SESO
STUDIECENTRUM VOOR ECONOMISCH EN SOCIAAL ONDERZOEK

V A K G R O E P P U B L I E K E E C O N O M I E

How the Belgian Treasury should auction its debt

Daam VAN REETH

report 95/326

July 1995

De auteur dankt Prof. Dr. J. Vanneste en G. Van Camp voor hun waardevolle opmerkingen bij vorige versies van het rapport.

Universitaire Faculteiten St.-Ignatius
Prinsstraat 13 - B 2000 Antwerpen

D/1995/1169/13

Abstract

Belgian money markets were thoroughly reformed on January 29, 1991. In this so-called 'Big Bang' a new market for Belgian Treasury Certificates was created. Instead of the 'on tap'-emission of Treasury Certificates at an administered rate, a discriminatory auction system was introduced.

The main purpose of the paper is to analyse this new auction system and to compare it with the alternative of using a uniform-price auction. In the first section, it is shown that the answer to the optimal auction technique can not readily be found in existing literature. The second section illustrates the auction techniques used for selling Treasury paper in different countries around the world. In the final section the Belgian situation is analysed. First the problem of collusion and market manipulation is discussed. Second discriminatory and uniform-price auctions are compared. Although the focus is on the revenue-generating potential of both techniques I also comment on some other issues.

Contents

Introduction

The Belgian money market was thoroughly reformed in January 1991. The so-called 'Big Bang' on January 29 created a new market for Belgian Treasury Certificates. Instead of the 'on tap'-emission[1] of Treasury paper at an administered rate, an auction system was introduced. This meant a dramatic change to the financial institutions: from a situation of close cooperation, the Belgian financial sector went to a situation of intense competition with the Treasury.

Next to modernizing the whole Belgian financial market place, one of the main objectives of the reform was to minimize borrowing costs to the Treasury. More explicit this means (1) borrowing at the lowest interest rate and, as collusion raises the interest costs to the Treasury, (2) reducing such collusion opportunities to a minimum.

In auction theory, auctions are generally classified by two criteria: (1) sealed-bid versus open-outcry auctions and (2) first-price versus second-price auctions. Combinating the two criteria leads to 4 auction types, of which only two are used for selling Treasury Certificates: the first-price sealed-bid auction and the second-price sealed-bid auction. Open outcry auctions are not so easy applicable to the case of Treasury Certificates because in such auctions each participant has to be present physically.[2]

As table 1 indicates, a terminological problem arises in auction literature. The two techniques used for auctioning Treasury Bills are the discriminatory auction (also American auction or multiple-price auction) and the uniform-price auction (also Dutch auction, single-price auction or competitive auction). To avoid all confusion, in what follows I prefer to use the terms 'discriminatory auction' and 'uniform-price auction' to describe both auction formats, since these terms specify best the rules of the auction technique in question.[3]

---

[1] This means financial institutions could at any time take up any amount of Treasury Certificates they want.

[2] It should be noted however that the implementation of such auction systems is currently under consideration in the United States (Joint Report on the Government Securities Market, 1992). Instead of having to be present physically, bidders would be linked electronically.

[3] All these terms could be very misleading for non-specialists. What is frequently called a 'Dutch' auction in financial literature is not the same as the 'Dutch' auction generally described in auction theory. Also, the use of the term competitive auction could evoke the wrong impression that other auction types are not competitive.

Table 1: Terminology used in the literature for describing different auction types.

	First-price	Second-price
Open-outcry	Descending auction Dutch auction	Ascending auction English auction
Sealed-bid	Discriminatory auction Multiple-price auction American auction (F)	Competitive auction Single-price auct. Uniform-price auct. Dutch auct. (F)

(F) In Financial Economics only.

In a uniform-price auction, each winning bidder is charged the same price: the market-clearing price that equates the demand for and the supply of Treasury Bills (second-price).[4] In contrast, in a discriminatory auction winning bidders pay different prices: the price the bidder has offered himself (first-price). As a result, under this system there is price discrimination amongst buyers of government securities. Currently, the Belgian Treasury uses this discriminatory auction system. Although literature on Belgian Treasury Bill auctions is still scarce, a switch to the uniform-price auction system has already been suggested by e.g. Vanhorebeek & Moesen (1993).

Of course, the choice of the auction format has implications on the strategies to be followed in the auction and consequently on the outcome of the auction. The central focus in this paper is to try to analyse which of the two briefly described auction techniques could be optimal (from a cost minimizing point of view) to the Treasury.

We should remark that in literature such a thing exists as the revenue equivalence theorem, implying that all auction techniques lead - on average - to the same expected revenue for the seller. However, as the basic assumptions[5] underlying the revenue equivalence theorem are not applicable to the case of Treasury Bill auctions, this theoretical masterpiece must be rejected in this contribution.

The paper is organised as follows. In the first section, I demonstrate that the answer to the optimal auction technique can not readily be found in existing literature. The second section illustrates the techniques used in different countries for auctioning government paper. Also this international perspective is not able to provide us with an unambiguous answer. In the final section I will analyse the Belgian case.

---

[4] To determine this price either the highest losing bid or the lowest winning bid can be used.

[5] The most important ones are: risk-neutral and symmetric bidders, independent private values and only one single unit sold.

1. The answer in the literature: inconclusive

Although a vast literature on auctions and auction theory exists[6], there remain a lot of questions especially when related to real-world situations like Treasury Bill auctions.

During the 1960s a hot debate developed in the United States about whether U.S. Treasury Bills should be sold in a uniform-price auction or in a discriminatory auction. Proponents of the uniform-price auction (amongst others Milton Friedman and Vernon L. Smith) claimed that, because it was a simpler auction, bid preparation would be less costly, so more bidders would participate. This would lead to a larger volume of bills being sold, more efficient allocations of the bills, and higher bids. Proponents of the discriminatory auction (A.F. Brimmer, H. Goldstein, M. Rieber) claimed the government would obtain higher revenue via price discrimination. Their respective arguments are further elaborated in the third section of this paper.

Although there has never been a formal conclusion to this debate, the discussion was closed in the mid seventies. For a long time then the focus in literature has been primarily on theoretical work concerning optimal auctions. Much theoretical progress has been made in the 1980s by e.g. Riley & Samuelson (1981), Milgrom and Weber (1982) and Myerson (1981). Excellent surveys of auction theory have been presented by McAfee & McMillan (1987) and Wilson (1992).

The discussion related to Treasury Bill auctions was re-opened in the U.S. in the early 1990s following the Salomon Brothers scandal. Salomon Brothers abused the U.S. Treasury in 1990 and 1991 by frequently submitting fraudulent bids, in an attempt to obtain a larger part of the Treasury Paper to be auctioned.[7] This scandal was the basis for a large parliamental debate and a combined inquiry by the U.S. Department of Treasury, the Securities and Exchange Commission (SEC) and the Board of Governors of the Federal Reserve System, which resulted in **The Joint Report on the Government Securities Market** (1992). In this report, amongst a number of measures to be taken to avoid fraudulent bids, a change to the uniform-price format was also proposed.

---

[6] Pioneering work in auction theory has been made by William Vickrey, and his paper "Counterspeculation, auctions, and competitive sealed tenders" is still worth reading as an introduction to the analysis of auctions.

[7] U.S. Treasury auction rules limited the awards to one bidder in any auction to 35 percent. By placing unauthorized bids in certain of its customers' names at several Treasury auctions, Salomon obtained higher portions of the newly issued notes and bonds - in one auction they even had a 94 percent holding - thus 'cornering' the market and earning higher profits.

In recent years some interesting studies have been published related specifically to Treasury Bill auctions. *Elizabeth Cammack* (1991) made a substantial analysis on bidding strategies and information contained in U.S. Treasury Bill auctions. *Sushil Bikhchandani* (1989) constructed a theoretical model for auctions with resale markets. The most interesting empirical study was made by *Steven R. Umlauf* (1993). He analysed the Mexican situation for the period 1986-1991. Because the Mexican government switched from a discriminatory to a uniform-price auction technique in July 1990, he was able to compare both auction formats empirically. He found that after switching from a discriminatory auction technique to a uniform-price auction technique, profits to the largest auction participants fell dramatically, indicating better borrowing conditions for the government. In contrast to his conclusions, however, the Mexican government switched back to the former technique in 1993.

Empirically well-studied auctions are also the U.S. timber auctions (e.g. Hansen, 1985 and Johnson, 1979) and the U.S. oil lease auctions (e.g. Hendricks & Porter, 1988, Hendricks, Porter & Boudreau, 1987 and Capen, Clapp & Campbell, 1971). Because these applications are outside our field of interest we will not discuss these papers further. We should remark nevertheless that also these studies provide conflicting results and no definite answer to the optimal auction technique is presented in these papers either.

2. The international experience: inconclusive

Instead of looking for the answer in the literature, also a study of the auction techniques used by different countries could be useful. Assuming that maybe the practictioners know best what technique is optimal, the answer could be found this way.The following survey makes clear, however, the answer from this international perspective is also rather inconclusive.

Some countries choose one auction format or another for auctioning all Treasury paper. The discriminatory auction technique is used exclusively in Japan, France, Australia, Canada, Belgium and New Zealand while in contrast only Denmark and Switzerland use exclusively the uniform-price technique. (A more detailed survey can be found in table 2). Apparently, most countries show a preference for the discriminatory auction technique.

Table 2: Auction techniques used in different countries for selling Treasury Paper.

Country	Technique	Items auctioned	Remarks
Australia	discrim.	All government securities	since 1982
Belgium	discrim.	Treasury Certif.	since 1991
		Linear Bonds	since 1989
Canada	discrim.	Short-term bills	
		Marketable bonds	only 3/4 of outstanding volume
Denmark	uniform	Short-term bills	also sold on tap
France	discrim.	Short-term bills	
		OAT Bonds	
Germany	discrim.	Medium-term notes	primarily used (since 1991)
		Bunds	since 1990 (only a portion of each Bunds sale)
	uniform	Medium-term notes	still used occasionally
Italy	discrim.	Short-term bills (Lire-denominated)	no minimum price set
	uniform	Short-term bills (ECU-denominated)	minimum price set
		Treasury Bonds (in ECU and Lire)	minimum price set
Japan	discrim.	All government securities maturing in 2, 3 and 6 months; and 2, 3, 4 and 20 years	
		10-year bonds	only for 60 % of the volume

Mexico	discrim.	All government securities	Before July 1990 and since 1993
	uniform	All government securities	Between July 1990 and 1993
Netherlands	discrim.	Bonds	stopped in March 1991
	uniform	6-month Certif.	since 1994
New Zealand	discrim.	All marketable securities	since 1985
Switzerland	uniform	3 & 6 month bills	always
		Long-term bonds	only occasionally
Unit.Kingdom	discrim.	Bills and longer term debt	
	uniform	Gilts	modified version: minimum price tender method
Unit.States	discrim.	All government securities	in use normally
	uniform	2 and 5 year notes	experimentally used during certain periods

Source: Joint Report on the Government Securities Market (U.S. Treasury, 1992) and Feldman & Mehra (1993b).

This preference should, however, not be overstated. Some countries show less conviction and use or have used both formats in recent years. The situation in Mexico was already made clear in the previous section. Another special case can be found in Italy, where Treasury Bonds and ECU-denominated bills are issued through uniform-price auctions and local-currency Treasury Bills through discriminatory auctions. Both auction techniques are also still used in the United Kingdom (though the uniform-price auction is implemented through a minimum price tender method) and - to a lesser degree - in Germany (where the Treasury is gradually abandoning the uniform-price technique). In the United States, the Treasury has been experimenting with uniform-price auctions for some government securities every now and then, but is still using discriminatory auctions for the moment. The Netherlands have abandoned the discriminatory auction technique for selling bonds in 1991 (these are currently sold 'on tap' only), and

have recently begun selling 6-month **Nederlandse Bank Certificaten** (NBC's) in a uniform-price auction.

Other applications of auction techniques in the monetary field also exist. Romania has conducted discriminatory auctions for refinance credit, while the former Czechoslovakia used uniform-price auctions. Common is also the use of an auction technique for providing foreign exchange. Bolivia, Ghana and Jamaica use a discriminatory auction technique, while Guinea, Nigeria and Uganda use the uniform-price auction technique.[8]

One of the more interesting studies to this respect was conducted by *Rafael Tenorio* (1993), using foreign exchange auction data for Zambia. In Zambia, between October 1985 and January 1987, 68 auctions were held for allocating foreign exchange. After the first 42 auctions, the uniform-price auction system was replaced by the discriminatory auction system, to compress the range of bids and to improve revenue collection. In his study, Tenorio concludes uniform-price auctions were revenue-superior.

3. The Belgian case: a starting analysis

Throughout this section, the emphasis is on the revenue-generating potential of the two auction formats under consideration. It should be noted, however, that other issues such as efficiency and transaction costs offer an important alternative to this revenue-based approach. We will briefly discuss some other issues in the final part of this section.

Looking for the optimal revenue-generating auction technique has two important aspects. The first issue relates to the question which system leads to the best average price to the Treasury. Second, there is the question to what extent each system is susceptible to collusion.[9] Although both issues are interrelated, they are essentially different. Of course, the higher the degree of collusion, the higher the costs to the Treasury. But also, irrespective of the level of collusion, one system or another can lead to higher costs on average, purely as a consequence of alternative bidding strategies.

---

[8] These examples are taken from Feldman & Mehra (1993a).

[9] We have to bear in mind that in fact all auction formats are potentially susceptible to collusion, and what really is important is the *comparative* incentive for collusion under the different auction formats.

3.1 Collusion and market manipulation

To be successful an auction-system requires a market situation in which there is an excess demand for public debt titles and the absence of collusion between the participants on the primary market. The first condition is no problem: in every auction until now total bids easily exceeded the demand from the Treasury, and consequently the Treasury never had to accept all bids. The possible existence of collusion between participants on the primary market, however, is a greater worry to the Treasury.

Two different approaches can be taken when analysing potential collusion. On the one hand, we can observe the bidders in Treasury Bill auctions as one group and analyse how their collective bargaining position versus the Treasury has changed with the reform. This could be thought of as an implicit or passive form of collusion. On the other hand, there could also be explicit collusion, in which market participants try to influence the prices at which the Treasury has to borrow.

3.1.1 Implicit collusion: the bargaining position of the financial sector versus the Treasury.

In his important contribution, Degryse (1992) was the first to analyse the relationship between the Belgian Treasury and the financial sector from a game-theoretic point of view. However to derive his conclusions he explicitly had to assume risk-neutrality. This approach was later reproduced in a paper by Vanhorebeek & Moesen (1993). A more general approach is presented here.

We start from the negotiating process between on the one hand the Treasury and on the other hand the subscribers for Treasury Bills. We assume that the two parties (from now on defined as the financial institutions and the Treasury) are engaged in a bargaining situation to determine the interest rate on Treasury Bills. Although the subscribers formally do not act as a single opponent party, in this model they are considered to be the opponent party of the Treasury. In this way, the relative change in bargaining power of the Treasury will be empirically testable.

Based on contacts with traders we think this approach is fairly realistic for the Belgian case. As on Tuesday morning prior to the auction Treasury Bills with comparable maturity are sold amongst financial institutions, traders get a good idea on the interest rate to be expected in the forthcoming auction. Furthermore, through their contacts they are able to exchange their personal views. In this way some sort of 'general consensus' or 'self-fulfilling prophecy' emerges between an important group of participants on the primary market.

3.1.1.1 Theoretical analysis

First we determine the threat points of both parties. Because the interbank market is the most important alternative for the Treasury Bills market, the Minister of Finance - when deciding on a marginal lending rate for issuing Treasury Bills - has to keep track of the alternative yield the financial institutions can earn on the interbank market.

The financial institutions can threaten to stop the financing of the short-term debt and go to the interbank market whenever the offered interest rate is below the BIBID rate (the Belgian interbank bid rate). The BIBID rate consequently is the best alternative the financial institutions have when they want to deposit their available funds. The Treasury also has a threat point. Whenever the Treasury Bills rate seriously exceeds the BIBOR rate (the Belgian interbank offered rate), the Minister of Finance can decide to borrow on the international money market. As a result, the interest rate on Treasury Bills must have a value that lies between the BIBID and the BIBOR rates.

The bargaining problem between the financial sector and the Treasury described in this way is, from a game-theoretic point of view, the same as a "dividing-the-dollar" problem. The "dollar" that has to be divided is in this situation the interbank interest spread. When we apply the methodology explained in Binmore (1992) to this case, we are able to take a closer look at the relationship between risk attitude and bargaining power on the final outcome of the bargaining model.

First we have to define the utility functions for the Treasury and the financial sector, respectively, as follows:

$$U_T = 1/a * Q * (1 - z)^a$$
$$U_f = 1/b * Q * z^b$$

with

Q : the amount of Treasury Bills to be issued
a : a measure for the risk aversion of the Treasury
b : a measure for the risk aversion of the financial sector
z : the fraction of the surplus ("the share of the dollar") the financial sector gets.

Nash showed that a unique outcome for this kind of bargaining problem can be found by maximizing $U_T * U_f$, subject to the constraint that the solution is located between the threat points of both parties. He made the assumption that both parties have equal bargaining powers. As a result, in a **symmetric Nash bargaining problem**, the parties divide the surplus in two equal pieces. This assumption was relaxed in an article by Kalai, in which he introduced a maximand to reach an **asymmetric Nash bargaining solution.** This maximand implies both players to act as if they maximize the weighted average of their utilities, the weights being their respective bargaining power coefficients (Degryse, 1992, p. 125).

Applied to the bargaining problem we are dealing with the Nash bargaining solution can be found by maximizing:

$$U_T^{1-\mu} * U_f^{\mu}$$

or $\left(1/a * Q * (1 - z)^a \right)^{1-\mu} * \left(1/b * Q * z^b \right)^{\mu}$

In which μ measures the relative bargaining position of the financial sector versus the Treasury ($0 < \mu < 1$). A large μ implies a weak bargaining power position of the Treasury in the price-setting process of Treasury Bills.

The solution to this optimization problem is as follows:[10]

$$z = \frac{b\,\mu}{b\,\mu + a\,(1-\mu)} \qquad (1)$$

(the share the financial sector gets)

$$\text{and } 1 - z = \frac{a\,(1-\mu)}{b\,\mu + a\,(1-\mu)} \qquad (2)$$

(the share the Treasury gets)

These solutions make it possible to analyse the impact of risk attitude and bargaining power on the outcome of the bargaining process separately. By applying the coefficient of relative risk aversion (R) - as defined by Pratt[11] - to the utility functions defined above, we can easily show that risk neutrality implies a = 1 for the Treasury and b = 1 for the financial sector. A value between 0 and 1 implies risk aversion (R>0), a value above 1 indicates a risk loving attitude (R<0).

The cases in which either a or b have a value above 1 should be ignored here. Intuitively, it is hard to believe that either the Treasury or the financial sector shows a risk loving behaviour. The consequences of such a behaviour are too important. This intuitive feeling is confirmed if we look at the situation from a game-theoretic point of view. Binmore proves that the only Nash bargaining solution in a "dividing-the-dollar"-problem with risk loving players is the solution in which both players toss a coin and see which of the players gets the surplus (Binmore, 1992, p. 194-195).

---

[10] Differentiate with respect to z and set the result equal to zero.

[11] $$R = \frac{-V''(x)}{V'(x)} * x$$

This coefficient equals 1-a for the Treasury and 1-b for the financial sector.If R>0 there is risk aversion while R<0 means the parties are risk loving. Risk neutrality implies R=0.

In tables 3 and 4, the simulated pay-offs for the financial sector and the Treasury are shown for different values of a and b. In table 3 we assume equal bargaining power for both parties (μ = 0.5), in table 4 we assume the Treasury having the better bargaining position (μ = 0.25).

Table 3: The pay-offs for the financial sector (z, left above) and the Treasury (1-z, right below) for differences in risk attitude, assuming equal bargaining power (μ= 0.50).

		b			
		1/4	1/2	3/4	1
a	1/4	0.50 0.50	0.67 0.33	0.75 0.25	0.80 0.20
	1/2	0.33 0.67	0.50 0.50	0.60 0.40	*0.67* *0.33*
	3/4	0.25 0.75	0.40 0.60	0.50 0.50	0.57 0.43
	1	*0.20* *0.80*	0.33 0.67	0.43 0.57	0.50 0.50

Starting with table 3, we see that the solution to the symmetric Nash bargaining model can be found on the diagonal. If both parties have equal bargaining powers and they are equally risk averse, they simply split the surplus in two equal pieces. In the other cases, the party that is the least risk averse ends up in the best position. It is obviously disadvantageous to be risk averse in this kind of bargaining situation: the more risk-averse you are, the less money you get. Finally, it is important to note that only the **relative** risk aversion (relative to the opponent party) matters; e.g. (a=1/2 ,b= 1/4) leads to the same solution as (a= 1, b= 1/2).

Table 4: The pay-offs for the financial sector (z, left above) and the Treasury (1-z, right below) for differences in risk attitude, assuming a better bargaining position for the Treasury (μ = 0.25).

		b			
		1/4	1/2	3/4	1
a	1/4	0.25 0.75	0.40 0.60	0.50 0.50	0.57 0.43
	1/2	0.14 0.86	0.25 0.75	0.33 0.67	0.40 0.60
	3/4	0.10 0.90	0.18 0.81	0.25 0.75	0.31 0.69
	1	0.08 0.92	0.14 0.86	0.20 0.80	0.25 0.75

In table 4 we have a different picture. If the two parties are equally risk averse when μ = 0.25, the Treasury takes the biggest part of the surplus, due solely to the fact that the Treasury has the better bargaining position. In the other cases, the difference in risk aversion between the Treasury and the financial sector also determines the way in which the surplus is split. If the Treasury is risk neutral, and the financial sector is very risk averse (b = 1/4), the Treasury takes more than 90 % of the entire surplus. If, on the other hand, the financial sector is less risk averse than the Treasury, they gain part of the surplus. We see that for a = 1/4 and b = 3/4 the surplus again is divided in two equal pieces. In this situation, the difference in bargaining power is entirely compensated by the difference in risk aversion.

This simulation shows the importance of two factors when studying the bargaining position between the Treasury and the financial sector: the bargaining power and the degree of risk aversion. When we assume risk neutrality, as was explicitly done by e.g. Degryse, we estimate the change in bargaining position and contribute it entirely to change in bargaining power. As a result, if this risk assumption is not valid, we easily jump to the wrong conclusions. Therefore, we have to be careful in analysing our estimation results and if unequal risk attitude could be detected the estimated results should be relaxed.

3.1.1.2 Some thoughts about risk attitude

Increasing a bidder's risk aversion heightens his fear of losing and so induces him to bid higher. A first-price sealed-bid auction insures a winner against fluctuations in the price he has to pay, and a risk-averse bidder is willing to pay, in the form of a higher bid, a premium for this insurance (Maskin & Riley, 1985). This results in the discriminatory auction yielding higher average revenue than the uniform-price auction in private value auctions while in the common value case[12] this ordering is reversed (McAfee & McMillan, 1987).

A change in risk attitude is not that unrealistic. As Treasury Bills were issued 'on tap' before the January 1991 reform, the financial institutions were subject to little risk, and the (price) risk was born by the Treasury. The high financing needs of the Treasury meant that de facto the Treasury almost always had to accept the price put forward by the financial institutions.

---

[12] Briefly described, "private values" means each bidder has an own valuation for the object being sold, independent of the value other bidders have. "Common values" means the personal valuation of the object is dependent on the valuations of others (which is clearly the case for Treasury Bills).

After the reform, this has changed. The Treasury can decide on the price and the amount issued in light of their needs and the financing conditions offered by the bidders. The financial institutions now face a price risk and a quantity risk. When financial institutions fail to win (enough) Treasury Bills in the regular auction they have to settle their positions on the secondary market or on the interbank market. Some financial institutions (the so-called Primary Dealers) also have access to a non-competitive round. In this non-competitive round, held after the auction, additional Treasury Bills can be bought at the weighted average rate of the auction. Theoretically this lessens the risk for these financial institutions. From contacts with traders, however, it appeared that they did not care very much about this non-competitive round. Therefore although a very distinctive characteristic of Belgian Treasury Bill auctions, we excluded it from this analysis.

For computational reasons, in the following empirical analysis we will adopt the risk-neutrality assumption but not without forgetting about the limiting implications of this assumption. It is important to note that we assume that the group of financial institutions as a whole is risk-neutral, while in reality some of the group members can be risk-neutral and others risk-averse. In fact, if the value of the individual bids is relatively small with respect to a bidder's total assets, a situation applicable here, risk-neutrality or mild risk-aversion could appear as a reasonable assumption.

3.1.1.3 Empirical analysis

By replacing z in equation (1) with the share the financial sector really gets[13], and assuming risk neutrality for both parties (a=1=b), we easily derive the following equation:

$$INT = BIBID + \mu \, (BIBOR - BIBID) \qquad (3)$$

In this equation the interest rate on Treasury Bills is explained by the BIBID rate and a fraction of the interbank interest rate margin. The stronger the bargaining position of the Treasury the smaller this fraction and the closer the Treasury Bill rate will be to the BIBID rate. This specification will now be used to test whether the Treasury has improved its bargaining position.

To analyse the effect of the money market reforms on the bargaining position of the Treasury the model was estimated for different periods of one year. The first regression used daily data for the period January 2, 1990 to January 28, 1991. This is the pre-reform period. The post-reform period was

---

[13] This is: (INT - BIBID)/(BIBOR - BIBID), with
INT = the interest rate on Treasury Bills
BIBID = the Belgian interbank bid rate
BIBOR = the Belgian interbank offered rate

analysed by a series of regressions using daily data for the period January 29, 1991 to October 26, 1994. If the Treasury has improved its bargaining position, the parameter μ should be significantly lower in the post-reform period.

Table 5: The results of the OLS-regression for estimating the relative bargaining power of the financial sector.

	Pre-reform period	Post-reform period			
		1991[1]	1992	1993	1994[2]
μ	0.694 (15.42)	0.382 (19.10)	0.271 (16.94)	0.151 (5.53)	0.170 (9.02)

[1] : From January 29 on.
[2] : Until October 26.

As can be seen in table 5, the bargaining power of the bidders has weakened significantly.Before the money market reform, the relative bargaining position of the financial sector versus the Treasury was almost 0.7; after the reform it initially decreased to 0.38 in 1991 and has later stabilized around 0.15. We have to note, however, that μ still is significantly different from zero, which means that the Treasury still pays an interest rate on Treasury Bills which is above the BIBID rate.

Comparing these estimates with tables 3 and 4, the above mentioned difficulties with interpreting the parameter μ become clear. Assuming risk-neutrality, the Treasury has improved its bargaining position: instead of getting 30% of the spread, the Treasury now takes over 80%. It could also be, however, that nothing has changed in terms of bargaining power, but that due to risk considerations, we have a different picture. Theoretically, it is indeed perfectly possible we have just moved from one position in table 3 to another (see italic figures), with equal bargaining power and new risk aversion parameters (from (a,b)=(1/2,1) to (a,b)=(1,1/4)).

It is important to note that this analysis does not deny the fact that the Treasury is facing better borrowing conditions under the present system. It merely states that it is not straightforward to award the whole gain to bargaining power alone. The issue probably seems academic, but could be of practical importance. If a larger part of the spread can be obtained by increasing the risk to the financial institutions even more, the introduction of auction features that increase risk to financial institutions could be considered. Attention should be paid, however, not to scare investors out of the market by doing so. (In fact, if one of the objectives is to enhance competition, lowering risk should be considered).

3.1.2 Explicit collusion: auction-day effects and cornering

To lower the borrowing costs to the Treasury, one of the indirect objectives of the January 1991 reform was to open the primary market for Treasury Bills to a larger group of potential subscribers to enhance competition. This opening to a broader range of investors seems however to be rather marginal.Evidence from the competitive tenders shows that financial institutions from Belgium and Luxembourg still account for about 90 % of the ownership of Treasury Bills. Also the number of bids received for each auction has fallen from on average around 30 in 1992 to just over 20 in 1993. This of course makes the feasiblity of collusion more explicit.

As there is no formal consortium anymore[14], the financial institutions can no longer directly influence the price the government has to pay. However, if these financial institutions are able to influence the price in an indirect way - i.e. via the secondary market - there remains a possibility for collusion. After all, when deciding on a maximum price in the auction, the Minister of Finance usually takes the return on the secondary market into consideration.[15] To draw any conclusions about the existence of this sort of collusion we consequently have to look at the evolution of these secondary market prices around auction days.

To study this we go back to our model. By extending the specification with a dummy-variable having value 1 only on auction days (usually Tuesday), it is possible to measure potential auction day-effects. The estimation results for this "collusion-equation" are given in table 6:

Table 6: The results of the OLS-regression for estimating the relative bargaining power of the financial sector and the occurrence of auction day effects.

	1991	1992	1993	1994
μ_1 (barg.)	0.364 (15.83)	0.251 (13.94)	0.135 (4.72)	0.152 (7.39)
μ_2 (dummy)	0.010 (1.67)	0.011 (2.39)	0.022 (1.68)	0.011 (2.05)

[14] Before the reform of Belgian debt management, a consortium of banks existed. The role of the consortium was to act as a subscriber to all government bonds issued.

[15] Evidence from the Treasury Bill auctions in 1991 and 1992 shows that the interest rate finally accepted by the Minister of Finance was always close to the interest rate on the secondary market: in 1991 the difference averaged 2 base points,in 1992 the difference often decreased to 1 base point.

These results indicate that the returns on the secondary market are indeed influenced by the tender emissions although the effect is rather small:the average increase in return on the secondary market on auction days averages about 1 base point. Only in 1993, this effect is somewhat larger and surpasses 2 base points, but this is entirely due to the impact of the auctions held during the EMS monetary crisis of late August begin September. Deleting these auctions from the sample again reduces the dummy to the magnitude of the other three sample years.

If we take into consideration that a slight increase in return can be necessary to allow a smooth absorption of these new Treasury Bills by the market, this small increase could simply be considered as a sort of 'introduction cost' of the auction to the Treasury. This result is consistent with both the prediction of auction theory that winning bids are downwardly-biased estimates of common values and the experience in other countries. Cammack (1991) finds the comparable figure for 3-month U.S. Treasury Bills is 4 base points and Umlauf (1993) mentions 1,71 base points for 1-month Mexican Treasury Bills. Furthermore, as newly issued Treasury Bills have a slightly longer maturity than the securities on the secondary market, this small increase in return could be considered normal.

The small tender effect of just over 1 base point consequently seems to indicate that the Belgian Treasury Bill market rather easily absorbs new emissions, especially compared to other countries, and that if part of this increase in return could be attributed to price manipulation, the importance of this manipulation would probably be negligible.

Another possible manipulation of the market is what is called "cornering" the market. This means that one bidder (or a very small group of bidders) obtains the bulk of the Treasury Bills auctioned, giving him (them) a monopoly position. Even when limits are imposed on the amount any party can obtain, by submitting fraudulent bids it still is possible to corner the market, as the case of Salomon Brothers (see infra) proved.

For succesfully cornering the market for Treasury Bills in a sealed-bid auction, the bidder or the group of bidders need only make a slightly more agressive bid than the other participants expect. If the cornerer succeeds in winning the bulk of the Treasury Bills auctioned, he then acts as a discriminating monopolist, carefully regulating secondary market sales to unsuccesful bidders, who are now short due to sales made in the when-issued market (Reinhart, 1992).

Since no when-issued market exists in Belgium and the existence of such a market is -though not essential- very important to corner a market, the problem of cornering could be thought of as perhaps less appropriate in this analysis. It should be noted nevertheless that to our knowledge in Belgium no limits are placed on total amounts any bidder can win in the auction and thus the potential danger of a cornered market remains,

especially during periods in which there is a high demand for Belgian Treasury Bills.

3.2 Discriminatory versus uniform-price auctions

In this section we analyse which of the two auction systems used for selling Treasury Bills is optimal to the Treasury. Due to the high financing needs in Belgium, cost-minimization (and consequently revenue-maximization) is an important goal for the Belgian Treasury. First we will thus analyse what auction technique is revenue-superior to the Treasury, irrespective of collusion-considerations. To conclude this chapter other issues related to the optimal auction technique are also briefly discussed.

3.2.1 Revenue-superiority

In the introductory part of the paper the revenue-equivalence theorem was mentioned. Among the factors that cause this result to break down in auction markets for Treasury Bills, the most important ones are value-affiliation, endogenous bidder participation, risk aversion and multiple units being sold simultaneously.

It is straightforward that in a discriminatory auction the Treasury realizes a budgetary saving by skimming the consumer surplus. As a discriminating monopolist, the Treasury's aim is to push the investor as far as possible along his price-investment curve, the limit being set by the Treasury's bargaining strength. However, this does not necessarily mean the discriminatory auction system is revenue-superior to the uniform-price auction system. To see this, basic bidding strategies under both auction formats are briefly introduced.

3.2.1.1 Basic bidding strategies

a) Basic strategies in a discriminatory auction

Theoretically, a discriminatory auction system should induce bids that are more market-oriented.If the bid is set too high, the bidder suffers the *winner's curse* (he risks ending up with Bills he can only sell at a loss).If the bid is set too low,it will not be accepted. Consequently, in order not to be caught out bids must be set very carefully. To avoid these costly bid preparation costs, some potential bidders (primarily the ones who have access to public information only) stay out of the primary market and prefer to operate via a primary dealer (mostly better-informed large financial institutions). The information advantage these primary dealers and professionals have over other potential market participants is rewarding under the discriminatory auction system because it alleviates

the winner's curse.[16]

Furthermore, auction theory predicts that bidders who do enter the market will never reveal their true value. To compensate for the winner's curse a rational bidder will always shade his bid. By doing so, the investor shows less of his true consumer surplus to the seller whose stated intention is to seize it (Reinhart, 1992).

A high bid lowers the profit from winning the auction, but raises the probability of winning. A rational bidder will trade between the two. The optimal strategy is to shade a bid towards the perceived market consensus. The more certain that consensus is, the more the rational bidder will shade his bid.

An often cited question is why financial institutions still participate in auctions, although they know the Treasury is price-discriminating. They could be better of by waiting for the auction results and consequently buy Treasury Bills on the secondary market it is argued.

Financial institutions still participate for two broad reasons. First, because they can not afford to remain absent for strategic reasons. For primary dealers, regular participation in the auctions is even one of their main obligations. Second, because even with price discrimination they still earn on these auctions. If they act as agents for other investors, they earn a commission fee. If they act for themselves and they do well, they can win Treasury Bills at a very favourable price (e.g. the stop-out price) and reselling these Treasury Bills on the secondary market thus earning a profit because the secondary market price usually is closer to the weighted average price of the auction.

b) Basic strategies in a uniform-price auction

In a uniform-price auction a bidder can offer a price as high as he likes[17], safe in the knowledge that he will not have to pay that price unless other bidders offer the same or more. If a lot of bidders act in this way, uniform-price auctions could help the Treasury to borrow more cheaply.

---

[16] For the primary dealers, this information advantage results not only from their daily activities in the markets for Treasury Bills, it could also result from their priviliged relationship with the Treasury.

[17] Auction theory though predicts bidders will reveal their true valuations in a uniform-price auction.

It is clear this method is less penalizing since agressive or uninformed bidders receive sure awards but pay a price closer to the market consensus. Consequently, in a uniform-price auction more investors could be encouraged to participate directly by bidding at the auction rather than by operating via a primary dealer. The information advantage the latter have is less rewarding in this case.

3.2.1.2 Comparative analysis

A theoretical starting point for an analysis of this optimal auction technique problem is offered in figure 1. In figure 1 two demand functions representing both auction types are shown. As explained, the succesful bidders in a discriminatory auction system suffer the winner's curse and pay different prices. In a uniform-price auction all bidders pay the same price.

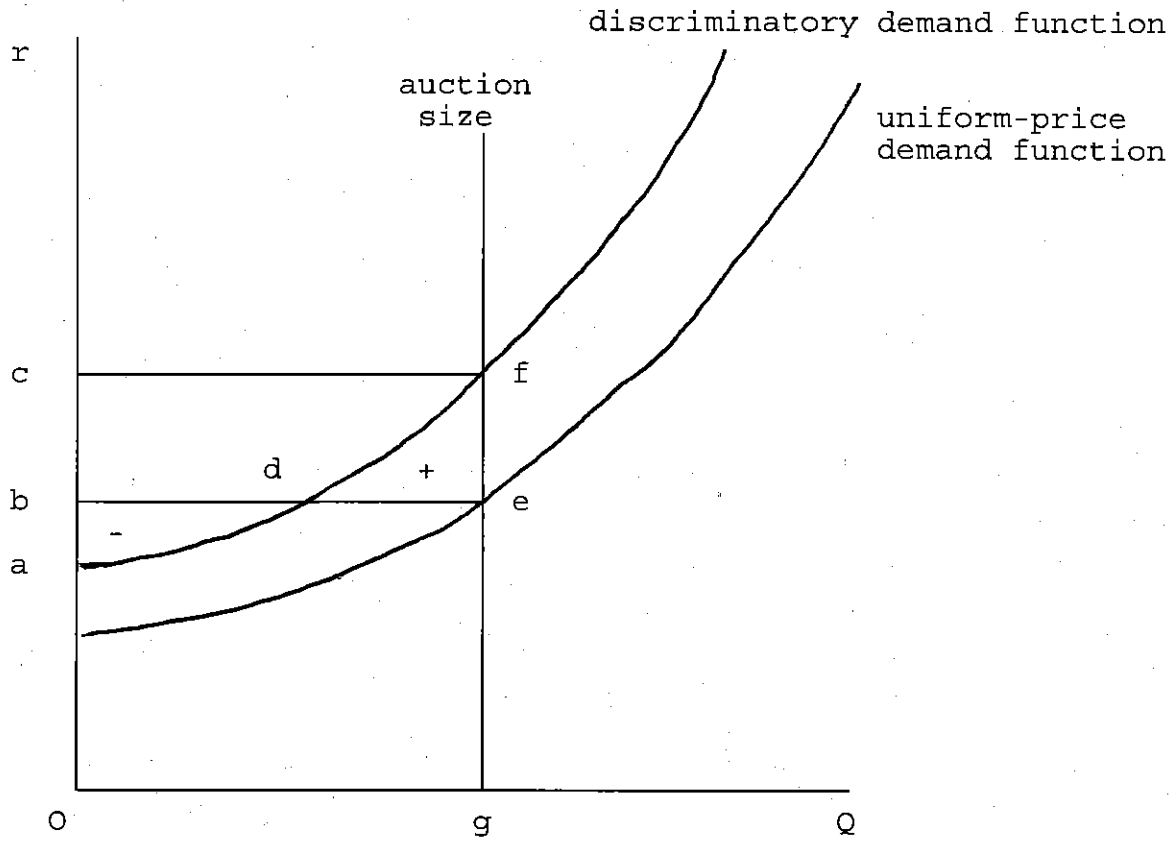
From the earlier described basic strategies a number of reasons can be deducted to explain, at least theoretically, why the uniform-price demand function should be located at the right hand side below the discriminatory demand function:

(1) Added investor demand (due to the removal of the "winner's curse" and less costly bid preparation costs),
(2) which in turn reduces the dominance of the primary dealers or the professional investors on the primary market (and the inherent potential for collusion),
(3) combined with more agressive bidding (no price discrimination),
(4) and finally the impact of uninformed or naive bidders.

The extent of this shift will determine which auction technique is most favourable to the Treasury.

Reason (1) is primarily responsible for an assumed horizontal shift to the right of the demand function. Reason (2) limits the capacity of the financial institutions to force a vertical shift upwards of the demand function. Reasons (3) and (4) both primarily explain the assumed vertical shift downwards.

FIGURE 1: Discriminatory auctions vs. uniform-price auctions: impact on government expenditures.[18]



abd(-) = extra cost Treasury (financial risk of switching)
dfe(+) = extra saving Treasury (gain from added demand)

In the discriminatory auction system, the Treasury pays a price (i.e. an interest cost) *Oafg* to receive an amount of money *Og*. Due to the price differentiation, the consumer surplus *acf* is skimmed by the Treasury. In a uniform-price auction system, to collect the same amount of money, the Treasury has to pay a price *Obeg*. To analyse which auction system is most favourable to the Treasury, we consequently have to compare *abd* (-) with *dfe (+)*. Concluding we can say that a switch to the uniform-price auction system is rewarding whenever the gain from added demand (*dfe*) outweighs the financial risk of switching (*abd*).

[18] Because in Belgium bids are made on the interest rate, and the price the bidders have to pay is inversely related to this interest rate, the demand function for Treasury Bills is upward-sloping in this figure.

What shift in the demand curve is necessary to compensate for clearing the market at one price instead of clearing all along the demand curve ? In the literature, one attempt to quantify this necessary change can be found in an article by Bolten (1973). Although they are very controversial, it is interesting to take a closer look at his results.

Bolten attempted a quantitative estimate of the increase in demand for 91-day Treasury Bills that would be required to offset the loss of discriminatory profits should the Treasury adopt a uniform-price auction procedure by estimating a demand function for Treasury Bills. By calculating the increase in revenue that would be produced by hypothetical increases in demand for Treasury Bills under a uniform-price auction, he found that an increase in this demand of as little as 1 % would already yield a higher revenue than the present procedure (under the assumtion that the volume of non-competitive bids would remain unchanged).

The central element in Bolten's estimates is the price elasticity of demand for Treasury Bills.The greater this elasticity, the less "consumer surplus" is available to be captured by a discriminatory auction procedure. This can be seen in figure 1: the flatter the demand curve for Treasury Bills, the greater the consensus amongst financial institutions on the interest rate that should be offered on the Treasury Bills to be auctioned and the more elastic the demand for Treasury Bills.

A problem with his analysis is that the demand for Treasury Bills, as specified in the auction, is not a certain demand but a derived demand. It is in fact a combination of the real demand for Treasury Bills (from both the bidders personally and on behalf of their clients) and of an incorporated probability they will win in the auction. In fact, they probably will bid more, to be certain to receive the minimum amount they require. Estimating the price elasticity of demand becomes rather complicated in this case. The links between the ultimate demand from the investors and the derived demand faced by the Treasury should probably be examined more closely to obtain meaningful results.

It is possible, however, that the increase in demand necessary to justify the change is indeed not that significant, since the total consumer surplus skimmed by the Belgian Treasury is rather limited.[19] But even if the necessary change is small, some authors argue that, due to existing entry barriers, it is not sure at all auction participation will even increase by changing from the discriminatory auction to the uniform-price auction. Auction participation might for instance also depend on the costs of "certification" and of establishing "creditworthiness" (Feldman & Mehra, 1993b). As these costs are

---

[19] Vanhorebeek & Moesen (1993) mention total consumer surplus up to December '92 amounts to 1.9 billion BEF, which is 0,02 % of the total amounts allotted.

unlikely to change if one changes auction formats, the cost of building a reputation remains a significant entry barrier to new competitors. Also institutional arrangements may act as an entry barrier. It is important to note, however, that this does not mean that the above described shift in figure 1 does not occur, since such a shift will also result from more *agressive bidding*.

A graphic analysis sheds another light on the strategic difference between both auction types. In a discriminatory auction, the whole demand function is of importance for the price the Treasury gets, because by definition, the *weighted average interest rate* is based on all the individual interest rates. In a uniform-price auction, only the intersection point matters. This intersection point is the *stop-out rate* that equals demand from the bidders with the amount of Bills the Treasury is willing to issue. The question is thus not how the whole demand curve will change by adopting the uniform-price auction format, but rather at what point under this format demand will equal the amount of Treasury Bills the Treasury is willing to sell.

Mathematically, it is easy to see that a switch to the uniform-price auction is rewarding whenever, for the same amount of Treasury Bills issued, the stop-out interest rate is below the weighted average interest rate from the discriminatory auction (or inversely: whenever at this weighted average interest rate more Treasury Bills can be sold). If there usually is a great consensus amongst bidders on the Treasury Bill rate resulting from the auction (reflected in a narrow spread and a rather flat demand curve), the weighted average rate is close to the maximum accepted rate, and only a small extra demand will be necessary to make a uniform-price auction rewarding. If however there is a lot of uncertainty, the Treasury will proportionally benefit more from price discrimination and a switch to the uniform-price auction format will not be rewarding. An obvious problem in this analysis is that uncertainty is a changing variable throughout time.

3.2.2 Other issues

Auction theory now generally recognizes that auctions in which information about the object being sold is symmetrically distributed among participants are qualitatively different from those in which information is asymmetrically distributed. The difference in social costs resulting from these information asymmetries is also an important issue in chosing between both auction formats. Because the investors that refrain from the market under a discriminatory auction pay a fee to the primary dealers, this boils down to a redistribution of wealth in exchange for information (i.e. the primary dealers act as agents for these investors, the principals). The price they have to pay thus is a result from the existing information asymmetries (see also footnote 13). The Treasury could lower these information asymmetries by giving additional information or she could tackle the impact of information asymmetries by

switching to a uniform-price auction technique. The socially undesirable costs associated with the redistribution of information could thus be saved. This is of course not primarily a revenue-consideration, but rather an issue of *economic efficiency*. Nevertheless, by tackling these information asymmetries the Treasury may attract some of the resources that otherwise would have been devoted to these socially less desirable activities. The society as a whole benefits from this situation.

There are two ways in which the Treasury can supply the market with accurate information: by releasing information prior to the auction or by creating a when-issued market. In some countries, a few days prior to the auction some general information concerning the upcoming auction is released. This information could be on the amount to be issued (e.g. in the U.S. and Switzerland) or an indication on the price the Treasury is willing to accept (e.g. in Hungary and Italy). The advantage is to remove uncertainty, alleviating the winner's curse and thus attracting new investors. To allow professional investors to make an accurate estimate of the Treasury Bill rate to be expected in the auction, in a lot of countries (e.g. U.S., Canada, France, Germany, Italy, New-Zealand, Switzerland, U.K.) a when-issued market was created. On this market the Treasury Bills to be issued can be sold or bought prior to the auction (when-issued). As it thus aggregates the diverse information and beliefs of the participants in the market for Treasury Bills, the obvious advantage here is again removing uncertainty, but now primarily for professional investors.

To this respect it is also interesting to note that, as pointed out by Bikhchandani & Huang (1993), not all collusion is necessarily bad for the seller. If bidders talk to each other before the auction merely to share their private information, but not to fix prices, then the winner's curse is diminished and auction revenues increase. As Treasury Bills with comparable maturity are traded in the morning prior to the auction, such contacts between bidders do exist, as we already made clear earlier in the paper.

In another article[20], Bikhchandani & Huang, also clarify the information issue. According to them, in a model with a resale market, it is not necessarily so that reporting information is always beneficial to the Treasury. If the auctioneer's information is a "substitute" for the bidder's information, then the price will drop. Only when the information is "complimentary" it is beneficial to announce this information.

---

[20] "Auctions with resale markets: an exploratory model of Treasury Bill markets", Review of Financial Studies, 1989 (311-339).

With respect to cornering a change in auction technique gives conflicting results. On the one hand, for bidders trying to corner the market, the costs of doing so are lower because each winning bidder gets the same price and consequently there may be a greater incentive to try to corner the market. On the other hand, succesful cornering will be much more difficult, due to the increased competition.

The impact of risk when switching from one auction format to another should also be given a closer look.In a discriminatory auction, bidders face two sorts of risk: a price-risk[21] and an allocational risk.[22] In a uniform-price auction, only the allocational risk remains.The reduction in risk following from a switch to the uniform-price auction system is one of the reasons why competition will be enhanced under the uniform-price auction. But as we analysed in section 3.1.1, reducing risk to the financial institutions could also have a perverse side-effect, because this increases the 'share of the dollar' the financial sector gets. So should the Treasury increase risk or not ?

An intuitive solution to this apparent contradiction can be given. As under a uniform-price auction, the price a bidder has to pay is determined primarily by what other investors have bid (and thus independent of his own bid), a rational bidder will not make the same risk considerations as under a discriminatory auction when deciding on his own bid. In fact, an investor need consult only his own tastes in a uniform-price auction, and he does not have to guess what the outcome of the auction will be. That is why we previously stated that under a uniform-price auction bidding will be more agressive.

There could also be an argument pro uniform-price auctions from an administrative point of view. It is indeed simplier administratively to charge one price to all winning bidders than to price discriminate amongst winning bidders.

---

[21] The fact that you will have to pay more than other bidders if you are bidding an interest rate too low.

[22] The fact that you will be unsuccesful in winning Treasury Bills when you are bidding an interest rate too high.

Finally a small note on the practical implementation of auction techniques. We stated in the introductory part of this paper only sealed-bid auctions could be used for selling Treasury Bills, because in open-outcry auctions participants have to be present physically. This might be impossible in large countries, but in a small country, as, for example, Belgium, where all auction participants can easily meet in one location, e.g. an ascending Dutch auction could also constitute a feasible and desirable option (Feldman & Mehra, 1993b). Strangely enough, this option has mostly been ignored in literature.[23]

[23] Only Reinhart (1992) and Feldman & Mehra (1993b) have suggested this technique as a potential alternative. See also footnote 2.

Concluding remarks

Although apparently the discriminatory auction technique is favoured by most countries, especially empirical literature seems to indicate that uniform-price auction systems are preferable. Possibly countries prefer the discriminatory auction system because they have the intuitive feeling of being better off by price discriminating.The impact on bidding strategies by using either auction format or another is often neglected by the legislators. But theory alone cannot yield unambiguous predictions for revenue across auction types. Under appriopriate assumptions, any one auction can be shown to yield greater revenue than the other. Future research on e.g. the topics handled in the third section of this paper is necessary to try to shed a light on this matter.

A definite answer can only be found by also taking country-specific elements (e.g. the degree of competition) into consideration. Most models in literature make specific assumptions when establishing revenue comparisons. No theory that tells us what would result from the interaction of all these factors has been presented yet. The ideal test for revenue equivalence, as pointed out by McAfee & McMillan, would thus require first testing the underlying conditions present in that market.

Some general thoughts can be given though. First, the Treasury should trade between risk and competition. Introducing more risk to the investors strengthens the bargaining position of the Treasury, but reduces competition with the inherent potential for collusion. Lowering risk weakens the bargaining position of the Treasury, but enhances competition and could thus be favourable to the Treasury. Second, to attract new investors or to obtain better borrowing conditions, an alleviation of the winner's curse appears to be necessary. This can be achieved by two means: (1) by switching to the uniform-price auction technique or (2) by releasing extra information while still conducting discriminary auctions.

The most drastic change is a switch to the uniform-price auction technique. This completely removes the winner's curse, which should lead to more competition and thus lower prices. The few empirical studies that have been carried out indicate the uniform-price auction is indeed revenue-superior to the discriminatory auction. These studies have been done, however, for immature auction markets (Mexico and Zambia),and it is not clear to what extent the obtained results would also apply to more developed auction markets in industrial countries. Some authors even argue that increased competition under a uniform-price auction is not sure at all. Furthermore, the uniform-price auction technique is more prone to collusion, a potential problem in Belgium with only a small amount of bidders.

If the Treasury is not willing to make this drastic change of switching to another auction technique, the winner's curse can still be reduced in a serious way by releasing extra information. If this is going to attract many new investors is also not sure a priori, but it will in any case reduce information asymmetries. The introduction of a when-issued market could also be considered to this respect.

Because of the difficulty of applying the extensive existing theoretical work on auctions to real-world settings like Treasury Bill auctions, and because of the importance of country-specific elements to this respect, a lot of work remains to be done for scholars studying Belgian Treasury Bill auctions. Despite its provocative title, this paper consequently does not claim to give the ultimate answer on the optimal technique to auction Treasury debt instruments and it does not claim the currently used procedure is not optimal. It merely includes some tentative ideas and constitutes a starting point for future research.

Selected bibliography:

(1) BIKHCHANDANI, Sushil & Chi-fu HUANG, "Auctions with resale markets: an exploratory model of the Treasury Bill markets", Review of Financial Studies, Vol. 2, N° 3, 1989, p. 311-339.

(2) BIKHCHANDANI, Sushil & Chi-fu HUANG, "The economics of Treasury Securities Markets", Journal of Economic Perspectives, Vol. 7, N° 3, Summer 1993, p. 117-134.

(3) BINMORE, K., Fun and games (A text on game theory), Lexington, Massachusetts, 1992, 656 pgs.

(4) BOLTEN, Steven, "Treasury Bill auction procedures: an empirical investigation", Journal of Finance, Vol. 28, N° 3, June 1973, p. 577-585.

(5) BRIMMER, A.F., "Price determination in the United States Treasury Bill market", Review of Economics and Statistics, Vol. 44, N° 2, May 1962, p. 178-183.

(6) CAMMACK, Elizabeth B., "Evidence on bidding strategies and the information in Treasury Bill auctions", Journal of Political Economy, Vol. 99, N° 1, 1991, p. 100-130.

(7) CAPEN, E.C., R.V. CLAPP & W.M. CAMPBELL, "Competitive bidding in high-risk situations", Journal of Petroleum Technology, Vol. 23, N° 6, June 1971, p. 641-653.

(8) CHARI V.V. & Robert J. WEBER, "How the U.S. Treasury should auction its debt", Quarterly Review (Federal Reserve Bank of Minneapolis), Fall 1992, p. 3-12.

(9) DEGRYSE, Hans, "Do Belgian banks have power vis-a-vis the Minister of Finance", Tijdschrift voor Economie en Management, Vol. 37, N° 2, 1992, p. 117-135.

(10) FEINSTEIN, Jonathan S., Michael K. BLOCK & Frederick C. NOLD, "Asymmetric information and collusive behavior in auction markets", American Economic Review, Vol. 75, N° 3, June 1985, p. 441-460.

(11) FELDMAN, Robert A. & Rajnish MEHRA, "Auctions: theory and possible applications to economics in transition", Working Paper (I.M.F.), February 1993, 26 pgs.

(12) FELDMAN, Robert A. & Rajnish MEHRA, "Auctions (theory and applications)", I.M.F. Staff Papers, Vol. 40, N° 3, September 1993, p. 485-511.

(13) FRIEDMAN, Milton, "Price determination in the United States Treasury Bill market: a comment", Review of Economics and Statistics, Vol. 45, N° 3, August 1963, p. 318-320.

(14) GOLDSTEIN, Henry, "The Friedman proposal for auctioning Treasury Bills", Journal of Political Economy, Vol. 70, N° 4, August 1962, p. 386-392.

(15) HANSEN, Robert G., "Empirical testing of auction theory", American Economic Review, Vol. 75, N° 2, May 1985, p. 156-159.

(16) HENDRICKS, Kenneth & Robert H. PORTER, "An empirical study of an auction with asymmetric information", American Economic Review, Vol. 78, N° 5, November 1988, p. 865-883.

(17) HENDRICKS, Kenneth, Robert H. PORTER & Bryan BOUDREAU, Journal of Industrial Economics, Vol. 35, N° 4, June 1987, p. 517-542.

(18) JOHNSON, Ronald N, "Oral auction versus sealed bids: an empirical investigation", Natural Resources Journal, Vol. 19, N° 2, April 1979, p. 315-335.
(19) MASKIN, Eric S. & John G. RILEY, "Auction theory with private values", American Economic Review, Vol. 75, N° 2, May 1985, p. 150-155.
(20) Mc.AFEE, R. Preston & John McMILLAN, "Auctions and bidding", Journal of Economic Literature, Vol. 25, June 1987, p. 699-738.
(21) MILGROM Paul R. & Robert J. WEBER, "A theory of auctions and competitive bidding", Econometrica, Vol. 50, N° 5, September 1982, p. 1089-1122.
(22) MYERSON, Roger B., "Optimal auction design", Mathematics of Operations Research, Vol. 6, N° 1, February 1981, p. 58-73.
(23) REINHART, Vincent, "An analysis of potential Treasury Auction techniques", Federal Reserve Bulletin, Vol. 78, N° 6, June 1992, p. 403-413.
(24) RIEBER, Michael, "Collusion in the market for Treasury Bills", Journal of Political Economy, Vol. 72, N° 5, October 1964, p. 509-512.
(25) RILEY, John G. & William F. SAMUELSON, "Optimal auctions", American Economic Review, Vol. 71, N° 3, June 1981, p. 381-392.
(26) SMITH, Vernon L., "Bidding theory and the Treasury Bill auction: does price discrimination incease bill prices?", Review of Economics and Statistics, Vol. 48, N° 2, May 1966, p. 141-146.
(27) TENORIO, Rafael, "Revenue equivalence and bidding behavior in a multiple-unit auction market: an empirical analysis", Review of Economics and Statistics, Vol. 75, N° 2, May 1993, p. 302-314.
(28) UMLAUF, Steven R., "An empirical study of the Mexican Treasury Bill auction", Journal of Financial Economics, Vol. 33, 1993, p. 313-340.
(29) USA, U.S. Department of Treasury, the Securities and Exchange Commission and the Board of Governors of the Federal Reserve System, Joint Report on the Government Securities Market, January 1992.
(30) VANHOREBEEK, Filip & Wim MOESEN, The modernization of Belgian government debt management: a review and assessment, Public Economics Research Paper, K.U. Leuven, N° 31, June 1993, 35 pgs.
(31) VAN REETH, Daam, The new public debt management in Belgium: impact on the financial and the government sector, Unpublished Doctoral Paper, UFSIA, May 1993, 61 pgs.
(32) VICKREY, William, "Counterspeculation, auctions, and competitive sealed tenders", Journal of Finance, Vol. 16, N° 1, March 1961, p. 8-37.
(33) WILSON, Robert, "Strategic analysis of auctions",published in: Handbook of game theory (volume 1), ed. by R.J. AUMANN & S. HART, North-Holland, 1992, p. 227-279.

LIJST VAN RECENTE SESO-RAPPORTEN

WITLOX F., *Discrete choice modelling in a context of spatial choice behaviour : a survey,* September 1994, 83 p. **(94/311)**

SCHROYEN F., *Optimal non-linear income taxation when income from elastic labour supply is costly to monitor,* October 1994, 39 p. **(94/312)**

DE GRAEVE D., DIERCKX G. en A. DIRCKX, *Ziekteverzuim en het toekennen van arbeidsongeschiktheid,* november 1994 **(94/313)**

VANDENBUSSCHE H., *How can Japanese and Central-European exporters to the EU avoid antidumping duties ?,* December 1994, 33 p. **(94/314)**

DE BORGER B., FERRIER G. en K. KERSTENS, *The choice of a technical efficiency measure on the free disposal hull reference technology : a comparison using US banking data,* January 1995, 34 p. **(95/315)**

KONINGS J. en H. VANDENBUSSCHE, *How does increased foreign competition affect UK employment and wages ? An empirical exploration,* February 1995, 19 p. **(95/316)**

HEYLEN F. en A. VAN POECK, *Central bank independence : only part of the inflation story,* February 1995, 20 p. **(95/317)**

VANHOUDT P., *Het belang van investeringen in mensen, materieel en know-how voor economische groei : empirische evidentie,* april 1995, 29 p. **(95/318)**

NONNEMAN W. en P. VANHOUDT, *A further augmentation of the Solow model and the empirics of economic growth for OECD countries,* April 1995, 12 p. **(95/319)**

MEERSMAN H. en D. CASSIMON, *Investment in the EC-countries : does reducing uncertainty matter ?,* April 1995, 35 p. **(95/320)**

VANDENBUSSCHE H., *Is European antidumping protection against Central Europe too high ?,* June 1995, 33 p. **(95/321)**

CORTENS I. en W. NONNEMAN, *Parental education and the demand for higher education : some evidence for Belgium,* June 1995, 22 p. **(95/322)**

SCHROYEN F., *Preference characterisation and indirect Allais coefficients,* June 1995, 40 blz. **(95/323)**

DOUVEN R. en J. PLASMANS, *S.L.I.M. - A small linear inter-dependent model of eight EU-member states, the USA and Japan,* June 1995, 35 blz. **(95/324)**

DOUVEN R. en J. PLASMANS, *Convergence and international policy coordination in the EU : a dynamic games approach,* June 1995, 39 blz. **(95/325)**