Bidder Behavior in Uniform Price Auctions

Evidence form Argentina[1]

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Introduction

Almost all governments in the world issue debt to manage their finances. Debt is generally sold by the way of an auction. Auctions are essentially a price discovery mechanism. When a seller of any item does not know how much potential buyers value the item for sale, it turns beneficial for the seller to use an auction mechanism. If the seller knew how much potential buyers would be willing to pay for the object, she would simply make a take it or leave it offer. Auctions have been used for thousands of years as a selling mechanism (McAfee and McMillan, 1987). The seller can create any auction mechanism to maximize the revenue of the transaction. However, not every auction is optimal in every setting. A lot of work has been written addressing the ranking of auctions, particularly for single-object auctions (Vickery, 1961). Nevertheless, there is a growing amount of literature devoted to multi-unit auctions (Back and Zender, 1993; Wang and Zender, 2002). Unfortunately, results of single-object auctions cannot be carried over directly to multi-unit auctions settings. The main reason is that in single-object auctions bidders compete only through price. In contrast, multi-unit auctions bidders have a large strategy space because they can choose any combination of price and quantities. In fact, they can submit any weakly downward-sloping bid schedule (Wang and Zender 2002).

The main difference between a single-object auction and a multi-object auction is that in the latter bidders submit bid schedules instead of a single price. Bid schedules are a collection of price-quantity pairs. In single-object auction, bidders submit the price at which they would be willing to buy the item for sale. In both cases, the auctioneer establishes the pricing mechanism beforehand. For example, a seller can commit to sell the item at the highest price submitted or can establish another pricing mechanism. Whichever gives the higher expected revenues. This set of rules that characterize different ways to design an auction is called auction format.

Within the multi-unit auctions setting, two there are two widely used auction formats that governments currently use to issue debt: discriminatory and uniform price auctions. In a discriminatory auction, each bidder is awarded the price and quantity they submitted until supply is exhausted. In a uniform price auction, all bidders are awarded the winning price. The winning price is called the stop-out price. To set the stop-out price, the auctioneer orders bids from the lowest price to the highest. When supply equals demand, the stop-out price is set. The question that remains unanswered is which of these two auctions format is best for auctioning government debt.

There has been substantial amount of effort allocated in testing the performance of the two competing auction formats. This testing was motivated partly by Friedman's (Friedman, 1959) critique of the U.S. Treasury's auction format. The U.S. Treasury has mainly used the discriminatory auction format to issue debt approximately since 1929. In the light of this discussion, the U.S. Treasury switched in the period 1973-74 and from September 1992 to uniform price mechanism to auction some issues experimentally (Malvey and Archibald, 1998). Friedman argues that the simple form of the uniform price auction would broader demand because of the reduction in the cost of preparing bids. Moreover, Friedman argues; these benefits would be greater because participants will not canalize their bids through specialized brokers, limiting their market power.

The main body of empirical research follows a laboratory market-experiment strategy that consists in controlling over the environment while varying institutions (Vernon Smith, 1989). This counterfactual strategy has been made possible because of the U.S Treasury switch of auction format, and other countries that followed it. These studies essentially test how revenues for the Treasury varied when a change of auction format was introduced. Revenues for the Treasury are measured as the difference between the stop-out yield and the market yield. These test are controlled by quantity of bidders, volume of the issue, liquidity of the market and volatility as an index of risk. Results of these studies suggest a *modest* consensus that uniform price format is best for auctioning government debt. This auction format provides higher revenues to the auctioneer and mitigates the effect of asymmetric information and information acquisition costs on the quantity of bidders. In short, demand is increased because less informed agents are encouraged to participate in the auction. Moreover, a well-known effect named "winner curse" is supposed to be diminished in this auction format. The winner curse arises when winning the auction is bad news. The bidder that wins at the auction learns from the result of the auction that she was the bidder with highest valuation for the object. Obviously, the winning bidder will suffer a loss because the market price of the object after the auction will be less than what she paid at the auction.

The main problem with this testing strategy is that it abstracts of bidders characteristics. For example, bidder behavior can be different in developed and emerging economies. A priori, nothing can be said in the base of these studies on the optimal auctioning mechanism for a particular economy or class of economy.

In two recent papers, Atle Berg, Landsberger and Boukai (1999) and Boukai and Landsberger (1998) inaugurated a new promising testing strategy. These authors discover the empirical regularity that market bid schedules can be approximated with remarkable fit by a three-parameter logistic growth curve. They use this strategy to estimate bid schedules for Norway and Israel. This new methodology can be given several uses.

The present paper has two main goals. First, with the same spirit as Atle Berg, Landsberger and Boukai (1999) and Boukai and Landsberger (1998), to provide evidence of a three-parameter logistic growth curve for Argentina. Second, to study an important determinant of bidders' behavior: risk aversion. We will address this task by inspecting the changes in the structure of the bid function induced by the changes of relevant economic variables on the three parameters. This paper finds that: first, the three-parameter logistic growth curve fits for the argentine data.

Second, based on previous theory, bidders in Argentina share many features of risk-averse behavior.

The remainder of this paper is as follows. Section 2 describes Argentina's data and auction design. Section 3 develops a model of risk averse bidders in uniform price format where we extract basic concepts of risk averse behavior. In Section 4 the methodology used for estimation is described. In particular, Section 4.a. shows the main characteristics of the three-parameter growth curve. Section 4.b., based on the model developed in Section 3, addresses the important issue of how this three-parameter logistic growth curve would behave if bidders were risk averse. We show the main results of the parametric estimation of the three-parameter growth curve and make a cross-country comparison of the estimated bid schedule in section 5.a. In Section 5.b., the Seemingly Unrelated Regression (SUR) estimation is performed, and summary data is shown. Section 6.a. is at the heart of the paper. In this section a comparison between the expected results developed in Section 4.b. and the SUR estimation is performed. In Section 6.b., using the Kernel density estimator we characterize bids distribution under different levels of risk. Finally, in Section 7 we provide our conclusions.

2. Data and Auction Design

2.a. Data

The data used for the estimation of the three-parameter logistic growth function are the bank's aggregate bid schedule in each auction, the market yield at the moment of the auction, and the Treasury's release after every auction. This release is disclosed approximately two hours after the auction and includes information such as stop-out yield and the volume announced for that auction within other information. To calculate the market yield for the same tenor than the bills auctioned we used linear interpolation. All the yields used are on a 365 basis. We only estimated the aggregate bid functions for Treasury bills of 91, 182 and 365 days to maturity; longer tenor bonds were excluded of the sample. 17 observations of 111 were thrown away because no market yield was available or was not reliable. The remaining 94 observations is the total sample for the three bills. To estimate the three parameters that underline the three parameter growth function we *normalized* the pair of quantities and yields that bidders submit at the auction. The quantities were normalized by the volume announced for each auction and yields were normalized by the secondary market's bid quote at the moment of the auction. Bid quotes are proxies of secondary market's yields because they do not give any information about the quantity that is behind that quote. Although the quotes do not reflect any transaction, the prices quoted in the Market Maker System are executable "on the screen".

For the SUR model, we regressed the parameters against six independent variables: maturity in weeks, number of auctions on the day of the auction, volume announced, total liquidity demand of the treasury on the day of the auction, the market yield and a measure of market volatility. As in Argentina's Treasury auctions a fix number of banks participated (twelve), we did not use the number of bidders at each auction as a regressor, but it would be useful to include this variable in another context.

2.b. Auction Design

Argentina implemented a Market Makers system since 1996. Market makers were the twelve largest banks of the argentine financial system. These twelve banks had some rights and obligations. Within the obligations, participating in the local primary issues and quoting prices in secondary local market with bid-ask spreads requirements were the most important. The argentine government paid fees depending on the degree of participation on the local primary issues and their performance on the secondary market. To pay the fees, the Treasury developed an index[2] that captured both primary and secondary market's performance.

Since 1996, the argentine Treasury chose the uniform price format to auction bills and bonds. A calendar with the auction dates and volumes to be auctioned is published at the beginning of every fiscal year. During the 1996-2001 period, 91-day bills were auctioned every two weeks, 182-day bills were auctioned monthly, while 365-day bills were auctioned only three times a year. Bids are submitted at 1:30 PM and results are released two hours later. Market Makers are the only authorized institutions that can submit bids. They can also submit bids in behalf of their clients and other non-authorized financial institutions. The Central Bank cannot bid for treasury's securities. Argentina's auction format has a competitive and a non-competitive trench. Individual investors are usually included in the non-competitive trench but account for a very small share of the total bid. Market Makers are only allowed to bid in the non-competitive trench up to 2% of their total bid. Bids submitted in the non-competitive trench are always accepted and are awarded at the competitive stop-out yield.

3. Theory

In this section, we sketch a multi-unit auction model that was first developed by Kyle (1989). To be precise, Kyle (1989) developed a model of imperfect competition with private information and risk adverse agents that could buy and sell in a market of noisy traders. In fact, the model is not a multi-unit auction model itself. The model was latter modified by Keloharju, Nyborg and Rydquvist (2001) for this purpose. By stripping private information and letting the noisy supply have positive expected

[2] The index was called "Indice General de Desempeño" (Disposicón de la Subsecretaria de Finanzas 11/2000

value, they obtain a multi-unit auction model with a small quantity of risk adverse bidders that choose schedules as strategies. However, there are many other multi-unit auctions models. We chose the Kyle modified version because it efficiently resumes much of other models results, and has been empirically supported in Keloharju, Nyborg and Rydquvist (2001). Other models, such as Back and Zender (1993) and Wilson (1979) use risk neutral bidders to explain equilibrium underpricing, Wang and Zender (2002) model would the closest substitute, because they derive results for risk neutrality and aversion, but the model is harder to solve. Both for computational simplicity and expositional convenience we will build on Kyle's modified version.

3.a The Model

Consider a uniform price auction with n symmetrical risk averse bidders. All bidders have perfect knowledge of the auction rules and do not have private information about the expected value of the item that is being sold. The item is sold by a risk-neutral agent. The seller does not know which is the value of the object, hence, he designs the mechanism for price formation. Let v be random variable

$$v \sim \left(\bar{v}, s_v^2\right)$$

that stands for the value of the item being sold. In our case, we will think about v as the resale price of the security. Define r as the profit of any bidder for bidding at the auction. If v_i is an realization of v,

$$r = \left(v_i - p\right)$$

The profit is the difference between the resale value and the stop-out price p. For a given p, the mean profit is given by,

$$m_r = \left(\bar{v} - p\right)$$

As r is a linear operation of v, r is itself a normally distributed random variable with mean m_r and variance s_r. The density function for the normal distribution is,

$$f\left(r, m_r, s_r\right) = \frac{1}{s_r\sqrt{2p}} \exp\left(-\frac{\left(r - m_r\right)^2}{2s_r^{\ 2}}\right)$$

Bidders represent their preferences in exponential utility function,

$$U(r) = -e^{-r\, rQ_R} \qquad (1)$$

Note that,

$$U' > 0, U'' < 0$$

and

$$r \in \left(-\infty, \infty\right)$$

Where r is the risk aversion parameter and Q_R is the residual supply after all other bidders have submitted their supply schedule. The total supply is given by Q. We will only focus on symmetric equilibria, so every bidder faces the same residual supply:

$$Q_R = Q - \left(N - 1\right)q\left(p\right)$$

r is normally distributed so the expected utility is given by the following expresion,

$$E(U(rQ_R)) = \frac{1}{s_r\sqrt{2p}} \int_{-\infty}^{\infty} -e^{-r\, rQ_R} \exp\left(-\frac{\left(r - m_r\right)^2}{2s_r^{\ 2}}\right) dr$$

Rearranging terms,

$$E(U(r)) = \frac{1}{s_r\sqrt{2p}} \int_{-\infty}^{\infty} -\exp\left(r\, rQ_R + \frac{\left(r - m_r\right)^2}{2s_r^{\ 2}}\right) dr \qquad (2)$$

The expression in brackets can be simplified,

$$\rho r Q_R + \frac{(r-\mu_r)^2}{2\sigma_r^{\,2}} = \left(r-\mu_r+\rho\sigma_r^{\,2}Q_R\right)^2 + \rho\left(\mu_r Q_R + \frac{1}{2}\rho\sigma_r^{\,2}Q_R^{\,2}\right) \quad (3)$$

and plugging (3) into (2) we get,

$$E(U(r)) = \frac{-e^{-\rho\left(\mu_r Q_R+\frac{1}{2}\rho\sigma^2 Q_R^{\,2}\right)}}{\sigma_r\sqrt{2\pi}}\int_{-\infty}^{\infty}\exp\left(\frac{\left(r-\mu_r+\rho\sigma_r^{\,2}Q_R\right)^2}{2\sigma_r^{\,2}}\right)dr$$

Define μ'

$$\mu_r' = \mu_r + \rho\sigma_r^{\,2}Q_R$$

Using that:

$$\frac{1}{\sigma_r\sqrt{2\pi}}\int_{-\infty}^{\infty}\exp\left(-\frac{(r-\mu_r')^2}{2\sigma_r^{\,2}}\right)dr = 1$$

The expected utility simplifies to

$$E(U(r)) = -\exp\left(-\rho\left(\mu_r Q_R - \frac{1}{2}\rho\sigma_r^{\,2}Q_R^{\,2}\right)\right)$$

So we can solve the bidder problem just by maximizing the expression in brackets of the exponent. The bidder problem can be rewritten to maximize the following expession,

$$\max_p \ (\bar{v}-p)Q_R - \frac{1}{2}\rho\sigma_r^{\,2}Q_R^{\,2}$$

Recall that Q_R is the residual demand, each bidder solves the problem,

$$\max_p \ (\bar{v}-p)\left(Q-(N-1)q(p)\right) - \frac{1}{2}\rho\sigma_r^{\,2}\left(Q-(N-1)q(p)\right)^2$$

The first order conditions are given by,

$$-\left(Q-(N-1)q(p)\right) - (N-1)(\bar{v}-p)q'(p) + \sigma_r^{\,2}\rho\left(Q-(N-1)q(p)\right)(N-1)q'(p) = 0 \quad (4)$$

By symmetry and market clearing (Nybourg (2000)),

$$Nq(p) = Q \quad (5)$$

After replacing (5) in the first order condition (4), we obtain,

$$-q(p) - (N-1)(\bar{v} - p)q'(p) + s_r^{2}\, r\, q(p)(N-1)q'(p) = 0$$

That is an ordinary differential equation with many solutions all of which will be consistent with any value of Q. Following Keloharju, Nybourg and Rydqvist (2001), we impose the linear equilibrium:

$$q(p) = g - g\ p \quad (6)$$

$$q'(p) = -g$$

Inserting the first derivative of the proposed equilibrium (6) in the first order condition,

We arrive to

$$q(p) = \frac{(N-1)(\bar{v} - p)\, g}{s_r^{2}\, r\, (N-1)g + 1}$$

we can solve for g,

$$g = \frac{N-2}{(N-1)s_r^{2}\, r}$$

Plugging γ in (6) we get bidders demand and the inverse demand.

$$q(p) = \frac{(N-2)(\bar{v} - p)}{(N-1)s_r^{2}\, r}$$

$$p(q) = \bar{v} - q\, s_r^{2}\, r\, \frac{(N-1)}{(N-2)}$$

As the number of bidders in Argentina is fixed for the period studied,

$$q(p) = k\frac{(\bar{v} - p)}{s_r^{\,2}\, r}$$

$$p(q) = \bar{v} - \frac{1}{k} q\, s_r^{\,2}\, r$$

4. Methodology

The goal of this paper is to address bidders attitude towards risk for the Argentinean case. To achieve this goal, we proceed in two steps (Preget and Waelbroeck, 2001). In the first step, an aggregate bid function for each auction is estimated using the specification proposed in earlier literature. The estimation will provide three consistent parameters per auction. Using this information, we will be able to compare the Argentinean aggregate bid schedules with Israel and Norway.

In a second step, the obtained parameters will be used as dependent variables in a system of simultaneous equations. The system of equations will be estimated by using the Seemingly Unrelated Regression (SUR) methodology introduced by Zellner (1962). Explanatory variables will be chosen to provide us insights on bidders attitude towards risk.

4.a. Logistic Specification

In this section the specification used to estimate the aggregate bid function will be described. The DGP to be estimated is,

$$q_j = Q(t_j; q) + e_j \qquad (1)$$

Where

$$Q(t;q) = \frac{b_1}{1+\exp\{-(t-b_3)b_2\}} \qquad \forall t \qquad (2)$$

where q is the normalized quantity and t is the normalized yield. Yields were normalized by the market yield at the moment of the auction. Quantities are normalized by the volume that the treasury announces before the auction. This normalization has two desirable consequences. First, it makes quantity bids a proportion of the volume auctioned. Supply and demand are interdependent because bidders essentially bid shares of the total volume auctioned (Wilson 1979). Second, normalization provides an easy cross-country and cross-security comparison.

An interpretation of the parameters of the logistic function is given in ABL (1999), Preget et.al. (2001) and BL (1999). For a better exposition we reproduce them here, with two important results that can be easily derived[3].

- b_1 represents the market satiation level relative to the auction's volume, beyond which there is no demand for the auctioned securities regardless of their yields. That is, b_1 is the asymptotic value of *Q(-)* as *t* goes to infinity.
- b_3 is a location parameter that is interpreted here as a measure of the relative position of the auction yields Y_j to the secondary market yield Y_s. Furthermore, b_3 is the unique inflection point of Q and it can be seen to be that value of t at which the market reaches half of its satiation level; namely $Q=b_1/2$ when $t=b_3$.
- b_2 is a scale parameters that may be interpreted here as a measure of spread of the auction's normalized yields around b_3. It is closely related to demand elasticity.

[3] For a better exposition of logistic curves and their properties see Kotz and Johnson (1985)

The stop out yield is given by

$$t_s = b_3 - \frac{\log(b_1 - 1)}{b_2} \qquad (3)$$

And the elasticity at the stop out yield is

$$e(t_s) \equiv b_2 \frac{b_1 - 1}{b_1} t_s \qquad (4)$$

In Figure 1 below, an example that illustrates how changes in the parameters, *ceteris paribus*, modifies the shape of the bid schedule is plotted.

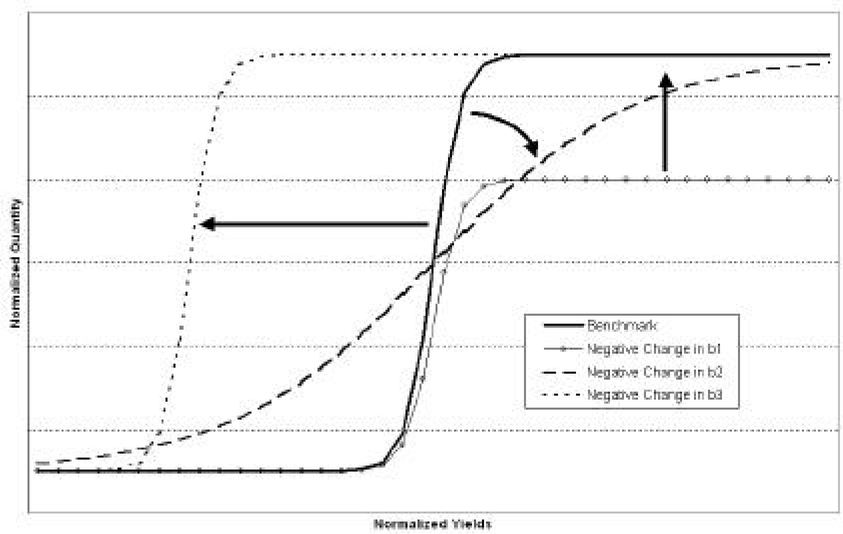

Figure 1: *The three-parameter logistic growth curve under changes in the parameters*

It can be observed that parameter b_1 has direct influence on the height of the curve, b_2 on the slope, and b_3 moves the curve along the normalized yield axis. In the specification described, bidders are assumed to choose the values of the parameters that underline the parametric bid schedule according their preferences and all the available information at the moment of the auction. Based on extant theories of bidder behavior, this simplification provides a setting to describe how one would expect these parameters to behave under different assumptions on bidders attitude toward risk

4.b. Logistic Specification and Risk Aversion

Risk averse bidders care about risk sharing. Thus, a risk averse bidder would only demand greater quantities at higher yields. This is because the same number of bidders must bear the risk of a larger quantity of the auctioned security. Moreover, as in the model described in section 3.a., if the standard deviation of the expected resale price is higher, underpricing increases and quantity demanded decreases. By the same token, if the expected resale price is high, underpricing decreases and quantity demanded increases.

In the proposed specification, this behavior would translate into particular changes in the values of the parameters, when an exogenous variable like quantity auctioned, volatility of resale price, or the expected value of the resale price is modified. This information is summarized in Table 1.

	b1	*b2*	*b3*
Δ *Auctioned Volume*	(*)	(-)	(+)
Δ *std.dev.Resale Price*	(-)	(-)	(+)
Δ *Resale Yield*	(-)	(*)	(*)

(*) no relation between the parameter and the exogenous variable

Table 1*: Expected relation between exogenous variables and the three parameters of the logistic growth curve under risk aversion.*

The table shows the relation between the parameters and the three exogenous variables that are proposed by the model. These results are not drawn from a formal optimization model, because parameters come from a parametric specification. However, using standard results of the model developed in section 3.a., we will specify which would be the parameter's changes under positive changes in the exogenous variables, to be consistent with the previous formal model. In the forthcoming paragraphs, a justification for the relationships suggested in Table 1 is provided.

Volume auctioned:

As bidders bid as a proportion of the auction volume, b_1 should not suffer changes when the auctioned quantity increases. However, bidders are bearing the risk of greater quantities of the item being sold. This can only be consistent with the risk aversion assumption if they bid higher yields. This implies that parameter b_3 should raise.

Standard Deviation of the resale price:

If the resale price is more uncertain or the standard deviation of the resale price increases, quantity bid should decline and yields bid raise –or prices decline-. In our specification, this implies that b_1 should fall and b_3 should increase.

The resale price:

If the resale price in the model of section 3.a increased, quantities and prices increased. We should expect the same to happen in the parametric specification of the bid schedule. However, the logistic specification is defined in normalized yields. This means that unless bidders bid differently at different levels of resale yield, one should not expect any effect on the b_3 parameter. Nevertheless, the effect over quantities remains intact. Thus, the quantity demanded, represented by b_1, should be related negatively to the resale yield.

The slope:

For b_2 results are not straightforward. Two transformations have to be done to the results of the benchmark model to infer directly from the model to our specification. The first transformation is to invert the quantities and price axis. Second, the price axis of the benchmark model should be sorted from high prices to low prices -i.e. from low yields to high yields-. By these transformations, a positive sloped bid schedule is obtained that resembles the imposed logistic specification. If the volume auctioned increases or the variance of the resale price increases, the transformed positive sloped curve turns less steep. In the opposite way, if the expected resale price increases, the transformed curve shifts upwards, with no change in the slope, reflecting that more quantity is demanded at the same price or yield.

In the logistic specification, both an increased standard deviation of the resale price and auctioned volume should translate into a less steep curve, to be consistent with risk averse behavior. This movement would require lower values of b_2, implying a negative relation between these two variables and b_2. Moreover, an increase in the resale price should not have any effect on the slope of the curve, as in the benchmark model.

5. The estimation

5.a. Cross-Country Comparision

We used non-linear least squares to estimate the DGP (1). We estimated the set of

	Elastiity at the Stop-out Yield	*Normalized Stop-out Yield*	*Normalized average Yield*
Argentina	17.09	0.980	
	(10.78)	(0.074)	
Israel	143.35	0.996	0.988
	(61.50)	(0.009)	(0.0101)
Norway	88.58	1.038	1.027
	(65.06)	(0.034)	(0.029)

Table 2: Average elasticity at the stop-out yield and average normalized stop-put yield

parameters that shape the specification. The estimated $q = (b_1, b_2, b_3)$ were replaced in equation (3) to obtain the stop-out yield. Afterwards, we replaced this value in (3) to compute the elasticity at the stop-out yield. We summarize our average results in Table 2. Two randomly selected auctions are plotted in Figure 2.

Country	*Average*	*Max*	*Min*
b_1			
Argentina	4.119	16.017	1.461
Norway	n.a.	2.970	0.940
Israel	n.a.	26.569	1.895
$1/b_2$*			
Argentina	0.041	0.184	0.010
Norway	n.a.	0.016	0.002
Israel	n.a.	0.013	0.002
b_3			
Argentina	1.007	1.414	0.912
Norway	n.a.	1.160	0.997
Israel	n.a.	1.026	0.987

** We report $1/b_2$ because we used a sligthly different specification*

Table 3: Cross-country comparison

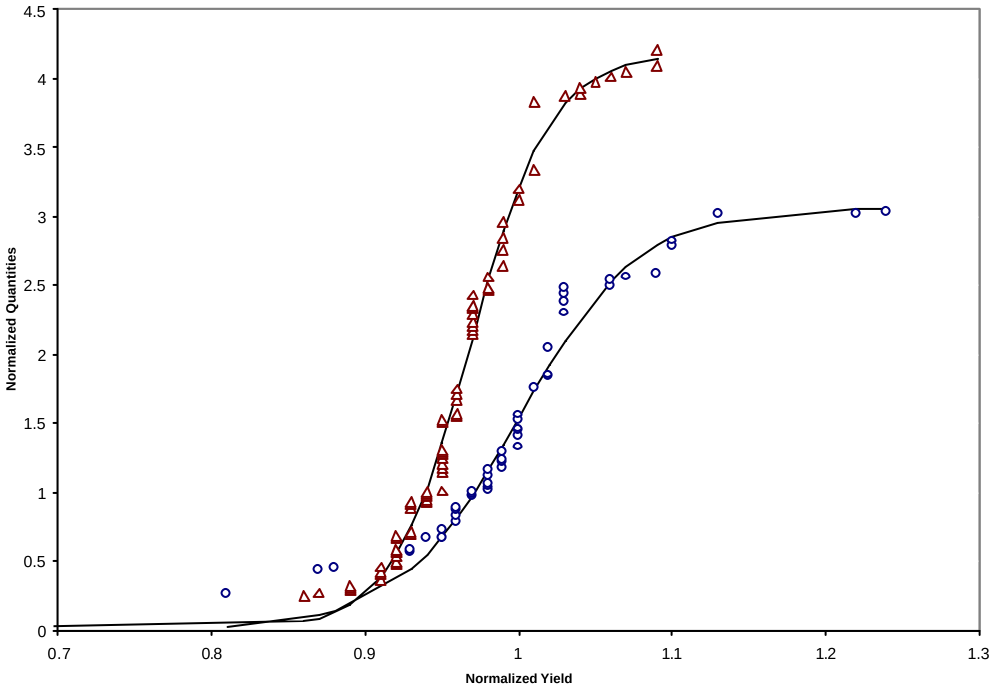

Figure 2: Fitted and observed values for two randomly selected auctions

Normalization of quantities and yields has the advantage of making our results comparable to those obtained in earlier studies of Norway and Israel (ABL (2000)).

Unfortunately, they did not report averages of the parameter estimates nor the standard deviations. To analyze the data, its important to be aware that Argentina uses a different auction format than Norway an Israel, which use discriminatory auctions, where each bid is awarded at its own price. Thus, to compare the revenues for the Treasury in these cases, we should use the weighted average yield for the Norwegian and Israeli cases and the stop out yield for the Argentinean case. A value of the normalized stop-out yield or weighted average yield lower than 1 means that the Treasury was able to sell securities at higher prices than the market yield, obtaining positive revenues.

We can see in Table 2 that revenues for the seller were greater for the Argentina's case than for Norway and Israel. Israel obtained the larger revenues of the two other cases studied. As yields are normalized by the market yield at the moment of the auction, the average stop-out yield for Argentina is approximately 98% of the market yield. In contrast, Norway issued Treasury Bills at yields 102.7% over the market yield. Interestingly, Israel was able to issue at 98.8% of the market yield and uses practically the same auction format as Norway. These results suggest that there may not exist an "optimal" auction format for all countries. One possible explanation is that bidders behave differently in each country. This question is the main motivation for the rest of the paper, where we make an attempt to unravel one fundamental aspect of bidders behavior: *risk aversion*.

5.b. The Seemingly Unrelated Regression (SUR)

In Section 5.a. we have obtained a set of parameters that determine the shape of the aggregate bid function for each auction. But which are the economic variables that influence on the parameters, hence, on the bid function? To answer this question, Preget and Waelbroeck (2001) successfully uses Zellner's (1962) Seemingly

Unrelated Regression (SUR) methodology applied to French Treasury's auctions. They were focused on developing a model to forecast auction results. For this reason, they used ten variables that are available for bidders at the moment of the auction, but with no theoretical basis. Our interests take us to use variables that are supposed to influence bidder behavior form the theoretical side. Theoretical models usually include two sets of exogenous variables. The first set is related to market power and the second set includes variables that have effect on bidder's attitude toward risk. As the number of bidders remains fixed in the argentine case, we will focus on the second set of variables. To capture the risk sharing ability of bidders we used variables such as number of auctions on the same day, the volume auctioned in that particular auction and the total liquidity demanded by the government on the day of the auction. In this group, we also include the maturity in weeks of the security auctioned to reflect the risk exposition over time that buying a certain quantity would imply. To capture the trade-off between risk sharing and the expected profit that arises when yields are high, we included the quoted yield variable. The uncertainty of the stop-out price is represented by the volatility variable.

Equation	*# Obs.*	*Parms.*	*RMSE*	*R-sq*	*chi2*	*P*
b_1	94	6	1.68	0.15	16.46	0.0115
b_2	94	6	14.33	0.19	21.87	0.0013
b_3	94	6	0.07	0.29	38.25	0.0000

Dependent Variable	*Constant*	*Maturity*	*Number of auctions*	*Total Liquidity*	*Volume auctioned*	*Quoted Yield*	*Volatility*
b_1	8.2843	-0.0848	0.0630	-0.0996	0.0723	-0.4349	0.0073
	(6.66)	(-0.28)	(0.09)	(-0.94)	(0.19)	(-3.1)	(0.18)
b_2	40.661	0.176	-10.301	1.744	-7.867	1.366	-0.888
	(3.82)	(0.07)	(-1.81)	(1.93)	(-2.44)	(1.14)	(-2.6)
b_3	1.076	0.004	0.033	-0.005	0.034	-0.028	0.008
	(20.5)	(0.28)	(1.17)	(-1.04)	(2.12)	(-4.72)	(5.03)

Seemingly Unrelated Regression: The parameters are regressed on Maturity, Number of auctions, Total liquidity, the Quoted Yield and Volatility. T-statistics are in parenthesis below. Significance level is 5%. Variables were scaled in the following way: Maturity: Weeks to maturity multiplied by 10^-1, Number of auctions is a binary variable for number of simultaneous auctions performed by the Treasury. If is grater that one it takes the value 1. Total Liquidity is the total funding demanded by the Treasury simultaneously multiplied by 10^-8. Volume auctioned is the volume for that particular issue multiplied by 10^-8. Quoted Yield is the secondary market quoted bid multiplied by 10^2. Volatility is the FRB 20 day volatility multiplied by 10^3.

The advantage of using Zellner's SUR methodology instead of equation-by-equation estimation is for efficiency matters, not consistency (Zellner, 1962, 1963). This advantage can only be exploited under a few assumptions (Denis Conniffe, 1982). In the first place, contemporaneous error terms must be correlated and, in the second place, regressors are supposed not highly correlated between equations.

We also ran the OLS equation-by-equation technique for our data. We found that coefficients were equal, and variances were higher than the SUR model's asymptotic variance. In the light of results, we believe SUR methodology applies to our case. To read the data, it must be pointed out that we changed the scale of the independent and dependent variables to undergo an order of magnitude problem.

6. Results

6.a Risk Aversion

Literature on Treasury auctions regards bidders as symmetric and risk neutral. In this section we will discuss if the risk neutrality assumption is consistent with the bidders attitude towards risk in Argentina. In Section 4.b. we discussed how parameters that shape the logistic specification should behave under changes in three exogenous variables to be consistent with the bidders maximization problem results under risk aversion. From the SUR estimation, the signs of these relationships

		b1	*b2*	*b3*
Auctioned Volume	*Expected*	(*)	(-)	(+)
	Observed	(**)	(-)	(+)
std.dev.Resale Price	*Expected*	**(-)**	(-)	(+)
	Observed	**(**)**	(-)	(+)
Resale Yield	*Expected*	(-)	**(*)**	**(*)**
	Observed	(-)	**(+)**	**(-)**

(*) no relation between the parameter and the exogenous variable

(**) Not significant at 5% level

Table 4: *Expected and observed relationships between exogenous variables and the three parameter logistic growth curve*

were extracted form the data. The following step is to compare the expected signs that were suggested by the model and those that were found in the data. Table 4 below shows a comparison between expected signs and the observed signs of the SUR estimation.

The data rejected three out of nine expected results. In the first place, the model predicted that a change in the resale yield would have no effect on the slope of the logistic curve. The estimation provided evidence that the resale yield has a statistically significant positive impact the slope. This means that the curve gets steeper when the market yield rises. The second disagreement between theory and the data is that the standard deviation of the resale yield was expected to have a negative relationship with the quantity demanded. The SUR estimation provided evidence that the standard deviation of the resale yield has no relationship with the quantity demanded. The third prediction that was not corroborated by the data is that the resale yield and the yields bid move exactly together. We will argument that this result is due to market inefficiency rather than to bidders attitude towards risk. However, all the remaining relationships have the signs the theory predicted.

The auctioned volume has no effect on the quantity demanded, because bidders bid as proportions of the auctioned volume. An increase in the volume to be auctioned makes the aggregate bid schedule flatter because a risk averse bidder is reluctant to make high marginal quantity bids. In the same token, a risk averse bidder would ask for more yield compensation for each marginal quantity she bids. Thus, it is also consistent for b_3 to have a positive relation with the volume auctioned.

The standard deviation of the resale price has the same effect as the volume auctioned variable. The more uncertain a risk averse bidder is about the resale price the more compensation she will ask for bidding an additional quantity. Moreover, a risk averse bidder is also supposed to bid lower prices in the presence of such uncertainty. However, theory expects that a risk averse bidder should bid for lower quantities when uncertainty rises. The estimation suggests no such relation. Our explanation for this feature is that the fact that supply and demand is interdependent in Treasury Bill auctions is stronger. Additionally, bidders can tradeoff with the values of other parameters to compensate for this loss in utility.

Finally, an increase in the resale yield has a negative effect on the quantity demanded because bidders value the item less. This is in line with the model developed in this paper. However, an unexpected result is that if market yields are high, bidders bid aggressively. The benchmark model analyzed is silent on the effect of the level of the resale price on the aggressiveness of bidders to submit their bids. The statistically significant negative sign of the market yield coefficient in the SUR estimation for the b_1 equation provides evidence that when yields are high, bidders bid aggressively. The explanation for these puzzle might be given by the fact that when yields are high, quoted yields do not reflect reliable prices as the large bid-ask spreads suggest. Market participants have knowledge of this market inefficiency and account for it when they submit bids.

6.b Bid dispersion and Risk Aversion

Extant theories of bidder behavior predict that bid dispersion may augment if the stop-out price is uncertain when bidders are risk averse. However, these results were derived for *discriminatory* auction formats and bidders with private information; one cannot be certain that these results would hold in other auction formats. On the other hand, Keloharju, Nybourg and Rydquvist (2001) have derived the higher order moments for the model studied in section 3.a. None of the higher order moments depend on an exogenous parameter as volatility. We studied normalized yields bid at every auction at the aggregate level for two different levels of volatility for Argentina (nota). We defined an arbitrary threshold on the 21-day Park volatility of the return of the FRB (Brady Floating Rate Bond) to split the sample. The FRB was chosen because it is considered as the benchmark risk-index by market participants. We centered both distributions by subtracting the mean value to each series. The rationale is that over the arbitrary value of volatility, bidders have relatively more uncertainty about the post-auction value of the security being sold at the auction. Table 5 shows the summary statistics for the two samples.

Statistic	*Low Volatility*	*High Volatility*
Centered Mean	0.00	0.00
Standard Deviation	0.06	0.11
Skewness	-0.10	0.80
Kurtosis	4.43	4.89

Table 5: Summary statistics of low and high volatility aggregate bid normalized yields

Our data suggests that uncertainty has a positive effect on bid dispersion. This is evidence against Kyle (1989) model, as well as Back and Zender (1993) with risk neutral bidders. These models predict that bid dispersion is independent of market volatility. Moreover, we report that kurtosis remains practically independent of volatility and that the distribution gets skewed to the right in risky states of nature and to the left when volatility is below the arbitrary threshold.

The values for skewness of our sample imply that linearity at the aggregate level is not a good working hypothesis. Previous work by Keloharju, Nybourg and Rydquvist (2001) arrive to the same conclusion at the individual level, although they find average skewness for the whole sample not statistically different form zero.

To illustrate the effect of uncertainty on bidders dispersion of bids we estimated the distribution of the two samples using the Kernel Density Estimator. The Kernel is plotted in Figure 3.

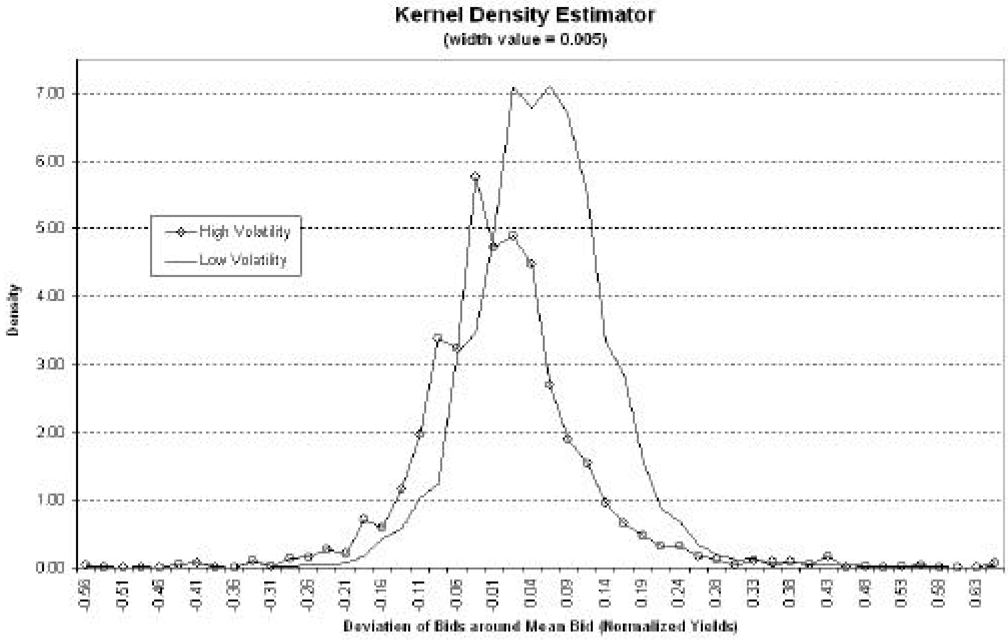

Figure 3: Kernel Density for two different risk levels

7. Conclusions

Based on theoretical foundations provided by previous work of Kyle (1989), Back and Zender (1993) and Wang and Zender (1998, 2002), we aim to add in a growing empirical literature. The focus of this paper was to undisguise bidder's behavior towards risk, mainly by analyzing the structure of their bid function. First, drawing on the work of BL (1999) ABL (1999), consistent estimates for a parametrical form were obtained. Afterwards, using the information dropped by Kyle's (1989) symmetric equilibrium solution we proposed some relevant variables to address the attitude toward risk of auction participants in Argentina's Treasury auctions.

This paper has two main findings. On the first place, Treasury's auctions in Argentina share the common "S" shape that has been found in Israel, Norway, Swiss and France. This is striking, because a cross-country invariant shape is rare in economics. Moreover, it provides a homogenization that can be useful for theorists. However, our analysis leaves unanswered the question of why this common shape arises in the first place. This methodology is also valuable because it allows to work on the entire bid schedules instead of only working with the stop-out quantity and price pairs. Thus, a lot of information on bidder behavior can be extracted from the curves, that would be lost if we disregarded bid schedules. After all, it is precisely bid schedules what distinguishes multi-unit auctions of single-unit auctions.

On the second place, replicating the same methodology as Preget et al. (2001) but from another stand point, we obtained meaningful results to conclude whether bidders were risk averse or risk neutral in our sample. Our findings are in line with predictions of extant theories of risk aversion and bidder behavior. Adding up, an increase in the auctioned volume produces an increase in the yields submitted by bidders. Moreover, the bid schedules gets flatter reflecting bidders' reluctance to make high marginal quantity bids. When the resale price is uncertain, the bid schedule gets flatter and yields bid augment. If the resale yield increases, bidders' demand falls and the bid schedule becomes steeper. A sticking result that is opposite to theory of risk aversion is that when the resale yield increases, bidders bid aggressively. Our impression is that this effect is reflecting market inefficiency rather than evidence against theory. In our opinion, all this evidence is strong enough to accept the null hypothesis that bidders in Argentina are risk averse. Finally, by using the Kernel Density Estimator, this paper provides evidence that bid dispersion augments in risky states of nature, which is not predicted by current theories. Kurtosis remains constant but skewness of bid distribution changes at different levels of risk suggesting that linearity is not a good working hypothesis for modeling aggregate bid schedules.

Our findings have policy implications. Auction theory for single-unit auctions when we allow for risk averse bidders tells us that to achieve the optimal auction the seller must design a scheme where aggressive bidders are subsidized and low bidders are penalized. The question remains if this scheme would be effective in multi-unit auctions. Argentina's market maker system involved paying fees according to the degree of participation on the auction. This can be one of the mobiles that made the Argentine experience successful in terms of revenues to the seller.

Another important result is that if bidders in Argentina are risk averse, there is a formal model (Nautz (1995)) that provides support for Argentina's auction design. Nautz (1995) states that in a uniform price auction is optimal for every bidder to bid truthfully regardless of the bidder's attitude toward risk and their expectations concerning the stop-out price. Nautz shows that risk adverse bidders should bid less aggressively than risk neutral bidders in a discriminatory auction.

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