science Fund of RANNÍS (The Icelandic Centre for Research) and the University of Iceland's Research Fund. The experiment's purpose is to study economic decision-making. At the end of the experiment you will be paid a sum of money according to your performance in addition to ISK 800 which is an unconditional honorarium for your participation. Amounts in the experiment are stated in terms of an imaginary currency, experimental dollars, which are converted into Icelandic kronur at the end of the experiment at a certain exchange rate which will be displayed on your screen.

Your task is to operate a production company which sells its products on the world market. The price of each product unit is 75 experimental dollars ($75) and will not change. The cost of production is variable depending on the number of units produced and also differs among companies. The product unit cost of your company will appear on your computer screen. For every unit produced you must own one *production permit*. You have been awarded a certain number of permits which will appear on the computer screen at the beginning of the experiment.

You have also been awarded a certain sum which you can use to purchase additional permits. You can also sell some or all of your permits. You are not allowed to own more than five permits or to sell more permits than you own. All participants in the experiment can take part in transactions in the market for production permits. More details on this market are displayed below.

The experiment will extend over 15 periods. During each period you will have an opportunity to trade in production permits and determine the volume of your production. The permits are valid for all 15 periods but become void after it is concluded; you are not entitled to compensation for any remaining permits.

All participants will receive the same kind of information as you do. However, the initial endowment and unit costs differ among participants. Each participant has only information about his own position in addition to market information.

More on each step:

Each period is divided into two decision steps, each of which has a special information screen. During each of the two decision steps, the number of the period concerned and the time you have left at your disposal for the information screen concerned will be displayed at the top of your monitor. Information about your cash position and number of own permits will be displayed to the bottom and left of the monitor. Uppermost, to the right, the unit cost for your first to fifth unit and the gross profit for each unit produced is displayed.

Step 1: Interactive market for production permits

The information screen is divided into five columns (see accompanying graph). In the column farthest to the left you can enter a sale offer, i.e. the amount for which you are prepared to sell one permit. The offer is active and irrevocable the moment you click on the button: “send”. You can enter a new lower sale offer at any time, but this will make any earlier sale offers void. However, earlier offers do not disappear from the screen until someone accepts your lowest offer.

Sale offers, both your own and those of others, appear in column 2, and are ranked so that the lowest offer is at the bottom. If you wish to accept the lowest sale offer – i.e. buy a permit – you click on the button: “buy” at the bottom of column 2. However, you cannot accept your own sale offer.

In column 5, farthest to the right, you can enter a buy offer, i.e. the amount you are prepared to pay for one permit. The offer is active and irrevocable the moment you click on the “send" button. You can enter a new higher buy offer at any time, but this will make your earlier offers void. However, they do not disappear from the screen until someone accepts your highest offer.

Buy offers, both your own and those of others, appear in column 4 (from the left) and are ranked so that the highest offer is at the bottom. If you wish to accept the highest buy offer – i.e. sell a permit – you click on the button: “sell” at the bottom of column 4. However, you cannot accept your own buy offer.

In column 3, permit transactions appear the moment they occur.

The market is open for 2½ minutes each time. In the event of a new offer or transaction near the very end, ten seconds are added to the clock. Therefore, the closing of the market can be slightly delayed if things are hectic during the last few seconds.

Step 2: Production decision

After transactions in permits are concluded, you may decide on the number of units produced. Only whole units may be produced and their number may not exceed that of permits.

The main results are shown after each period. In the left of the screen you will see the profit on production and transactions in permits during the preceding period. You will also see the fee (tax) you will need to pay because of production permits owned. On the right side selected results from earlier periods are displayed. When you have studied the results, click on "continue". When all participants have clicked on “continue” the period is ended and the next one begins (unless the experiment is over).

Remember that you will be paid an amount which corresponds directly to your company’s performance, i.e. the cash position at the end multiplied by the exchange rate, plus the ISK 800 you receive for your participation alone. *Remember that the*

permits are transferred between periods but are voided at the end of the experiment without compensation.

If you would like any further explanations, raise your hand and an instructor will come to you and answer your questions. If you feel you understand these instructions you should start the program k:\jonthor\c\zleaf.exe. A gray information screen will appear on the screen with some text. The experiment will begin when everyone is ready. Good luck.

EXAMPLE - The numbers do not mirror the experiment
[Translation of terms below]

[Translation of the Icelandic terms:
Tímabil 1 af 1 = Time Period 1 of 1
Tími eftir (sekúndur) = Time left (seconds) 31

Framleiðslueining = Production unit

Sjóður = Cash
Fjöldi eigin leyfa = Number of units owned
Verð framleiðslu = Product price

Einingakostnaður = Unit cost
Framlegð á einingu = Gross profit per unit

Sölutilboð = Sale offers
Viðskipti = Transactions
Kauptilboð = Buy offers

Sölutilboð = Sale offer
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Senda = Send
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Instructions (B)

Thank you for participating in this experiment, which is being conducted at the University of Iceland with the support of the Science Fund of RANNÍS (The Icelandic Centre for Research) and the University of Iceland's Research Fund. The experiment's purpose is to study economic decision-making. At the end of the experiment you will be paid a sum of money according to your performance, in addition to ISK 800 which is an unconditional honorarium for your participation. Amounts in the experiment are stated in terms of an imaginary currency, experimental dollars, which are converted into Icelandic kronur at the end of the experiment at a certain exchange rate which will be displayed on your screen.

Your task is to operate a production company which sells its products on the world market. The price of each product unit is 75 experimental dollars ($75) and will not change. The cost of production is variable depending on the number of units produced and also differs among companies. The product unit cost of your company will appear on your computer screen. For every unit produced you must own one *production permit*. You have been awarded a certain number of permits which will appear on the computer screen at the beginning of the experiment.

Although the initial allocation is free of charge, you must pay a fee or tax of $15 for each production permit you own at the end of each period.

You have also been awarded a certain sum which you can use to purchase additional permits. You can also sell some or all of your permits. You are not allowed to own more than five permits or to sell more permits than you own. All participants in the experiment can take part in transactions in the market for production permits. More details on this market are provided below.

The experiment will extend over 15 periods. During each period you will have an opportunity to trade in production permits and determine the volume of your production. The permits are valid for all 15 periods but become void after it is concluded; you are not entitled to compensation for any remaining permits.

All participants will receive the same kind of information as you do. However, the initial endowment and unit costs differ among participants. Each participant has only information about his own position in addition to market information.

More on each step:

Each period is divided into two decision steps each of which has a special information screen. During each of the two decision steps, the number of the period concerned and the time you have left at your disposal for the information screen concerned will be displayed at the top of your monitor. Information about your cash position and number of own permits will be displayed to the bottom-left of the monitor. Uppermost, to the right, the unit cost for your first to fifth unit and the gross profit for each unit produced is displayed.

Step 1: Interactive market for production permits

The information screen is divided into five columns (see accompanying graph). In the column farthest to the left you can enter a sale offer, i.e. the amount for which you are prepared to sell one permit. The offer is active and irrevocable the moment you click on the button: “send”. You can enter a new lower sale offer at any time but this will make any earlier sale offers void. However, earlier offers do not disappear from the screen until someone accepts your lowest offer.

Sale offers, both your own and those of others, appear in column 2, and are ranked so that the lowest offer is at the bottom. If you wish to accept the lowest sale offer – i.e. buy a permit – you click on the button: “buy” at the bottom of column 2. However, you cannot accept your own sale offer.

In column 5, farthest to the right, you can enter a buy offer, i.e. the amount you are prepared to pay for one permit. The offer is active and irrevocable the moment you click on the “send" button. You can enter a new higher buy offer at any time but this will make your earlier offers void. However, they do not disappear from the screen until someone accepts your highest offer.

Buy offers, both your own and those of others, appear in column 4 (from the left) and are ranked so that the highest offer is at the bottom. If you wish to accept the highest buy offer – i.e. sell a permit – you click on the button: “sell” at the bottom of column 4. However, you cannot accept your own buy offer.

In column 3, permit transactions appear the moment they occur.

The market is open for 2½ minutes each time. In the event of a new offer or transaction near the very end, ten seconds are added to the clock. Therefore, the closing of the market can be slightly delayed if things are hectic during the last few seconds.

Step 2: Production decision

After transactions in permits are concluded, you may decide on the number of units produced. Only whole units may be produced and their number may not exceed that of permits.

The main results are shown after each period. In the left of the screen you will see the profit on production and transactions in permits during the preceding period. You will also see the fee (tax) you will need to pay because of production permits owned. On the right side selected results from earlier periods are shown. When you have studied the results, click on "continue". When all participants have clicked on “continue” the period is ended and the next one begins (unless the experiment is over).

Remember that you will be paid an amount which corresponds directly to your company’s performance, i.e. the cash position at the end multiplied by the exchange rate, plus the ISK 800 you receive for your participation alone. *Remember that the*

permits are transferred between periods but are voided at the end of the experiment without compensation.

If you would like any further explanations, raise your hand and an instructor will come to you and answer your questions. If you feel you understand these instructions you should start the program k:\jonthor\c\zleaf.exe. A gray information screen will appear on the screen with some text. The experiment will begin when everyone is ready. Good luck.

EXAMPLE - The numbers do not mirror the experiment
[Translation of terms below]

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Tímabil 1 af 1 = Time Period 1 of 1
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Sjóður = Cash
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Kauptilboð = Buy offers

Sölutilboð = Sale offer
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Senda = Send
Kaupa = Buy
Selja = Sell
Senda = Send]

Instructions (C)

Thank you for participating in this experiment, which is being conducted at the University of Iceland with the support of the Science Fund of RANNÍS (The Icelandic Centre for Research) and the University of Iceland's Research Fund. The experiment's purpose is to study economic decision-making. At the end of the experiment you will be paid a sum of money according to your performance, in addition to ISK 800 which is an unconditional honorarium for your participation. Amounts in the experiment are stated in terms of an imaginary currency, experimental dollars, which are converted into Icelandic kronur at the end of the experiment at a certain exchange rate which will be displayed on your screen.

Your task is to operate a production company which sells its products on the world market. The price of each product unit is 75 experimental dollars ($75) and will not change. The cost of production is variable depending on the number of units produced and also differs among companies. The product unit cost of your company will appear on your computer screen. For every unit produced you must own one *production permit*. You have been awarded a certain number of permits which will appear on the computer screen at the beginning of the experiment.

You have also been awarded a certain sum which you can use to purchase additional permits. You can also sell some or all of your permits. You are not allowed to own more than five permits or to sell more permits than you own. All participants in the experiment can take part in transactions in the market for production permits. More details on this market are provided below.

The experiment will extend over 15 periods. During each period you will have an opportunity to trade in production permits and determine the volume of your production. The permits are valid for all 15 periods; however, at the beginning of each period 20% of all existing permits will be rendered void. The specific permits lost are determined randomly by computer. You can never lose more than one permit in any one period, even though the chance of losing a permit increases in proportion to the number of permits. For example, if you own two permits at the beginning of a period, there is a 40% chance that you will lose one of them. If you own four permits, there is an 80% chance that you will lose one of them.

Since the voiding of permits is determined randomly, it will affect participants differently. Therefore, if the voiding affects you more severely than other participants, a transfer is calculated which compensates you for lost revenue. The transfer comes from those who have been affected less than others and is designed to make the consequences of voiding equal among participants. You can therefore take it as given that you will lose 20% of your permits during each period, or the equivalent in money.

Once specified permits (possibly one of yours) have been voided, they are sold in a sealed-bid auction. You will receive information on the number of permits on offer, k, and then enter an offer price for one and only one permit. The number of "winners" in the auction is equal to the number of permits on offer – i.e. those who submitted the k highest offer prices will each receive one permit. The price is equal to the $k+1$ highest offer price - i.e. the highest offer price which did not secure a permit. This auction

rule is well known in auction science and is meant to ensure that no one will have an incentive to submit an offer other than one which corresponds to his valuation of the permit's worth. The same applies here. If you secure a permit, your offer will not have any influence on the price and therefore there is no reason to bid less than what you judge the permit's worth to be.

All participants receive the same kind of information as you do. However, the initial endowment and unit costs differ among participants. Each participant only has information about his own position in addition to market information.

More on each step:

Each period is divided into two decision steps each of which has a special information screen. During each of the two decision steps, the number of the period concerned and the time you have left at your disposal for the information screen concerned will be displayed at the top of your monitor. Information about your cash position and number of own permits will be displayed to the bottom and left of the monitor. Uppermost, to the right, the unit cost for your first to fifth unit and the gross profit for each unit produced is displayed.

Step 1: Sealed-bid auction of previously voided production permits

After it is revealed whether or not you lost a permit after a particular period, the auction information screen will appear. There you will enter your offer price - the price you are ready to pay for one additional permit. The auction was described in more detail above. At the end of the auction, an additional information screen will appear showing you the auction's results: whether you received a permit and what price was paid for it. The same information screen shows the transfer mentioned before, i.e. compensation for proportionately great voiding or charge because of proportionately little voiding.

Step 2: Interactive auction market for production permits

The information screen is divided into five columns (see accompanying graph). In the column farthest to the left you can enter a sale offer, i.e. the amount for which you are prepared to sell one permit. The offer is active and irrevocable the moment you click on the button: "send". You can enter a new lower sale offer at any time but this will make any earlier sale offers void. However, earlier offers do not disappear from the screen until someone accepts your lowest offer.

Sale offers, both your own and those of others, appear in column 2, and are ranked so that the lowest offer is at the bottom. If you wish to accept the lowest sale offer – i.e. buy a permit – you click on the button: "buy" at the bottom of column 2. However, you cannot accept your own sale offer.

In column 5, farthest to the right, you can enter a buy offer, i.e. the amount you are prepared to pay for one permit. The offer is active and irrevocable the moment you click on the "send" button. You can enter a new higher buy offer at any time but this

will make your earlier offers void. However, they do not disappear from the screen until someone accepts your highest offer.

Buy offers, both your own and those of others, appear in column 4 (from the left) and are ranked so that the highest offer is at the bottom. If you wish to accept the highest buy offer – i.e. sell a permit – you click on the button: “sell” at the bottom of column 4. However, you cannot accept your own buy offer.

In column 3, permit transactions appear the moment they occur.

The market is open for 2½ minutes each time. In the event of a new offer or transaction near the very end ten seconds are added to the clock. Therefore, the closing of the market can be slightly delayed if things are hectic during the last few seconds.

Step 3: Production decision

After transactions in permits are concluded, you may decide on the number of units produced. Only whole units may be produced and their number may not exceed that of permits.

The main results are shown after each period. In the left of the screen you will see the profit on production and transactions in permits during the preceding period. You will also see the fee (tax) you will need to pay because of production permits owned. On the right side selected results from earlier periods are shown. When you have studied the results, click on "continue". When all participants have clicked on “continue” the period is ended and the next one begins (unless the experiment is over).

Remember that you will be paid an amount which corresponds directly to your company’s performance, i.e. the cash position at the end multiplied by the exchange rate, plus the ISK 800 you receive for your participation alone. *Remember that the permits are transferred between periods but are voided at the end of the experiment without compensation.*

If you would like any further explanations, raise your hand and an instructor will come to you and answer your questions. If you feel you understand these instructions you should start the program k:\jonthor\c\zleaf.exe. A gray information screen will appear on the screen with some text. The experiment will begin when everyone is ready. Good luck.

EXAMPLE - The numbers do not mirror the experiment
[Translation of terms below]

[Translation of the Icelandic terms:
Tímabil 1 af 1 = Time Period 1 of 1
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Sjóður = Cash
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Sölutilboð = Sale offer
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Senda = Send
Kaupa = Buy
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[Version for experienced subjects]

Instructions (A)

Thank you for participating in this experiment, which is being conducted at the University of Iceland with the support of the Science Fund of RANNÍS (The Icelandic Centre for Research) and the University of Iceland's Research Fund. The experiment's purpose is to study economic decision-making. At the end of the experiment you will be paid a sum of money according to your performance, in addition to ISK 800 which is an honorarium for your participation. Amounts in the experiment are stated in terms of an imaginary currency, experimental dollars, which are converted into Icelandic kronur at the end of the experiment at an exchange rate of 0.55.

Your task is to operate a production company which sells its products on the world market. The price of each product unit is 80 experimental dollars ($80) and will not change. The cost of production is variable depending on the number of units produced and also differs among companies. The product unit cost of your company will appear on your computer screen. For every unit produced you must own one *production permit*. You have been awarded a certain number of permits which will appear on the computer screen at the beginning of the experiment.

You have also been awarded a certain sum which you can use to purchase additional permits. You can also sell some or all of your permits. You are not allowed to own more than five permits. All participants in the experiment can take part in transactions in the market for production permits. More details on this market are provided below.

The same experiment will be repeated four times. Each round extends over four periods. During each period you will have an opportunity to trade in production permits and determine the volume of your production. The permits are valid for each individual round, or for four periods at a time, but they become void before the experiment is repeated or concluded. Although the same experiment is repeated four times, you will have a new role each time, with different awards and cost of production.

The first round is solely for practice and you will not receive any monetary reward for it.

All participants will receive the same kind of information as you do. However, the initial endowment and unit costs differ among participants. Each participant only has information about his own position in addition to market information.

More on each step:

Each period is divided into two decision steps, each of which has a special information screen. During each of the two decision steps, the number of the period concerned and the time you have left at your disposal for the information screen concerned will be displayed at the top of your monitor. Information about your cash position and number of own permits will be displayed to the bottom-left of the

monitor. Uppermost, to the right, a table which should help you decide how many permits you wish to own in light of prevailing permit market prices is displayed. In the first line you will see the unit cost for your first to fifth unit. The second line shows the gross profit for each unit produced (i.e. sale price less unit cost of production of your nth unit). Finally, in the third line is shown the present value of owning a permit to produce your nth unit (gross profit over all periods remaining).

Step 1: Interactive market for production permits

The information screen is divided into five columns (see accompanying graph). In the column farthest to the left you can enter a sale offer, i.e. the amount for which you are prepared to sell one permit. The offer is active and irrevocable the moment you click on the button: "send". You can enter a new lower sale offer at any time, but this will make any earlier sale offers void. However, the earlier offers do not disappear from the screen until someone accepts your lowest offer.

Sale offers, both your own and those of others, appear in column 2, and are ranked so that the lowest offer is at the bottom. If you wish to accept the lowest sale offer – i.e. buy a permit – you click on the button: "buy" at the bottom of column 2. However, you cannot accept your own sale offer.

In column 5, farthest to the right, you can enter a buy offer, i.e. the amount you are prepared to pay for one permit. The offer is active and irrevocable the moment you click on the "send" button. You can enter a new higher buy offer at any time, but this will make your earlier offers void. However, they do not disappear from the screen until someone accepts your highest offer.

Buy offers, both your own and those of others, appear in column 4 (from the left) and are ranked so that the highest offer is at the bottom. If you wish to accept the highest buy offer – i.e. sell a permit – you click on the button: "sell" at the bottom of column 4. However, you cannot accept your own buy offer.

In column 3 permit transactions appear the moment they occur.

The market is open for 2½ minutes each time. In the event of a new offer or transaction near the very end ten seconds are added to the clock. Therefore, the closing of the market can be slightly delayed if things are hectic during the last few seconds.

Step 2: Production decision

After transactions in permits are concluded, you may decide on the number of units produced. Only whole units may be produced and their number may not exceed that of permits. This information screen needs no further explanation.

The main results are shown after each period. In the left of the picture you will see the profit on production and transactions in permits during the preceding period. On the right side selected results from earlier periods are shown. When you have studied the results, click on "continue". When all participants have clicked on "continue" the period is ended and the next one begins (unless the experiment has come to a conclusion).

Remember that you will be paid an amount which corresponds directly to your company's performance, i.e. the cash position at the end of each round multiplied by the exchange rate, plus the ISK 800 you receive for your participation alone. *Remember that the permits are transferred between periods but are voided at the end of each round.*

If you would like any further explanations, raise your hand and an instructor will come to you and answer your questions. If you need no further explanations you should start the program k:\jonthor\c\zleaf.exe. A gray information screen will appear on the screen with some text, which is normal. The experiment will begin when everyone is ready. Good luck.

EXAMPLE - The numbers do not mirror the experiment
[Translation of terms below]

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Tímabil 1 af 1 = Time Period 1 of 1
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Sölutilboð = Sale offer
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Senda = Send
Kaupa = Buy
Selja = Sell
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[Version for experienced subjects]

Instructions (B)

Thank you for participating in this experiment, which is being conducted at the University of Iceland with the support of the Science Fund of RANNÍS (The Icelandic Centre for Research) and the University of Iceland's Research Fund. The experiment's purpose is to study economic decision-making. At the end of the experiment you will be paid a sum of money according to your performance, in addition to ISK 800 which is an honorarium for your participation. Amounts in the experiment are stated in terms of an imaginary currency, experimental dollars, which are converted into Icelandic kronur at the end of the experiment at an exchange rate of 0.64.

Your task is to operate a production company which sells its products on the world market. The price of each product unit is 80 experimental dollars ($80) and will not change. The cost of production is variable depending on the number of units produced and differs also among companies. The product unit cost of your company will appear on your computer screen. For every unit produced you must own one *production permit*. You have been awarded a certain number of permits which will appear on the computer screen at the beginning of the experiment.

You have also been awarded a certain sum which you can use to purchase additional permits. You can also sell some or all of your permits. You are not allowed to own more than five permits. All participants in the experiment can take part in transactions in the market for production permits. More details on this market are provided below.

Although the initial allocation is free of charge, you must pay a fee or tax of $11 for each production permit you own at the end of each period.

The same experiment will be repeated four times. Each round extends over four periods. During each period you will have an opportunity to trade in production permits and determine the volume of your production. The permits are valid for each individual round, or for four periods at a time, but become void before the experiment is repeated or after it is concluded. Although the same experiment is repeated four times, you will have a new role each time, with different awards and cost of production.

The first round is solely for practice and you will not receive any monetary reward for it.

All participants will receive the same kind of information as you do. However, the initial endowment and unit costs differ among participants. Each participant only has information about his own position in addition to market information.

More on each step:

Each period is divided into two decision steps, each of which has a special information screen. During each of the two decision steps, the number of the period

concerned and the time you have left at your disposal for the information screen concerned will be displayed at the top of your monitor. Information about your cash position and number of own permits will be displayed to the bottom and left of the monitor. Uppermost, to the right, a table which should help you decide how many permits you wish to own in light of prevailing permit market prices is displayed. In the first line you will see the unit cost for your first to fifth unit. The second line shows the gross profit for each unit produced (i.e. sale price less unit cost of production of your nth unit). Finally, the third line shows the present value of owning a permit to produce your nth unit (gross profit over all periods remaining).

Step 1: Interactive market for production permits

The information screen is divided into five columns (see accompanying graph). In the column farthest to the left you can enter a sale offer, i.e. the amount for which you are prepared to sell one permit. The offer is active and irrevocable the moment you click on the button: “send”. You can enter a new lower sale offer at any time, but this will make any earlier sale offers void. However, earlier offers do not disappear from the screen until someone accepts your lowest offer.

Sale offers, both your own and those of others, appear in column 2, and are ranked so that the lowest offer is at the bottom. If you wish to accept the lowest sale offer – i.e. buy a permit – you click on the button: “buy” at the bottom of column 2. However, you cannot accept your own sale offer.

In column 5, farthest to the right, you can enter a buy offer, i.e. the amount you are prepared to pay for one permit. The offer is active and irrevocable the moment you click on the “send" button. You can enter a new higher buy offer at any time, but this will make your earlier offers void. However, they do not disappear from the screen until someone accepts your highest offer.

Buy offers, both your own and those of others, appear in column 4 (from the left) and are ranked so that the highest offer is at the bottom. If you wish to accept the highest buy offer – i.e. sell a permit – you click on the button: “sell” at the bottom of column 4. However, you cannot accept your own buy offer.

In column 3, permit transactions appear the moment they occur.

The market is open for 2½ minutes each time. In the event of a new offer or transaction near the very end ten seconds are added to the clock. Therefore, the closing of the market can be slightly delayed if things are hectic during the last few seconds.

Step 2: Production decision

After transactions in permits are concluded, you may decide on the number of units produced. Only whole units may be produced and their number may not exceed that of permits. This information screen needs no further explanation.

The main results are shown after each period. In the left of the picture you will see the profit on production and transactions in permits during the preceding period. You will also see selected results from earlier periods. When you have studied the results,

click on “continue”. When all participants have clicked on “continue” the period is ended and the next one begins (unless the experiment has come to an end).

Remember that you will be paid an amount which corresponds directly to your company’s performance, i.e. the cash position at the end of each round multiplied by the exchange rate, plus the ISK 800 you receive for your participation alone. *Remember that the permits are transferred between periods but are voided at the end of each round.*

If you would like any further explanations, raise your hand and an instructor will come to you and answer your questions. If you need no further explanations you should start the program k:\jonthor\c\zleaf.exe. A gray information screen will appear on the screen with some text, which is normal. The experiment will begin when everyone is ready. Good luck.

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Senda = Send
Kaupa = Buy
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[Version for experienced subjects]

Instructions (C)

Thank you for participating in this experiment, which is being conducted at the University of Iceland with the support of the Science Fund of RANNÍS (The Icelandic Centre for Research) and the University of Iceland's Research Fund. The experiment's purpose is to study economic decision-making. At the end of the experiment you will be paid a sum of money according to your performance, in addition to ISK 800 which is an honorarium for your participation. Amounts in the experiment are stated in terms of an imaginary currency, experimental dollars, which are converted into Icelandic kronur at the end of the experiment at an exchange rate of 0.64.

Your task is to operate a production company which sells its products on the world market. The price of each product unit is 80 experimental dollars ($80) and will not change. The cost of production is variable depending on the number of units produced and also differs among companies. The unit cost of your company will appear on your computer screen. For every unit produced you must own one *production permit*. You have been awarded a certain number of permits which will appear on the computer screen at the beginning of the experiment.

You have also been awarded a certain sum which you can use to purchase additional permits. You can also sell some or all of your permits. You are not allowed to own more than five permits. All participants in the experiment can take part in transactions in the market for production permits. More details on this market are provided below.

The same experiment will be repeated four times. Each round extends over four periods. During each period you will have an opportunity to trade in production permits and determine the volume of your production. The permits are valid for each individual round, or for four periods at a time, but they become void before the experiment is repeated or concluded. Although the same experiment is repeated four times, you will have a new role each time, with different awards and cost of production.

The first round is solely for practice and you will not receive any monetary reward for it.

At the beginning of each period 20% of all existing permits are rendered void. Whether you lose a permit is determined randomly computer. You can never lose more than one permit in any one period, even though the chance of losing a permit increases in proportion to the number of permits. For example, if you own two permits at the beginning of a period, there is a 40% chance that you will lose one of them. If you own four permits, there is an 80% chance that you will lose one of them.

Since the voiding of permits is determined randomly, it will affect participants differently. Therefore, if the voiding affects you more severely than other participants, a transfer is calculated which compensates you for lost revenue. The transfer comes from those who have been affected less than others and is designed to make the consequences of voiding equal among participants. You can therefore take it as given

that you will lose 20% of your permits during each period, or the equivalent in money.

Once specified permits (possibly one of yours) have been voided, they are sold in a sealed-bid auction. You will receive information on the number of permits on offer, *k*, and then enter an offer price for one and only one permit. The number of "winners" in the auction is equal to the number of permits on offer – i.e. those who submitted the *k* highest offer prices will each receive one permit. The price is equal to the *k+1* highest offer price - i.e. the highest offer price which did not secure a permit. This auction rule is well known in auction science and is meant to ensure that no one will have an incentive to submit an offer other than one which corresponds to his valuation of the permit's worth. The same applies here. If you secure a permit, your offer will not have any influence on the price and therefore there is no reason to bid less than what you judge the permit's worth to be.

All participants receive the same kind of information as you do. However, the initial endowment and unit costs differ among participants. Each participant only has information about his own position in addition to market information.

More on each step:

Each period is divided into two decision steps each of which has a special information screen. During each of the two decision steps, the number of the period concerned and the time you have left at your disposal for the information screen concerned will be displayed at the top of your monitor. Information about your cash position and number of own permits will be displayed to the bottom and left of the monitor. Uppermost, to the right, a table which should help you decide how many permits you wish to own in light of prevailing permit market prices is displayed. In the first line you will see the unit cost for your first to fifth unit. The second line shows the gross profit for each unit produced (i.e. sale price less unit cost of production of your nth unit). Finally, the third line shows the present value of owning a permit to produce your nth unit, taking into account expected voidings (gross profit over all periods remaining after voiding).

Step 1: Sealed-bid auction of previously voided production permits

After it is revealed whether or not you lost a permit after a particular period, the auction information screen will appear. There you will enter your offer price - the price you are ready to pay for one additional permit. The auction was described in more detail above. At the end of the auction, an additional information screen will appear showing you the auction's results: whether you received a permit and what price was paid for a permit. The same information screen shows the transfer mentioned before, i.e. compensation for proportionately great voiding or charge because of proportionately little voiding.

Step 2: Interactive market for production permits

The information screen is divided into five columns (see accompanying graph). In the column farthest to the left you can enter a sale offer, i.e. the amount for which you are prepared to sell one permit. The offer is active and irrevocable the moment you click on the button: "send". You can enter a new lower sale offer at any time, but this

will make your earlier sale offers void. However, earlier offers do not disappear from the screen until someone accepts your lowest offer.

Sale offers, both your own and those of others, appear in column 2, and are ranked so that the lowest offer is at the bottom. If you wish to accept the lowest sale offer – i.e. buy a permit – you click on the button: “buy” at the bottom of column 2. However, you cannot accept your own sale offer.

In column 5, farthest to the right, you can enter a buy offer, i.e. the amount you are prepared to pay for one permit. The offer is active and irrevocable the moment you click on the “send" button. You can enter a new higher buy offer at any time but, this will make your earlier offers void. However, they do not disappear from the screen until someone accepts your highest offer.

Buy offers, both your own and those of others, appear in column 4 (from the left) and are ranked so that the highest offer is at the bottom. If you wish to accept the highest buy offer – i.e. sell a permit – you click on the button: “sell” at the bottom of column 4. However, you cannot accept your own buy offer.

In column 3, permit transactions appear the moment they occur.

The market is open for 2½ minutes each time. In the event of a new offer or transaction near the very end ten seconds are added to the clock. Therefore, the closing of the market can be slightly delayed if things are hectic during the last few seconds.

Step 2: Production decision

After transactions in permits are concluded, you may decide on the number of units produced. Only whole units may be produced and their number may not exceed that of permits. This information screen needs no further explanation.

The main results are shown after each period. In the left of the screen you will seethe profit on production and transactions (including auctions) in permits during the preceding period. You will also see the fee (tax) you will need to pay because of production permits owned. On the right side selected results from earlier periods are shown. When you have studied the results, click on "continue". When all participants have clicked on “continue” the period is ended and the next one begins. And so it goes until the end of the last period.

Remember that you will be paid an amount which corresponds directly to your company’s performance, i.e. the cash position at the end of each round multiplied by the exchange rate, plus the ISK 800 you receive for your participation alone. *Remember that the permits are transferred between periods but are voided at the end of each round.*

If you would like any further explanations, raise your hand and an instructor will come to you and answer your questions. If you need no further explanations you should start the program k:\jonthor\c\zleaf.exe. A gray information screen will appear on the screen with some text, which is normal. The experiment will begin when everyone is ready. Good luck.

EXAMPLE - The numbers do not mirror the experiment
[Translation of terms below]

[Translation of the Icelandic terms:
Tímabil 1 af 1 = Time Period 1 of 1
Tími eftir (sekúndur) = Time left (seconds) 31

Framleiðslueining = Production unit

Sjóður = Cash
Fjöldi eigin leyfa = Number of units owned
Verð framleiðslu = Product price

Einingakostnaður = Unit cost
Framlegð á einingu = Gross profit per unit

Sölutilboð = Sale offers
Viðskipti = Transactions
Kauptilboð = Buy offers

Sölutilboð = Sale offer
Kauptilboð = Buy offer

Senda = Send
Kaupa = Buy
Selja = Sell
Senda = Send]