Auctioned and Re-Auctioned Children in 19th Century Sweden*

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Abstract

During the 19th century, poor and orphan Swedish children were boarded out. The foster-parents' compensation was determined in English auctions. Some children were re-auctioned. We use historical data from such auctions to study whether informational asymmetry and possibly adverse selection affected the outcome in the market for re-auctioned children. The empirical findings are consistent with adverse selection.

Key Words: Adverse selection, asymmetric information, common value, English auction, private values.

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1. Introduction

This paper studies bidder behaviour in an historical auction institution in Sweden during the 19th century. In this period, orphans and the children of the poorest of the poor were sold in auctions. Potential foster-parents bid against each other and the lowest bidder got the child who had been put up for sale. These auctions were managed by the local Public Assistance Board (which we shall refer to as the "Assistance Board"). The auctions were open and children put up for sale were present at the auction (Ejdestam, 1969). The Assistance Board compensated the foster-parent with an annual amount equal to the lowest bid. After the auction, a contract on the child was drawn up between the Assistance Board and the foster-parent. Auctions were held whenever necessary. The boarding spell could be temporary or it could last until the child's fifteenth birthday. Auctions of children in Sweden were prohibited by law in 1918.

The child auctions can be viewed as descending-bids auctions in which the Assistance Board procured services from a number of potential suppliers. On behalf of the Assistance Board, the foster-parents provided the child with its legal rights to housing, upbringing and education.

Alternatively, we can focus on the foster-parents' valuation of the child. A foster-child could substitute for a biological child or provide labour for household tasks in the family. In the auctions, the custody of the child was transferred from the Assistance Board to the foster-parents, so in this sense, the child was "sold". The fact that the foster-parents were paid by the Assistance Board (that is, that the cost of caring for the child was higher than the value the foster-parents put on the child) speaks in favour of the former point of view. However, we have chosen to see the foster-parents as the buyers. This is in accordance with Lundberg (1997), who shows that there are reasons to believe that foster-parents bought children (at least partially) for their own gain. Children who could be useful in the household commanded a lower price (compensation) than those who could not. Age and health were two of the factors that affected the child's usefulness.

Almost 40 percent of the children in the data set used in the present paper were auctioned more than once, changed foster-parent and/or the price of the child was changed.[1] In particular, in many cases there was a change in the annual compen-

[1] See Table A.1 in the appendix for more details.

sation while the child remained with the same foster-parents. When a child was re-auctioned, a new contract was established between a new foster-parent and the Assistance Board. It has not been possible to establish whether the foster-parent who held the current contract usually took part in the new bidding. Therefore, we use two alternative assumptions. The first assumption is that the foster-parents holding the current contract had the right to participate in the bidding. Then, compensation levels are considered as set in new auctions, whether the child moved from one family to another or not. The second, alternative, assumption is that current foster-parents did not have the right to bid and that price changes occurring when the child remained with the same family were the result of renegotiations.

We assume that each bidder formed an expectation of the child's value, and that this value could be common, private, or a combination of both. See Vickrey's seminal contributions (1961, 1962). In private-values auctions, the object being sold has a value v_i for bidder i. Each bidder knows his valuation, but not that of the others, and the valuations are usually assumed to be independently drawn from a common distribution. This is common knowledge among the bidders.

In common-value auctions, all bidders are assumed to have the same valuation, v, of the object. The value v is unknown for all or some of the bidders, but drawn from a known distribution.[2] In our model, the current holder of the contract (the informed bidder) knows v and therefore has an informational advantage. New prospective foster-parents (uninformed bidders) know only the distribution from which the common value is drawn.

Asymmetric information in common-value auctions has been studied by Wilson (1977), Weverbergh (1979) and Engelbrecht-Wiggans et al. (1983). Influential empirical studies (of offshore oil and gas-drainage lease sales) have been carried out by Hendricks and Porter (1988, 1993).[3] Greenwald and Glasspiegel (1983), in a paper on adverse selection in the market for slaves sold in New Orleans 1830-1860,

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[2]In the standard formulation of the common-value model, the bidders observe v plus an idiosyncratic error term ϵ_i. Now the *error terms* are independently drawn from a known distribution. Thus, bidder i's estimate is $x_i = v + \epsilon_i$. With this formulation, adding the information in separate estimates improves the precision. In the present paper we use a formulation where there is no such effect.

Milgrom and Weber (1982) have developed a general model, which includes the private-values model and the common-value model as special cases. For an accessible presentation, see Milgrom (1989), who also provides an overview of the main findings in auction theory.

[3]See also Laffont (1997).

present a model with some features in common with our model (e.g. both private and common values), although the information structure is quite different in the two papers. Hendricks and Paarsch (1995) provide a recent survey of empirical studies of auction markets.

In Section 2 we present a simple model of a situation where the current foster-parent *is* allowed to participate in a new auction. Theory suggests that if the current foster-parent has better information on the value of the child, he can exploit this information to his benefit.

In Section 3 we present a model of a situation where the current foster-parent is *not* allowed to participate in a new auction. Then, price changes occurring when the child remained with the same family were the result of renegotiations. Only if no new agreement could be reached between the Assistance Board and the present foster-parent (or if the foster-parent died) was the child re-auctioned and a new foster-parent appointed. Under this assumption, adverse selection could have had the result that the (unobservable) common value of re-auctioned children was lower than average. Given the existence of an economic motive in these auctions (Lundberg, 1997), the propensity to re-auction the child could be higher if the child had lower-than-average skills.[4] Glasspiegel and Greenwald (1983) present evidence of adverse selection in the market for slaves in New Orleans 1830-1860. Our model of adverse selection is presented in Section 3.

The aim of this study is, first, to analyse wether there was asymmetric information between the bidders and adverse selection in the market for re-auctioned children, and, second, to examine wether the data is more consistent with the assumption that previous foster parents were allowed to bid in re-auctions than the opposite assumption, or vice versa.[5] There are no general theoretical results for all the situations which we consider possible (e.g., asymmetric information when there are both private and common values). Therefore, we first analyse six possible situations with a simple model: private values, common values and both private and

[4] Akerlof (1970) analysed markets with asymmetric information. He referred to worse-than-average used cars as "lemons"; for this reason markets where adverse selection plays a role are sometimes known as "lemons markets".

[5] A typical advantage of empirical studies of auction markets is that the rules of the game are well known. This simplifies the analysis of the effect of varying parameters, for example in an experimental setting. In the present study, the rules of the game are not well known. In a sense, the situation resembles the case were an experimenter guesses what behavioural rules govern the bidders' actions in an auction.

common values, where the informed agent is either allowed to bid (Section 2) or not allowed to bid (Section 3). Our empirical analysis, presented in Section 4, is based on a stochastic cost-frontier approach applied to data collected from historical documents[6] from three cities[7] in Northern Sweden. The results indicate that when children were re-auctioned the foster-parents were awarded higher compensation, perhaps because of adverse selection.

2. Previous foster-parent allowed to bid

This section proceeds under the assumption that the first foster-family usually participated when a child was re-auctioned. If the previous foster-family won the auction, the level of compensation was adjusted; otherwise, the child changed family. In Section 3 we make the alternative assumption that the first foster-family did not participate when a second auction was held.

We adopt the convention that the informed bidder - the first foster-family - is bidder 1. Without loss of generality, we assume that the $n-1$ uninformed bidders' private valuations can be ranked $v_2^p > v_3^p > ... > v_n^p$. (For the most part, we will assume that there is only one uninformed bidder present.) Further, we assume that bidders are risk neutral, that there are no repeated-games effects present (i.e. that the bidding behaviour in one auction does not affect the outcomes in other auctions), and that the "seller" (the Assistance Board) has no reservation value.

It appears reasonable to assume that each bidder's valuation of a child has an element that is common to all bidders - i.e. a common-value component - and an idiosyncratic element - i.e. a private-value component. The common value could be determined both by easily observable characteristics of the child, such as sex and age, and by "unobservable" characteristics; e.g. skills. The private values could be determined by the bidders' characteristics and by the bidders' preferences regarding the child's characteristics. Some of the observable characteristics were used in an earlier study of prices in child auctions (Lundberg, 1997).

The unobservable characteristics are only unobservable to an outsider: if the child has lived in the family for an extended period of time, these characteristics are assumed to have been revealed to the family members. If a child is auctioned a

[6] Records from the Local Public Assistant Board's meetings, cash registers and parish books.
[7] Skellefteå, Sundsvall and Umeå.

second time, this implies that information is asymmetric: the previous foster-parent knows both the common value and his private value, while other participants in the auction know only their private values.

We assume that the value V_{ij} of a child j to bidder i is given by a function U, so that:

$$V_{ij} = U(S_j, s_j, R_i, r_i) \tag{2.1}$$

where S_j (s_j) is a vector of observable (unobservable) variables representing characteristics of child j and $R_i(r_i)$ is a vector of observable (unobservable) variables representing characteristics of the bidder that influence the value. To simplify matters further, assume that U is separable, so that:

$$V_{ij} = u(S_j) + v^p(R_i, r_i) + v^c(s_j) = u(S_j) + v_i^p + v_j^c = u(S_j) + v_{ij} \tag{2.2}$$

where u is a function for the part of the value that is attributable to observable child characteristics, v_i^p is the private-value component, v_j^c is the common-value component and v_{ij} is the sum of these two. If at least two bidders bid competitively for the child, $u(S_j)$ will be reflected one for one in the price. In the following, we suppress indexation with respect to child. To focus on the unobservable components, subtract $u(S)$ from the observed price P. Thus, $p = P - u(S)$ should reflect the payment attributable to the private and common value components.

We consider three alternative specifications of the auction model in this section: the private-values model, the common-value model and a model with both private and common values. Somewhat incorrectly, we refer to the previous foster-parent as the informed bidder also in the private-value model, so as to use a consistent terminology.

2.1. Private-value auctions

In the simplest case, there are two bidders: one informed and one uninformed. The valuations of the two bidders are drawn from the uniform distribution $[0, 1]$.

In English auctions, the dominant strategy is to bid up to one's valuation. Given that the informed bidder has valuation v_1 and wins, the expected payment is equal to $v_1/2$. The probability that an informed bidder with valuation v_1 wins is v_1. Thus, the expected payment of the informed bidder, conditional on winning, is $1/3$. This is the integral of $(v_1)^2/2$ over the interval $[0, 1]$, divided by the probability that the informed bidder wins, which is $1/2$. By symmetry, the uninformed bidder's expected price is also $1/3$.

In the appendix, we explore the idea that the informed bidder's valuation is systematically higher than that of the uninformed bidder, or vice versa. We show that the high-valuation bidder wins more than half of the time and pays a lower expected price than the low-valuation bidder. The expected revenues of the seller increase when the expected valuation of one bidder increases.

It is well known that the expected winning price increases with the number of bidders (Vickrey, 1961).

2.2. Common-value auctions

In an English auction with a common value that is unobservable to all but one bidder, the uninformed bidders' best strategy is to bid no more than the lowest possible value. This is so because the informed bidder's optimal strategy is to outbid the other participants until the highest bid is equal to or above the true value. Then, if an uninformed bidder's maximum bid is below the true value, he will loose the auction and earn zero profit. If the uninformed bidder bids above the true value, the best he can hope for is zero profit; if another uninformed bidder bids above the true value, he may loose. However, the loss can be restricted to a small number ϵ, if the uninformed bidder employs the strategy of overbidding the informed bidder by ϵ.

Of course, there may be reasons that prevent the informed bidder from participating in the auction: one obvious case would be if the previous foster-parent died. If no informed bidder is present, then the uninformed bidders will participate in the auction and bid as if the child had never been auctioned before.[8] Thus, on average, the uninformed bidders' price will be higher.

2.3. Auctions with common and private values

With this set-up, it is still a dominant strategy for the informed bidder to bid up to his valuation. For the uninformed bidder, a naive strategy would be to bid up to his private valuation plus the prior expected common valuation, which is $1/2$, given

[8] The issue of adverse selection is discussed in Subsection 2.4 and in Section 3.

that the common value is uniformly distributed in the interval $[0,1]$. This strategy, however, does not take into account the fact that the uninformed bidder is more likely to win, when the common value is low. A more appropriate strategy is the solution to the following maximisation problem:[9]

$$\max_{b_2} E\left[\pi_2 \left| b_2 \right.\right] = \max_{b_2} \Pr\left[b_2 > b_1\right] E\left[\pi_2 \left| b_2 > b_1 \right.\right] \tag{2.3}$$

where π_2 is the uninformed bidder's payoff and b_2 his optimal maximum bid, and $b_1 = v_1^p + v^c$ is the informed bidder's maximum bid. In the appendix, it is shown that the solution to expression 2.3 is:[10]

$$\bar{b}_2 = 2v_2^p \tag{2.4}$$

The expected price paid by the two types can be calculated as follows.

The informed bidder's expected price

The density function for the informed bidder's valuation v_1 is given by

$$\begin{cases} v_1 \\ 2 - v_1 \end{cases} \text{when} \begin{cases} 0 \leq v_1 \leq 1 \\ 1 < v_1 \leq 2 \end{cases} \tag{2.5}$$

Given (2.4), the probability that an informed bidder with valuation v_1 wins is

$$\Pr\left[v_1 > v_2 | v_1\right] = \frac{1}{2} v_1 \tag{2.6}$$

Given that the informed bidder wins, the expected payment is given by

$$E\left[p | v_1 > v_2\right] = \frac{1}{A}\left[\int_0^1 \frac{1}{4} x^3 dx + \int_1^2 (2 - x)\frac{1}{4} x^2 dx\right] = \frac{7}{12} \tag{2.7}$$

since $A = \frac{1}{2}$ is the probability that the informed bidder wins. Expression 2.7 is the integral over the range of v_1 (i.e. over $[0,2]$) of the product of the density function, the probability that the informed bidder wins and the expected price, given that the

[9] In our model, an uninformed bidder cannot draw inferences from the observed behaviour of other uninformed bidders, because adding the uninformed bidders' information does not increase precision. See note 3.

[10] Actually, we show somewhat more generally that the uninformed bidder should bid $\bar{b}_2 = 2v_2^p - k$, where k is the difference in expected valuation between the informed and the uninformed bidder.

informed bidder wins, divided by the probability that the informed bidder wins.

The uninformed bidder's expected price

A similar derivation for the uninformed bidder is slightly more complicated. The density function is now $\frac{1}{2}$ over the range $[0, 2]$. However, the expected payment, given that an uninformed bidder with valuation v_2 wins, is

$$E\left[p|v_2 > v_1; v_2\right] \begin{cases} \frac{2}{3}v_2 \\ \frac{2(1-3(v_2)^2+(v_2)^3)}{3(2-4v_2+(v_2)^2)} \end{cases} \text{when} \begin{cases} 0 \leq v_2 \leq 1 \\ 1 < v_2 \leq 2 \end{cases} \tag{2.8}$$

The probability that an uninformed bidder with valuation v_2 wins is

$$\Pr\left[v_2 > v_1|v_2\right] = \begin{cases} \frac{1}{2}(v_2)^2 \\ \frac{1}{2}(4v_2 - 2 - (v_2)^2) \end{cases} \text{when} \begin{cases} 0 \leq v_2 \leq 1 \\ 1 < v_2 \leq 2 \end{cases} \tag{2.9}$$

Taking the integral of the product of these three functions over the interval $[0, 2]$ and dividing by the probability that the uninformed bidder wins gives

$$E\left[p|v_2 > v_1\right] = \frac{1}{A}\left[\frac{1}{24} + \frac{3}{8}\right] = \frac{5}{6} \tag{2.10}$$

since again $A = \frac{1}{2}$.

We find that the informed bidder pays a lower expected price.[11]

2.4. Incentives for adverse selection and summary of results

We are exploring the assumption that the foster-parent could bid for a child who was re-auctioned. Under these circumstances, would the foster-parent's propensity to terminate the contract be higher when his valuation of the child was low? In other words, would there be adverse selection?

In Section 2.2 we have argued that an informed bidder will win at the lowest possible price, if the valuation is of the *common-value* type. Therefore, it is in the interest of the winner to terminate all contracts, irrespective of valuation, since no uninformed bidder will participate in a second auction and there will be no adverse

[11] We have explored the consequences of a "naive" strategy, in which the uninformed bidder bids his private value plus the unconditional expected common value, 1/2. Surprisingly, such a stragegy raises the expected price of the informed bidder above that of the uninformed bidder and reduces the expected payoff of the informed bidder dramatically, but causes only a small decrease in the uninformed bidder's payoff.

selection.[12] The price paid in the first period will reflect the option value in winning the auction. Under these assumptions, we expect the prices paid by informed bidders to be lower than the prices paid by uninformed bidders.

If the good is of the *private-value* type, matters are more complicated. If the participants are the same in the second auction, the price will also be the same. Thus, first-period winners are indifferent between terminating and not terminating the contract. However, if there is a likelihood that new bidders will participate, first-period winners risk loosing a second auction and prefer not to terminate the contract. On the other hand, if some of the previous participants drop out, the first-period winner may win at a lower price and will prefer to terminate the contract.

In the appendix, we analyse the special case where the informed bidder faces (only) one new uninformed bidder, whose valuation is unknown, if the contract is terminated. We show that the informed bidder will terminate the contract if

$$p > v_1^p - \frac{1}{2}(v_1^p)^2 \tag{2.11}$$

From the point of view of the "uninformed" bidder, there can be no adverse selection. However, from condition 2.11 it follows that, from the point of view of the informed bidder, there is "positive selection". That is, the informed bidder will be more likely to terminate a contract if his private valuation is high. By the analysis in 2.1, the informed bidder will win more than half of the times and pays a lower average price.

To sum up, the winner in the first auction has an incentive to terminate a contract and enter a second auction if the common-value component dominates, irrespective of whether the *realised* common value is high or low. If the private-value component dominates, the incentive to terminate a contract is strong if the realised price is high relative to the winner's valuation and if his valuation is high, i.e. if a lower price is likely in a second auction. Both these effects suggest that the informed bidder will pay less than the uninformed bidder when a child is re-auctioned.

In the above theoretical analysis, the price is paid from the buyer to the seller, while in the empirical data, it is the other way around. Thus the theoretical pre-

[12] To be precise, the uninformed bidder will submit a bid equal to $u(S) + v_l^c$, where v_l^c is the lower support for the distribution of v^c , which the informed bidder will outbid by an infinitesimal amount.

dictions must be "reversed". With this in mind, the predictions of the theoretical analysis can be summarised as follows:

1. If there is a common-value component, this tends to make the informed bidder´s compensation higher than that of the uninformed bidders or that obtained for children who have never before been auctioned.

2. This tendency is strengthened if the informed bidder can selectively terminate contracts.

3. If there is no unobservable common-value component and no possibility for selective termination of contracts, then all types of bidders (informed and uninformed bidders and bidders for children who have never before been auctioned) receive the same expected compensation.

4. If the expected valuation of the informed bidders is higher than that of the uninformed bidders, this tends to make the expected compensation to the former higher than that to the latter, and vice versa.

3. Adverse selection

In contrast to the previous section, let us now assume that the first foster-parent did not participate when children were re-auctioned. If either part was not satisfied with the price stipulated by the contract, there could have been negotiations over a new price; if the negotiations broke down, there was a new auction, from which the previous foster-parent was - expressly or implicitly - excluded.

When the contract is terminated by the Assistance Board, there is no reason to expect adverse selection. However, when the contract is terminated by the foster-parent, this could be precisely because the common value was lower than expected, i.e. we could have adverse selection. We focus on the latter case, and model the situation as a four-stage game. In the first stage, the potential foster-parents bid for a "new" child. The winner cares for the child and pays the price.[13] In the second stage, the winner determines whether or not to keep the child. In the third stage, the Assistance Board possibly offers a lower price to the first foster-parent (The Assistance Board is assumed to have all bargaining power). Finally, if no agreement can be reached, the child is auctioned again in the fourth and final stage. The

[13] Again, we assume that the foster-parent pays the "seller", the Assistance Board.

previous foster-parent is not allowed to participate, so a new foster-parent takes care of the child and pays the price.

3.1. Private-value auctions

If the bidders' valuations are purely private, then there can be no adverse selection effects. This suggests that when a child is re-auctioned, the bidders should optimally bid up to their valuations.

3.2. Common-value auctions

Assume that the child has a common value v^c, drawn from the uniform distribution $[0, 1]$. We start the analysis in the fourth stage and then proceed by solving the four-stage game backwards. If the first foster-parent has been offered y for the final period, but has not accepted that offer, the expected value of the child is $y/2$. This is the equilibrium auction price in the final stage. In the third stage, the Assistance Board determines whether or not to offer a lower price y. Suppose that the price was x_1 in the first period, and suppose that for all values $v^c < x_1$, the first foster-parent terminates the contract. The Assistance Board has the opportunity to offer a lower price, y, to the current foster-parent or else hold a new auction. If a lower price y is offered, with probability $(x_1 - y)/x_1$, the new price is accepted, and with probability y/x_1 a new auction must be held, with an expected price $y/2$. The expected revenue of The Assistance Board is:

$$(x_1 - y)y/x_1 + y^2/2x_1 \tag{3.1}$$

It is easy to see that maximal revenue is obtained when $y = x_1$, that is when the first-period winner is not offered a lower price. This simplifies the analysis, since otherwise all first-period winners would wish to renegotiate the price. Now, first-period winners will terminate the contract only if $v_c < x_1$. In the first stage, the bidders must determine how much to bid. The expected value of the child is $1/2$. However, in the second period, the winner only keeps the child if the value exceeds the per-period price x_1, in which case the expected value of the child is $(1 + x_1)/2$. This happens with probability $(1 - x_1)$. The winner pays x_1 in the first period and, with probability $(1 - x_1)$, he pays x_1 also in the second period. The equilibrium winning bid will be such that the expected value equals the expected payments, i.e.:

$$1/2 + (1 - x_1)\frac{1 + x_1}{2} = x_1 + (1 - x_1)x_1 \tag{3.2}$$

One of the roots to equation 3.2 gives the first-period price:

$$x_1 = 2 - \sqrt{2} \approx 0.586 \tag{3.3}$$

The second-period price is thus:

$$x_2 = x_1/2 = 1 - 1/\sqrt{2} \approx 0.293 \tag{3.4}$$

In this model we do not expect renegotiations to be successful: either the first buyer has to accept the original price, or else the child is re-auctioned (to another bidder).[14] However, this analysis focuses exclusively on the unobservable qualities. If observable characteristics (e.g. age) change, or if the economic environment causes the value of the child to change (e.g. if the price level changes), then a renegotiation of the price may be successful. Thus, there may well be instances of price changes even though the child remains with the same family, although we do not expect adverse-selection effects under these circumstances.

Would the seller be better off allowing the informed bidder to participate in the new auction or not? In the two-period model used in this section, it is easy to see that the expected revenues of The Assistance Board are equal to 1. This can be calculated using equations 3.3 and 3.4, noting that equation 3.3. also provides the probability that a second auction is held.

Under the same assumptions, if the informed bidder is allowed to participate in a second auction, then in equilibrium the informed bidder wins the second auction at price zero. Since the expected value is 1/2 in both periods, this is reflected in the equilibrium price in the first auction, which must be equal to 1. Thus, in a simple setting, the seller is indifferent to whether or not the informed bidder is allowed to participate. We have not analysed whether this conclusion holds under more general assumptions.

[14] A somewhat related result is reported by Bulow and Klemperer (1996), who find that an auction with $n + 1$ participants yields higher expected revenues than negotiations with one agent followed by an auction with n participants.

3.3. Private and common value auctions

If a winner in a previous auction chooses to terminate a contract, the uninformed bidders can conclude that the sum of the former winner's private value and the common value is less than the price. However, additional inferences can be drawn by analysing the decision problem of the winner before he became informed. We use the same model as in the previous section, except that the Assistance Board does not have the option of offering a higher compensation to the previous winner. Ex ante, the winner's expected first-period net value from winning was his private value plus 1/2 minus the agreed price. His second-period net expected value was $v_1^p + \frac{1+a}{2} - p$ times the probability that the contract was not terminated, θ, where a is the lowest common value for which the contract is not terminated. Thus:

$$v_1^p + \frac{1}{2} - p + \theta(v_1^p + \frac{1+a}{2} - p) \geq 0 \tag{3.5}$$

Substituting the equalities $a = p - v_1^p$ and $\theta = 1 - a = 1 - p + v_1^p$ into 3.5 and solving for v_1^p, we find that:

$$v_1^p \geq p - 2 + \sqrt{2} \tag{3.6}$$

Now, when a contract is terminated, we know that:

$$\begin{aligned} v_1^p + v^c &\leq p && (3.7)\\ 0 &\leq v_1^p \leq 1 && (3.8)\\ 0 &\leq v^c \leq 1 && (3.9)\\ v_1^p &\geq p - 2 + \sqrt{2} && (3.10) \end{aligned}$$

The possible combinations of private and common valuations that the first-period winner can have, given this set of inequalities, are illustrated in Figure 3.1.

An uninformed bidder can calculate the expected common value, given the first-period price, as the centre of gravity along the vertical axis of the shaded area. It is clear from the figure that if the last inequality binds, i.e. if $p \geq 2 - \sqrt{2}$, then the effect of this inequality is to reduce the expected common value. That is, the adverse-selection effect is aggravated. Compared to Subsection 3.2, the uninformed bidders have less exact information when they form an expectation of the common-value, since the informed party's (unknown) private valuation introduces "noise".

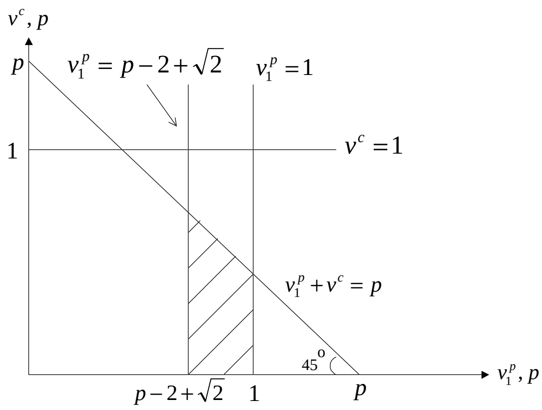

Figure 3.1: Adverse selection, possible outcomes given equations (3.7) to (3.10).

However, the adverse-selection effect persists. This effect still tends to make the second-period price lower than the first-period price.

3.4. Conclusions

Again, we have to "reverse" our results. As long as we have some component of common-value, adverse selection causes the compensation to be higher when a child is re-auctioned to an uninformed bidder. This is in contrast with the predictions of the model of Section 2, where the previous foster-parent was allowed to participate in a second auction. There, we predicted that the *informed* bidder would receive the highest compensation, unless the uninformed bidder's expected valuation was sufficiently higher than that of the informed bidder.

4. The Empirical Study

4.1. Data

The sample consists of 601 observations from three cities in Northern Sweden: Sundsvall, Skellefteå[15] and Umeå[16]. There are 212 auctions in this sample in which the amount of compensation was changed in some way and/or there was a new foster-parent. Of the 212 auctions, 111 were changes in the compensation paid without a change of foster-parent and 101 were auctions in which the child was assigned to a new foster-parent. These data are used to study real differences in compensation between different categories of sale. Only the winning bids were observable in the data set. For descriptive comparisons we use a sub-sample consisting of children auctioned for the first time, who were later re-auctioned (either to a new foster-parent or to the existing foster-parent but at a new level of compensation) and a sub-sample with children auctioned for the first time. Finally, there is a sub-sample of children auctioned for the first time, but who were later re-auctioned to a new foster-parent. Table A.2 in the appendix gives an overview of the data for each category. Age frequencies are given in Table A.3 in the appendix, followed by Table A.4 with descriptive statistics regarding age[17] for the different categories of sale. Generally, re-auctioned children were older than children auctioned for the first time. Children observed for the first time who were later re-auctioned had the lowest average age, 6.5 years. According to Lundberg (1997) the compensation was generally higher for younger children than for older ones. The apparent reason was that older children were more useful to the foster-parent than younger children (see also Ejdestam, 1969). Table 4.1 presents descriptive statistics concerning real compensation for the different categories.

The average real compensation for uninformed bidders is significantly lower than the average real compensation for children observed for the first time who were later re-auctioned, and it is also significantly lower than the average real compensation

[15] Missing information in the documents from Sundsvall and Skellefteå has been added with the help of a database, INDIKO, Umeå University.

[16] For Sundsvall the years are 1863-1882 and 1885-1888, for Skellefteå, 1869-1871, 1880, 1885 and 1888 and for Umeå 1874-1874, 1878-1879, 1881 and 1884-1889, respectively.

[17] In the empirical analysis age has been counted as the difference between the year when they were auctioned and the year of birth. This is why some children are actually 15 years old.

Table 4.1: Descriptive statistics concerning real compensation

	Full sample	Auctioned for the 1:st time	Re-auctioned children	Informed bidders	Un-informed bidders	1:st time observed, later re-auctioned	1:st time observed, later new foster-parent
Mean	55.22	55.50	54.70	57.46	51.67	57.11	54.91
Max	168.42	153.06	168.42	168.42	97.09	152.54	135.14
Min	8.77	10.42	8.77	8.77	9.80	17.82	25.77
Std.dev.	19.98	20.75	18.53	20.44	15.72	21.03	18.87
Variance	399.26	430.39	343.31	417.80	247.08	442.37	356.23
No of cases	601	389	212	111	101	151	83

for informed bidders.[18] The latter is consistent with the theoretical predictions that follows from the assumptions in Section 2. Note, however, that the values in Table 4.1 are unconditional arithmetic means only. In particular, the fact that the average age differs between the three categories is not accounted for. Differences in real price between informed and uniformed bidders is also shown in Figure A.3 in the appendix.

If the previous foster-parent was not allowed to participate, according to the analysis in Section 3, we would, on the contrary, expect the highest level of compensation in the uninformed-bidder category.

Figure 4.1 shows the contract period measured in years for informed and uninformed bidders in the city of Sundsvall during the 1863-1882 period. This was the time series with the most consecutive observations. Because of the nature of data, the contract period is measured in whole years only. The most common contract period was one year. Note that there is a selection bias towards short contracts. Contracts signed at the end of the period can be included in this sample only if they were terminated in 1882 or earlier. The average contract period was 3.74 years for informed bidders and 3.64 years for uninformed bidders.

[18] The t-values are 2.22 and 2.29 respectively.

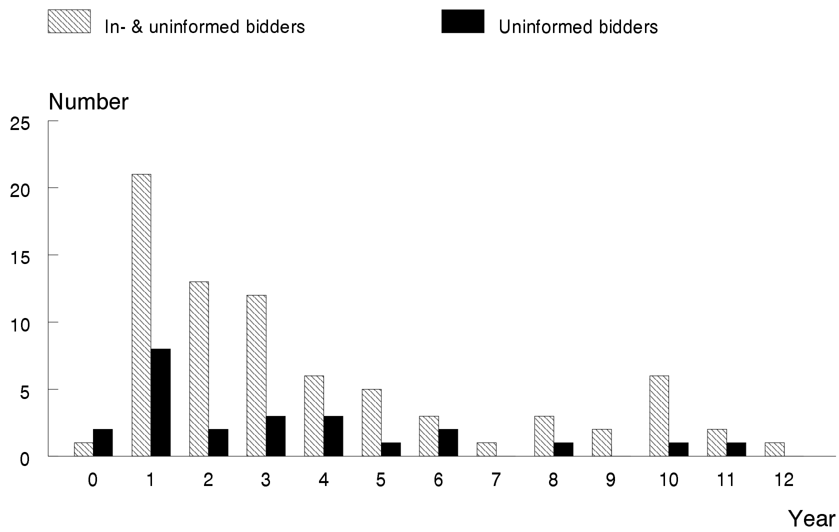

Figure 4.1: Contract period, Sundsvall, 1863-1882.

4.2. Method

We use a stochastic cost[19] frontier approach to examine whether the actual compensation paid differs, between informed bidders, uninformed bidders and bidders for children who had never before been auctioned. For comparison, results from ordinary least-squares regressions are presented. The regression equation, in matrix form, is:

$$
\begin{aligned}
P &= X\beta + \varepsilon \qquad (4.1)\\
\varepsilon &= \gamma + \omega \text{ where } \omega \geq 0
\end{aligned}
$$

The inefficiency residual vector, ω, in the stochastic frontier captures the difference between the winning bid, P, and the winners' reservation value, V_1 (given by equation (2.1)) in each auction, i.e. the winners' net profit is:

$$\omega = P - V_1 \qquad (4.2)$$

[19]A cost frontier is used instead of a production frontier since the second disturbance term is positive (Greene, 1993). This is so since the winning bid cannot be *lower* than the reservation value; in a production frontier the production cannot be *higher* than the maximum possible production.

This disturbance term is assumed to be exponentially distributed.

The real price (compensation) vector P is measured in Swedish "Riksdaler" and X is a matrix containing a constant and (observable) explanatory variables related to the child, the winning bidder and a dummy variable representing the city in which the auction took place. Within X, the submatrix S[20] contains variables related to the child: age[21], age squared, a gender dummy variable (1 for girls) and a dummy variable for the child's health[22] (1 for not healthy). The submatrix R_1 contains two variables that are related to the winning bidder. These are a dummy variable for occupational category[23] and one that takes the value 1 if the winning bidder's home was located in the countryside and 0 if it was located in a city. There are seven occupational categories.[24] The compensation is deflated using an historical price index developed by Englund, Persson and Svensson (1990). All compensations are given in 1863 prices. Occupational category 6, non-property owners, and the city of Umeå are used as references.

4.3. Results

Table 4.2 shows the maximum likelihood estimates (MLE) of the stochastic frontier and the ordinary least squares regression (OLS). In the case of *informed-bidder participation* the parameters are estimated together with two dummy variables: one that takes the value 1 if the child was auctioned to an uninformed bidder and one that takes the value 1 if the child was auctioned to an informed bidder. The reference group is children auctioned for the first time.

The informed bidder gets a smaller amount of compensation than the uninformed bidder but a larger amount than the one predicted from observable characteristics. The uninformed bidder dummy is significant at the 10-percent level, but the dif-

[20] C.f. equation (2.1).

[21] Age is measured in months, to avoid multicollinearity between age and age squared.

[22] Mental or physical health.

[23] There could be an endogeneity problem if the winner is determined by the price instead of the reverse. This has been tested by comparing the residuals from the maximum likelihood regression with residuals from a probit model for each occupational category. The test shows that exogeneity can not be rejected.

[24] The profession categories are: 1. Senior civil servants, university graduates and managers of larger firms; 2. Junior civil servants and managers of smaller firms; 3. Farmers; 4. Upper class unmarried women; 5. Skilled workers; 6. Crofters and unskilled workers (non-property owners); 7. Unspecified occupation and widows. Norman's (1974) and Lunander's (1988) classification forms the base for these categories.

Table 4.2: Estimation Results

	Informed-bidder participation				No informed-bidder participation			
	MLE		OLS		MLE		OLS	
Variable	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
Age (in months)	-0.173	-4.153	-0.329	-6.445	-0.172	-4.118	-0.327	-6.446
Age^2 (in months)	0.000	1.414	0.001	3.926	0.000	1.415	0.001	3.921
Gender	-3.984	-3.548	-3.264	-2.593	-4.024	-3.592	-3.276	-2.606
Health	13.648	6.811	19.902	7.089	14.049	7.128	20.024	7.211
Sundsvall	5.819	3.622	5.115	2.525	5.923	3.720	5.161	2.557
Skellefteå	-9.372	-4.858	-12.029	-5.655	-9.382	-4.945	-12.035	-5.663
Provincials	-0.652	-0.449	-1.000	-0.579	-0.587	-0.413	-0.961	-0.558
Senior civil....	1.131	0.148	-1.663	-0.305	1.110	0.148	-1.674	-0.307
Junior civil...	-4.788	-2.228	-4.672	-1.743	-4.863	-2.270	-4.742	-1.777
Farmers	0.977	0.646	1.200	0.734	0.947	0.637	1.175	0.729
Upper class...	6.064	2.143	8.028	1.981	6.272	2.221	8.103	2.005
Skilled workers	-1.746	-0.978	0.818	0.346	-1.723	-0.965	0.823	0.348
Unsp. occupation	2.179	1.195	3.887	1.812	2.145	1.204	3.856	1.801
Constant	59.596	19.223	78.011	21.938	59.577	25.557	77.992	21.953
Inf. bidder	1.050	0.700	0.519	0.306				
Uninf. bidder/ new foster-parent	3.229	1.918	2.531	1.452	2.982	1.826	2.409	1.421
θ	0.092	16.942			0.092	16.919		
σ_v	8.800	20.877			8.822	20.996		
Log likelihood	-2408.09				-2408.38			
R^2_{adj}				0.43				0.44

ference between the dummies is not significant.[25] Contrary to these results, the theoretical predictions in Section 2 suggest that the informed bidder should get *higher* compensation.

In the *no informed-bidder participation* case, we estimate a similar regression with only one dummy variable taking the value 1 if the child was assigned to a new foster-parent.[26] Again the difference in compensation between new foster-parents and others is significant at the 10-percent level.[27] This indicates adverse selection.

[25] The value of the Wald statistic is below the critical value. As such, the hypothesis that the uninformed bidder parameter is equal to the informed bidder parameter cannot be rejected.

[26] Now the reference group consists of children auctioned for the first time *and* children with renegotiated contracts.

[27] When the variables reflecting bidder characteristics are excluded the difference becomes significant at the 5-percent level.

New foster-parents received approximately 5 percent (or 2.98 “Riksdaler”) higher compensation than others.

There is some support for the notion that there was adverse selection in the market for re-auctioned children. The bidders demanded higher compensation for taking a re-auctioned child. Table 4.2 shows that real compensation is decreasing with age, on average 2.1 “Riksdaler” per year. Girls commanded a lower compensation than boys (3-4 “Riksdaler” less) and a healthy child commanded a lower compensation than an unhealthy one (13-14 “Riksdaler” less). See Lundberg (1997) for further interpretation of the other variables.

The estimated average net profit, computed as:

$$E[\omega] = \frac{1}{\theta} \tag{4.3}$$

is 10.87 Swedish “Riksdaler”. The parameter θ is the hazard rate for the exponential distribution.

Did the child and bidder characteristics affect the probability of the child being re-auctioned?[28] A probit analysis shows that this probability increased if the winning bidder’s home was located in the countryside. It also increased if the foster-parent was an upper class unmarried woman and if the child was not healthy. The last two probabilities are significant at the 10 per cent level. We also estimate what factors affected the probability of getting a new foster-parent. This probit analysis shows no significant result. A similar analysis to determine if child and bidder characteristics affected the probability of the compensation[29] to be renegotiated show significant results. This probability increased with the child’s age but at a decreasing rate. If the winning bidder’s home was located in the countryside the probability of a renegotiated compensation increased and it also increased if the child was not healthy.

5. Summary and discussion

In this paper we study asymmetric information and adverse selection in the auctioning of children in 19th century Sweden. We distinguish between two assumptions

[28] Remember that a re-auctioned child means that the compensation was changed in some way and/or there was a new foster-parent.

[29] In this case the compensation was changed without a change of foster-parent.

depending on whether or not the previous foster-parent was allowed to take part in the new auction. The first assumption, when this was permitted, focuses on the effect of asymmetric information *between* active bidders. Auction theory suggests three ways to model the bidders' behaviour in this case: the private-values model, the common-value model and a combination of both. A common-value component would tend to increase the amount of compensation paid, when an informed bidder is present. It would also result in lower compensation for the uninformed bidders than for the informed bidders. The second assumption, when the former foster-parent is not allowed to bid in a new auction, focuses on adverse selection. Now the informed party uses his information to determine who will be auctioned again. In theory, the amount of compensation paid to bidders who won a re-auctioned child should be higher.

To test these predictions empirically, we used historical data from auctions of children in three cities in Northern Sweden in a stochastic cost frontier model. This was done under the two assumptions. Assuming that the previous foster-parent was allowed to participate in a second auction, we found evidence that both categories of bidders received a higher level of compensation than they would have gotten if the child had not been auctioned before. The coefficient for uninformed bidders was slightly higher than that for informed bidders, and only the former was significant (at the 10-percent level). The fact that the uninformed bidders' compensation was higher suggests that a more appropriate assumption may be that the previous foster-parent was *not* allowed to participate. Re-estimating the model without informed bidders, we again obtained higher compensation in re-auctions, consistent with adverse selection.

In many circumstances auctions are efficient allocation mechanisms. They can be used to determine a market price for items where this is not known. Often, they have the desirable property that the item for sale is allocated efficiently, i.e. to the buyer with the highest valuation. In a sense, the Assistance Board managed to determine a market price for boarded-out children. However, in this particular context the allocation is likely to have been inefficient. While the auctions may well have minimised the Assistance Board's costs and allocated the children to the foster-parents with the highest valuation (net of costs), the allocation mechanism was not responsive to the childrens' valuation of their potential foster-parents. To the extent that the cost of care is negatively correlated with the quality of care, allocation through auctions may have the result that negligent foster-parents could systematically overbid the conscientious ones.

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A. Appendix

Systematic differences in valuation

Private values

Let the uninformed bidder's valuation v_2 be drawn from the uniform distribution $[0, 1]$, and the informed bidder's valuation v_1 be drawn from the uniform distribution

$[k, 1+k]$, where $k \geq 0$.

Given that the informed bidder has valuation v_1 and wins, the expected payment is equal to the expected valuation of the uninformed bidder, conditional on the informed bidder winning and on the informed bidder's valuation v_1, i.e.;

$$E\left[p\,|v_1 > v_2; v_1\right] = E\left[v_2\,|v_1 > v_2; v_1\right] = \begin{cases} \frac{0+v_1}{2} = \frac{v_1}{2} \\ \frac{1}{2} \end{cases} \text{if } \begin{cases} 0 \leq v_1 \leq 1 \\ 1 < v_1 \leq 1+k \end{cases} \tag{A.1}$$

The probability that an informed bidder with valuation v_1 wins is:

$$\Pr\left[v_1 > v_2\,|v_1\right] = \begin{cases} v_1 \\ 1 \end{cases} \text{if } \begin{cases} v_1 \leq 1 \\ v_1 > 1 \end{cases} \tag{A.2}$$

Thus, the expected payment of the informed bidder, conditional on winning, is:

$$E\left[p\,|v_1 > v_2\right] = \frac{1}{A}\left[\int_k^1 x\frac{x}{2}dx + \int_1^{1+k} 1\frac{1}{2}dx\right] = \frac{1+3k-k^3}{6A} \tag{A.3}$$

This is the integral over $[k, 1+k]$ of the product of equations A.1 and **??**, divided by A, where $A = 1-(1-k)^2/2 \geq 1/2$ is the probability that the informed bidder wins. A similar derivation for the expected payment of the uninformed bidder, conditional on winning, shows that:

$$E\left[p\,|v_2 > v_1\right] = \frac{1}{1-A}\int_k^1 (x-k)\frac{x+c}{2}dx = \frac{1-3k^2+2k^3}{6(1-A)} \tag{A.4}$$

where 1-A is the probability that the uninformed bidder wins. Subtracting equation A.3 from equation A.4, we obtain the price difference δ as:

$$\delta = E\left[p\,|v_2 > v_1\right] - E\left[p\,|v_1 > v_2\right] = \frac{1}{3}\frac{k(1+3k-k^2)}{1+2k-k^2} \tag{A.5}$$

For $k \in [0,1]$, $\delta > 0$, i.e., the expected price of the uninformed bidder is higher than the expected price of the informed bidder. Since $A > 1/2$ for $k > 0$, the informed bidder wins more than half of the times. If k exceeds 1, the uninformed bidder will never win.

Private and common values

Now assume that there are both private and common values, as well as a difference k in expected private value between informed and uninformed bidders. Let b_2 denote the maximum bid that (uninformed) bidder 2 is willing to submit and let $\widehat{b}_1$ be the highest observed bid submitted by (informed) bidder 1 in some stage of the auction. Thus $b_1 \geq \widehat{b}_1$, i.e. bidder 1 may be willing to submit a higher bid later in the auction. When bidder 2 considers whether to overbid $\widehat{b}_1$, he must account for the possibility that he may win. If he wins, then bidder 1's valuation is $b_1 = \widehat{b}_1$, which permits bidder 2 to form a conditional expected value for the common-value component as:

$$E\left[v^c \middle| b_1 = \widehat{b}_1\right] = \frac{1 + \widehat{b}_1 - 1 - k}{2} = \frac{1}{2}(\widehat{b}_1 - k) \tag{A.6}$$

This is illustrated in Figure A.1. Bidder 2 is willing to overbid bidder 1 by an infinitesimal amount ε if the expected value of winning, $E[\pi_2]$, at price $\widehat{b}_1$ is at least zero. Thus, the solution to the following equation gives the optimum maximum bid that bidder 2 should submit, b_2:

$$E\left[\pi_2 \middle| b_2 + \varepsilon = b_1 = \widehat{b}_1\right] = v_2^p + E\left[v^c \middle| b_2 + \varepsilon = b_1 = \widehat{b}_1\right] - b_1 = v_2^p - \frac{1}{2}(b_2 + k) = 0 \tag{A.7}$$

or $b_2 = 2v_2^p - k$.

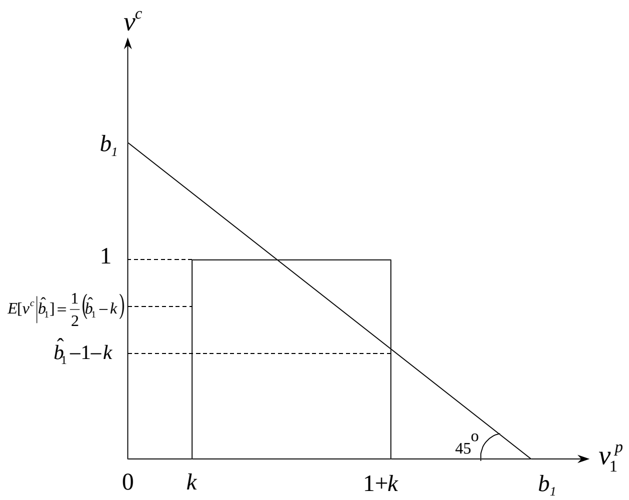

Figure A.1: Expected common value conditional on observed bids.

The "positive selection" case

Consider private values only. Assume that if the first-period winner terminates the contract and a new auction is to be held, then a single new bidder enters, whose private value is drawn from the uniform distribution on [0,1]. The informed bidder's expected payoff in period 2 if he terminates the contract is given by:

$$\text{Prob}\left[v_1^p > v_2^p\right]\left(v_1^p - E\left[v_2^p \left| v_1^p > v_2^p\right.\right]\right) = \frac{1}{2}\left(v_1^p\right)^2 \tag{A.8}$$

i.e. the probability that he wins again times his valuation minus the expected price. The informed bidder's payoff if he does not terminate the contract is given by $v_1^p - p$. A risk neutral first-period winner terminates the contract if:

$$\frac{1}{2}\left(v_1^p\right)^2 > v_1^p - p \tag{A.9}$$

or if:

$$p > v_1^p - \frac{1}{2}\left(v_1^p\right)^2 \tag{A.10}$$

From Figure A.2 it is clear that the informed bidder is more likely to terminate the contract if his valuation is high, in the sense that an informed bidder who chooses to terminate the contract has a higher expected valuation than one who chooses not to terminate the contract.

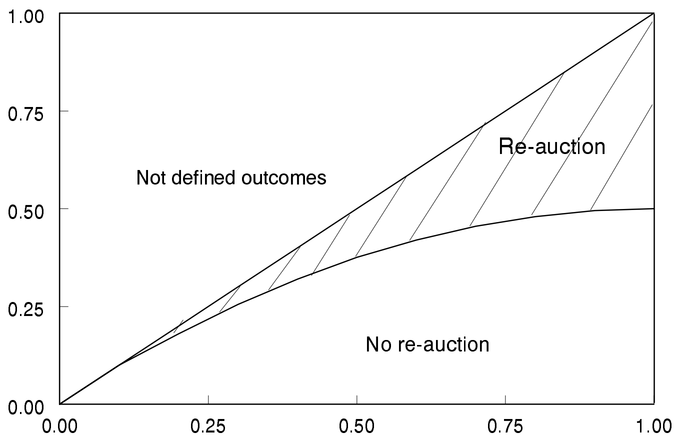

Figure A.2: "Positive" selection, possible outcomes given equation A.5.

Figures and Tables

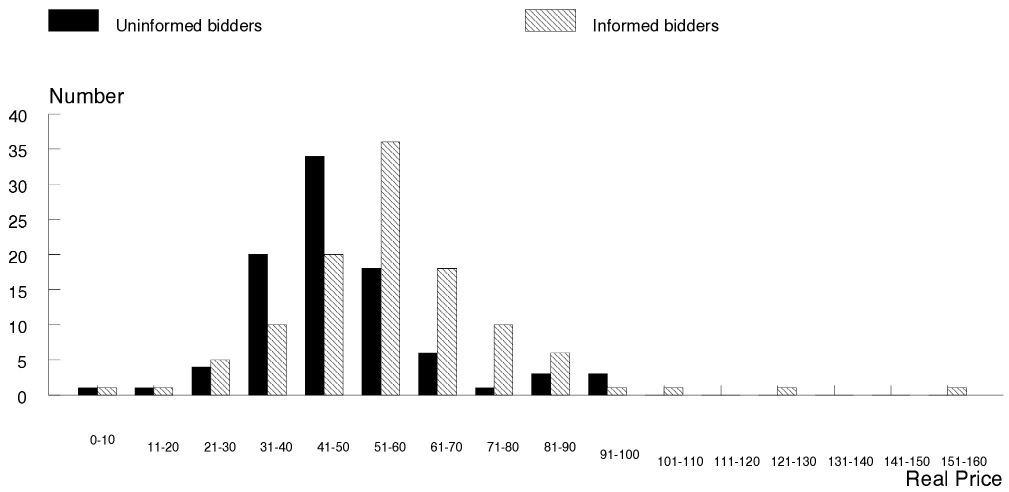

Figure A.3: Distribution of real price, uninformed bidders and informed bidders.

Table A.1: Number of auctions per child

No of auctions	No of children	Sum
1	238	238
2	100	200
3	42	126
4	8	32
5	1	5
Sum	389	601

Table A.2: Frequencies

	The sample	Auctioned for the first time	Re-auctioned children	Informed bidders	Un-informed bidders	First time observed, later re-auctioned	First time observed, later new buyer
Girls	280	188	92	44	48	67	42
Boys	321	201	120	67	53	84	41
Unhealthy	32	15	17	15	2	10	3
Provincials	465	294	171	92	79	119	62
Sundsvall	290	190	100	68	32	68	28
Skellefteå	238	50	89	34	55	66	42
Umeå	73	149	23	9	14	17	13
Senior civil...	8	5	3	2	1	2	-
Junior civil...	42	35	7	3	4	8	5
Farmers	202	132	70	34	36	54	32
Upper class women	15	6	9	5	4	3	-
Skilled workers	61	42	19	12	7	20	13
Crofters...	203	120	83	44	39	44	20
Unspec. occupation, and widows	70	49	21	11	10	20	13
No of cases	601	389	212	111	101	151	83

Table A.3: Frequencies, age

Age	The sample	Auctioned for the first time	Re-auctioned children	Informed bidders	Un-informed bidders	First time observed, later re-auctioned	First time observed, later new buyer
0	12	11	1	-	1	6	3
1	19	17	2	1	1	11	5
2	23	20	3	2	1	9	3
3	37	28	9	7	2	20	9
4	32	21	11	7	4	9	5
5	37	29	8	2	6	10	6
6	43	27	16	10	6	9	4
7	30	23	7	3	4	11	8
8	60	42	18	12	6	15	9
9	60	35	25	14	11	13	8
10	42	30	15	7	8	7	4
11	52	33	19	11	8	14	9
12	47	27	20	9	11	8	4
13	38	13	25	11	14	4	2
14	43	25	18	8	10	5	4
15	23	8	15	7	8	-	-
No of cases	601	389	212	111	101	151	83

Table A.4: Descriptive statistics regarding age

	The sample	Auctioned for the first time	Re-auctioned children	Informed bidders	Un-informed bidders	First time observed, later re-auctioned	First time observed, later new buyer
Mean	8.3	7.6	9.6	9.2	10.0	6.5	7.0
Max	15	15	15	15	15	14	14
Min	0	0	0	1	0	0	0
Std.dev.	4.0	4.0	3.7	3.7	3.7	3.9	3.8
Variance	15.9	15.8	13.6	13.5	13.4	15.2	14.73
No of cases	601	389	212	111	101	151	83