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Open versus Sealed-Bid Auctions: Testing for Revenue Equivalence under Singapore's Vehicle Quota System*

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Abstract

Using data from the auction of vehicle quota licenses in Singapore, we study if revenue equivalence holds when the auction format was switched from a sealed-bid format (May 1990 to June 2001) to an open bidding format since July 2001. Our econometric analysis indicates the change in auction format led to a change in bidding behavior. On average, the quota license premium under the open bidding format is about US$1,000 (about 7.5% of the Category E license price in June 2001) lower, compared to the forecast level that would have prevailed if there had been no change in the auction format.

JEL Classification number: D44, D45, L91, R48

Keywords: vehicle quotas, licenses, auction theory, revenue equivalence

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I. Introduction

This paper studies the bidding behavior in a multi-object uniform price auction, under both the sealed-bid and open formats. The context of our study is the Vehicle Quota System (VQS) in Singapore, which was implemented in May 1990. Under the VQS, a prospective car buyer must first obtain a vehicle quota license, referred to as a Certificate of Entitlement (or more commonly, COE). Each quota license allows a vehicle to be on the roads for ten years. Until June 2001, the vehicle licenses were allocated through a sealed-bid uniform price auction that was held monthly.[1] Following a government review of the VQS, an open online bidding format was implemented in phases from July 2001 onwards. From July 2001 to March 2002, two auctions were conducted each month, one using the sealed-bid format and the other using the open-bid format. This 'overlapping' phase is essentially a learning phase for bidders to get acquainted with the online system, and to fine-tune the bidding system. From April 2002, the fortnightly vehicle licenses auctions were conducted using the open bidding format (during the first and third weeks of each month). The switch from a sealed-bid format to an open bidding format for the quota license auctions offers us a unique opportunity to study the issue of the choice of auction format and its implications on the auction revenue generated.

A important result in auction theory is the revenue equivalence theorem, which states that if identical objects are auctioned in a simultaneous auction where the set of winners are those who submit the highest bids, and where valuations are independent and participants are risk-neutral, then it does not matter whether the auction is conducted in a sealed-bid format or as in an open format. The revenue equivalence theorem, as first proven in Vickrey (1961), and subsequently generalized in Myerson (1981) and Riley and Samuelson (1981), implies that all standard auctions, such as the first-price sealed-bid

[1] The first auction was held in May 1990, which covered the period May to July 1990. From August 1990 to June 2001, the auction was conducted monthly, and from July 2001 onwards, twice a month.

auction (where each winner pays his own bid), the second price sealed-bid auction (where the winners pay the highest rejected bid), the open outcry ascending (English) auction, or the open outcry descending (Dutch) auction are equivalent in terms of the expected revenue generated for each object auctioned.

However, if the assumptions of independent valuations or risk neutrality do not hold, then the different auctions rank differently in terms of their expected revenue generated per object put up for auction. Specifically, when the participants in an auction are risk-averse but valuations are independent, a first-price sealed-bid auction will generate higher revenue than an open uniform-price auction (as shown in Maskin and Riley, 1984). The intuition behind this result is that if individuals are risk-averse, they would bid more aggressively in a sealed-bid auction to increase the probability of winning, by giving up some of the net payoff conditional on winning an allocation.[2]

On the other hand, if bidders are risk-neutral and valuations are not independent, but affiliated[3] so that there is a common-value element in the bidders' valuations, the second-price open (i.e. ascending English outcry) auctions will generate higher expected revenue than the second-price sealed-bid auction, which in turn, dominates the first-price sealed-bid auction. The underlying principle at work here is the greater informational linkage among bidders in the open auction format that allows bidders to revise their valuations as the auction takes place (see Milgrom and Weber, 1982). A recent paper that

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[2] Since the second-price sealed-bid auction is strategically equivalent to the uniform-price open auction, bidding one's valuation is the dominant strategy in both cases. Hence, even if participants are risk averse, the revenue equivalence principle continues to hold for the second-price auctions when bidders' valuations are private values.

[3] Roughly speaking, if one bidder observes a favorable signal regarding some relevant aspect of the bidding environment, it makes the conditional probability of favorable values for the other relevant aspects more likely. The practical implication for bidding behavior under the VQS is that if a participant in the quota license auction is willing to submit a higher bid because he observes a signal that demand for cars is likely to be higher (due to, say, seasonal demand), then he should think that other bidders are also prepared to do so. In other words, if one bidder forecasts a higher price, then he should expect that other bidders should also forecast higher prices.

examines the revenue equivalence hypothesis in an experimental context is Chew and Nishimura (2003).

In the context of the quota license auctions in Singapore, the valuation of a vehicle license is not strictly private value, since the bids that car buyers are willing to submit, through the car dealers, are dependent on the expected vehicle demand in each auction, the available quota in future auctions, as well as the outlook on the economy, etc. Hence, if car buyers are risk averse and the valuations that they place on vehicle licenses are affiliated, the switch of the quota license auction from a sealed-bid format to an open online format should produce an empirical difference in the bidding behavior and the revenue generated per quota license. This provides the motivation for our study in this paper.

To study if revenue equivalence holds, we constructed an econometric model for the quota license auction under the sealed-bid format (for the period January 1996 to June 2001), and then use the estimated model to forecast the quota license premium under the open online auction format. The hypothesis we are testing is that if revenue equivalence holds, the estimated regression model should produce close estimates for the quota license premiums under the open online format (specifically, for the period of our study from May 2002 to March 2003). Based on our analysis, we found evidence to support the view that the revenue equivalence does not hold following the switch in the auction format of the VQS. Our analysis shows that the auction revenue generated under the open online auction format are lower than would have been the case if the sealed-bid format had continued to be in place.

Although a number of studies have been conducted to assess the equity and efficiency of the VQS – among them, Phang (1993), Koh and Lee (1994), Phang, Wong and Chia (1996), Chin and Smith (1997), Tan (2001) and Koh (2003) – this paper is the first to test if revenue equivalence holds for Singapore's quota auction.

The rest of the paper is structured as follows. Section II provides a brief review of the VQS in Singapore. Section III discusses the issues involved in modeling the vehicle

quota license auctions. Section IV presents the econometric model and discusses the results from the forecasting exercise and its implications for testing if revenue equivalence holds. Section V concludes the paper.

II. The Vehicle Quota System in Singapore

The VQS was introduced in May 1990 to control the growth of the motor vehicle population. A vehicle registered with a quota license has an initial lifespan of ten years. At the end of this period, the owner may either deregister the vehicle or renew the vehicle license for a further 5-year or 10-year period, by paying a "prevailing quota license premium", calculated as the three-month moving average of the quota license premium. Under the VQS, motor vehicles are classified into several categories, with a separate license quota for each category. When first introduced in 1990, there were seven quota license categories, namely: Category 1 for cars of 1000 cc and below; Category 2 for cars of 1001-1600 cc and below, and taxis; Category 3 for cars of 1601-2000 cc and below; Category 4 for cars of above 2000 cc; Category 5 for goods vehicles and buses; Category 6 for motorcycles; Category 7, an "Open" category for registration of all types of vehicles.

Every quota year beginning in May, the quota for new vehicles is determined based on the target growth rate in the car population and the forecast number of de-registrations. The Land Transport Authority of Singapore (LTA) releases on its website (http://www.lta.gov.sg) the exact calculations for the target vehicle population and the number of licenses available for auction each month.[4] The projected quota for each category is allocated equally over twelve months. To allow flexibility in the composition of the vehicle population, 25% of the deregistered vehicles in each category are allotted to

[4] Since the change in the total vehicle population is given by the number of new registrations less the number of de-registrations, the total number of quota licenses available for auction each year is equal to the sum of the target vehicle population, the projected number of de-registrations and unallocated quota carried forward from the previous year.

the “Open” category, where the licenses can be used to register vehicles belonging to any category.

Since 1990, the VQS has undergone a number of modifications. Some of the major changes include: (i) the quota licenses were initially transferable but made non-transferable following public anger over speculative activities; (ii) a “weekend” car quota license category was also introduced in May 1991, but discontinued in 1994 due to lack of popularity; (iii) the number of quota categories was reduced to five in 1999 with the merger of Categories 1 and 2 to form category A, and the merger of Categories 3 and 4 to form Category B. The other categories were renamed accordingly; (iv) the introduction of an open bidding format for quota licenses, in phases from July 2001 onwards. Figure 1 below shows the movements in the quota license premiums from May 1990 to March 2003.

INSERT FIGURE 1 HERE

Following a government review in 1999, the format of the license auction was changed to an open format. The switch was carried in several phases, beginning in July 2001 for the Open category license. The open auction is conducted online in real time, at the website of the LTA. Each online auction takes place over three days, at the beginning and middle of the month. Bidders can see the market-clearing bids in real time, and use the information to update their valuations, decide to enter or drop out of the auction, or revise their bids on-line.

The market-clearing bid is the lowest successful bid. As there many participants in the license auctions, the distribution of bids is approximately continuous; hence, the lowest successful bid is generally be close to the highest rejected bid, so that the license auction is a second-price auction. Although a license auction may be over-subscribed, not all the

quota licenses may be allocated. This is because there is no tie-breaking procedure for identical bids at the market-clearing level. These bids are treated as unsuccessful bids, and the next highest bid sets the license premium. The unallocated licenses are carried over to the next auction.

As of June 2003, a total of 905,281 licenses were auctioned in 156 auctions. In total, these auctions generated revenue totaling S$20.22 billion (US$11.55 billion) for the Singapore government (source: LTA). Each auction yielded an average revenue of S$129.05 million (US$74.06 million), and each quota license issued since May 1990 had cost an average of S$22,334 (US$12,762). Tables 1 and 2 show the average quota license premiums and its volatility, respectively. The calculations were based on an exchange rate of US$1 to S$1.75.

INSERT TABLES 1 AND 2 HERE

III. Modeling the Quota License Auction

We briefly discuss the main considerations in modeling the quota license auctions. First, we note that the VQS is an example of an affiliated-values repeated multiple-object auction. In other words, the valuations of bidders and the sealed bids that they submit have a common-value element. The participants in these auctions form expectations about the intensity of demand in each auction, based on their assessment of the economic environment and the anticipated vehicle demand in the current and future auctions. Bidders' beliefs and expectations, as well as their decision to participate in a particular auction, may be based on both private information and public information (such as the outlook on economic growth and interest rates, changes in government policies, and modifications to vehicle quota system, etc.).

Additionally, announcements of changes in future license quotas will lead to revisions in the expectations of future quota premiums, and this will affect bidders' decision to participate in a particular auction – either postponing participation or bringing forward the participation. Auction participants may also study the bid distributions of previous auctions (available from September 1994 to June 2001 for the sealed-bid format). Conditional on the public information and their private information, each car buyer computes his valuations for the quota licenses in each auction. As shown in Milgrom and Weber (1982) and Klemperer (1999), for second-price auctions with affiliated valuations, each player's optimal strategy is to bid as if as he is the marginal successful bidder.

The difference between the sealed-bid and open auction format is the stronger informational linkage under the open auction. Under the sealed-bid format, bidders submitted their bids independently and did not have the opportunity to observe other bids and revise their valuations. In contrast, under the open auction, car buyers can monitor the market clearing price in real time, and then decide if they should participate in the auction, revise their bids or drop out of the auction (e.g. by not raising their bids above the prevailing market-clearing bids). The greater transparency of the open auction provides stronger informational linkage.

Therefore, if risk aversion among car buyers is small, an application of the results of Milgrom and Weber (1982) should lead us to expect that the switch to the open online auction format for the vehicle license auction (which is akin to an English outcry second-price auction) will produce a higher expected revenue per license compared with the sealed-bid second-price quota license auction. However, if risk aversion among car buyers is significant, this will produce a countervailing effect as the switch to an open-online auction, by producing greater transparency will lead to less aggressive bidding. [5]

[5] These issues are discussed in more details in Koh and Lee (1994) and Koh (2003).

IV. Econometric Analysis

Our study focuses on the period from January 1996 to June 2001 (66 monthly auctions) for the sealed-bid format, and the period April 2002 to March 2003 (24 fortnightly auctions) for the open online format. Although data from 1990 to 1995 on the sealed-bid auctions were available, we exclude them from our study in order to minimize the impact of structural changes in the economy on the econometric analysis. The data on the license auctions are obtained from LTA's website, while the macro-economic data were obtained from the website of the Monetary Authority of Singapore (http://www.mas.gov.sg) and the Department of Statistics, Ministry of Trade and Industry, Singapore (http://www.singstat.gov.sg).

Under the open online auction, bidders whose valuations are lower than the market clearing bids will not enter the auction. Thus, the realized bid distributions under open auction format are necessarily truncated distributions, since the data from participants who had chosen not to enter the auction are not captured. It is therefore not appropriate to use the bid distributions of the open auction to compute a measure of the demand comparable to the bid-quota ratio under the sealed-bid format. We have elected to construct an econometric model of the demand for quota licenses based macro-economic factors.

The forecasting model is constructed as follows. The demand for vehicle licenses is a function of car demand, which is in turn influenced by the macro-economic environment. The appropriate macro-economic indicators to use are Singapore's industrial production and non-oil exports; these are reported on a monthly basis and impact the economic outlook, consumer confidence and purchasing behavior. Other variables used to construct the econometric model are the interest rate differentials of the 3-month commercial bank paper and the 5-year Singapore government bond, against the 3-month Singapore Treasury bill rates. The use of bond-bill spread and paper-bill spread as a predictor of economic activity has been documented by Stock and Watson (1989), Bernanke (1990), Friedman and Knutter (1992), Harvey (1991, 1997) and Tse (1998). We consider the first-order

differences in the monthly license premiums as function of the interest rate differentials and the first-order differences in the non-oil exports and the industrial production indices.

Our objective is to examine if the revenue equivalence result holds for the vehicle quota license auctions under the sealed-bid and the open online formats. Using the estimated econometric model for the sealed-bid auction, for the period of January 1996 to June 2001, we apply the model to forecast the quota license premiums in the open auction from April 2002 to March 2003.[6]

We shall use the following notation in the forecasting model. Let P_t denote the quota license premium (i.e. the market clearing winning bid); NOE_t denote the level of non-oil exports; IP_t denote the index of industrial production; PBS_t denote the interest rate differential of 3-month commercial bank paper over the 3-month Treasury bill; TS_t denote the interest rate differential of the 5-year government bond over the 3-month Treasury bill. We shall consider the following first-order differences in the regression equation. Let $\Delta P_t \equiv P_t - P_{t-1}$ denote the monthly variation in quota license premiums. We similarly define ΔNOE_t and ΔIP_t to be the monthly change in the non-oil exports and industrial production, respectively. We estimate the following econometric model:[7]

$$\Delta P_t = \beta_0 + \beta_1 \Delta NOE_t + \beta_2 \Delta IP_t + \beta_3 PBS_t + \beta_4 TS_t \qquad (1)$$

For the estimation of the above econometric model, we consider the quota license auctions in Categories 1, 2, 3, 4 and 7 from January 1996 to June 2001. We focus on the

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[6] In June 2003, the data for industrial production and non-oil export were available up to March 2003.

[7] Clearly, we can fine-tune the methodology used to construct the econometric model. For instance, we could include other economic variables, such as inflation rates and stock market indices that may have an impact on the bidding behavior of car buyers. Furthermore, we could introduce appropriate lags in the regression estimation. However, the qualitative aspects of our results are likely to remain the same.

household demand for passenger cars, and exclude Categories 5 (goods vehicles and buses) and 6 (motorcycles) from our study, as these categories are largely for commercial purposes.

As we noted earlier, in May 1999, Categories 1 and 2 were merged to form Category A, while Categories 3 and 4 were merged to form Category B. Category 7 was renamed as Category E. For the purpose of data continuity, we have decided to calculate, for the period of January 1996 to April 1999, an index of the quota license premiums for Categories 1 and 2, weighted by the number of quota licenses in each category, to proxy for a "Category A" quota license premium. A similar index is constructed for Categories 3 and 4 over the same period.

We also noted earlier that between July 2001 to March 2002, the open online format was gradually introduced, beginning with the "Open" category, and was conducted alternately with the sealed-bid format. Specifically, the sealed-bid format was conducted at the beginning of each month, while the open online format was conducted in the middle of the month. During this period, adjustments were made to various aspects of the online open-auction format, as bidders learnt to use the system. In light of the fine-tuning that took place during the initial months of the open-auction format, we have decided to exclude this "overlapping" phase of nine months for the purpose of testing if the revenue equivalence proposition holds after the change in the bidding format for the license auctions.

Finally, we wish to point out that the Singapore economy was largely stable over 2001 to 2002. Therefore, although there was a nine-month gap between the cessation of the fully sealed-bid auction format in June 2001 and the start of the fully online open-auction format in April 2002, the macro-economic environment in Singapore was largely unchanged, so that the econometric forecasting model remains valid for the purpose of our study.

Results

The results of the regression analysis are presented in Table 3. Using the estimated regression equations, we forecast the quota license premiums for the period April 2002 to March 2003 under the open online format. We then compare the forecast quota license premiums with the actual quota license premiums to compute the forecast errors, which are presented in Table 4.

INSERT TABLES 3 AND 4 HERE

We checked the robustness of the econometric model under the sealed-bid system as follows. We estimated the model for 58 observations, from September 1994 to November 2000, and used it to predict the quota license premiums for the sealed-bid auctions from December 2000 to May 2001 (six months). The forecast errors of the license premiums in these auctions were statistically not significant. Varying the estimation sample up to 60 observations with the corresponding forecast observations down to 4 data points produced similar results. Thus, we conclude that there was no structural break in the model under the sealed-bid auction format, as indicated by its success in providing unbiased post-sample forecasts. Failure of the model in providing unbiased forecasts under the open-auction format is therefore attributed to the structural break in bidding behavior, caused by the switch to a different auction format.

As is evident from Table 4, the forecast errors are negative for all three quota categories, and are statistically significant at the 5% level for Categories B and E. The results suggest that revenue equivalence does not hold following the switch from the sealed-bid format to the open online format. The switch in the auction format appeared to have produced a dampening impact on the auction revenue per license.

The results suggest that by providing greater transparency, the open online format also led to less aggressive bidding in the license auctions. A plausible explanation that is consistent with this result is that risk aversion among bidders is significant, so that bidding behavior had been particularly aggressive under the sealed-bid format of the license auctions.

Table 5 below presents the estimated net impact on auction revenue in each quota license auction, following the switch in the auction format. The cumulative impact from May 2002 to March 2003 is an estimated decrease of S$128,323,108 (or US$73,327,490) in auction revenue. This translates into average difference of S$2,040 (or US$1,166) for the 62,900 quota licenses auctioned in the three categories during this period. The price of a Category E license in June 2001 is S$27,048; thus, the average difference of S$2,040 represents an estimated 7.5% drop in license price over the period May 2002 to March 2003.

The estimated reduction in auction revenue does not affect in any significant manner the government's fiscal position. Since the reduction in uncertainty over cost of car ownership is an important issue for car buyers, it is likely that net social welfare has improved as a result of the switch to the open online auction format.

INSERT TABLE 5 HERE

V. Concluding Comments

Since the VQS was introduced in 1990, it has been suggested many times by the Singaporean public for a change in the format of the quota license auction from a sealed-bid format to an open format. The basic argument put forward was that the sealed-bid

format puts car buyers at a disadvantage as they were not able to learn about the market conditions and bid appropriately. As a result, car buyers typically delegated the bidding decision to the car distributors, who determined the bids to submit, on behalf of the car buyers. In fact, the common practice is for car dealers to offer a bundled package, with a "subsidy" for a quota license if the car buyer lets the dealer bid on his behalf.

The results in this paper indicate that revenue equivalence does not hold in the case of the quota license auction in Singapore. Furthermore, it also provides support for the view that an open auction is beneficial for car buyers, as each car buyer stands to save an average of about S$2000 (or about US$1100) – roughly 7.5% of the price of a Category E quota license in June 2001 – for a vehicle license that they must obtain. With greater transparency and less uncertainty, buyers are better off under the open auction system.

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TABLE 1:

Annual Average Quota License Premiums

(Singapore dollars)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Cat 6	Cat 7	Cat 8
1990	2,686	4,694	6,195	2,007	708	205	5,545	
1991	5,207	6,734	8,047	8,049	2,095	244	8,644	4,640
1992	14,864	18,717	20,457	20,138	6,536	1	23,413	13,355
1993	21,142	25,802	26,742	24,681	18,365	1	26,880	15,340
1994	26,945	42,622	68,757	74,749	28,289	291	72,606	28,383
1995	21,057	39,830	55,338	60,966	26,092	2,677	57,888	
1996	19,191	43,447	45,525	47,683	26,415	2,585	48,361	
1997	33,075	54,128	66,949	66,925	33,658	2,977	67,425	
1998	28,668	34,504	28,803	34,303	16,891	731	32,751	
Max	41,008	62,208	95,100	100,500	39,000	4,202	105,000	45,300
Date	Jun 97	Jun 97	Nov 94	Dec 94	Dec 94	Nov 95	Nov 94	Sep 94
	Cat A		**Cat B**		**Cat C**	**Cat D**	**Cat E**	
1999	40,242		43,068		24,645	770	42,683	
2000	37,845		36,189		19,936	1,332	36,961	
2001	26,987		28,379		16,878	814	27,891	
2002	30,896		31,982		19,317	225	23,395	
2003	29,236		29,142		11,354	263	29,093	

TABLE 2:

Volatility of Quota License Premiums

(Singapore dollars)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Cat 6	Cat 7	Cat 8
1990	1,754	3,022	3,857	2,216	759	117	3,046	
1991	3,600	3,767	5,022	6,005	2,643	235	5,436	2,791
1992	3,470	4,639	5,410	7,542	1,924	0	4,124	2,460
1993	6,635	7,081	9,005	9,487	7,987	0	8,946	2,951
1994	4,977	7,062	14,165	19,442	5,978	694	17,760	8,507
1995	4,680	4,878	9,246	7,244	4,227	778	11,489	
1996	3,643	2,800	6,166	2,444	3,266	535	3,707	
1997	5,349	6,587	6,543	6,740	1,796	438	6,347	
1998	4,069	5,996	12,711	9,006	5,594	341	6,332	
	Cat A		**Cat B**		**Cat C**	**Cat D**	**Cat E**	
1999	10,962		12,193		6,750	276	6,662	
2000	4,815		11,257		6,880	247	8,639	
2001	8,912		4,933		6,990	239	3,616	
2002	2,475		4,202		4,557	268	6,260	
2003	1,786		2,440		676	320	2,472	

Notes for Tables 1 and 2:

a. The figures reported here are for each calendar year. The figures for 2003 are up to end-June.

b. The annual average quota license premiums are calculated as weighted averages of the monthly quota license premiums. The weights are the number of quota licenses available for tender each month. In some cases, the weighted average quota license premiums differ substantially from simple monthly average quota license premiums.

c. The volatility of quota license premiums is calculated as the standard deviation of monthly quota license premiums.

Source: Land Transport Authority of Singapore (http://www.lta.gov.sg)

TABLE 3:

Estimation of the Econometric Model for January 1996 to June 2001

	Quota License Category		
	Category A	**Category B**	**Category E**
β_0	−324.977 (−0.188)	1204.863 (0.418)	2111.729 (1.290)
β_1	0.327 (0.269)	−2.310 (−1.140)	−0.181 (−0.157)
β_2	−8.517 (−0.110)	115.436 (0.896)	1.467 (0.020)
β_3	−907.9141 (−0.680)	−5182.020 (−2.326)	−3324.959 (−2.628)
β_4	215.088 (0.243)	1123.713 (0.762)	−100.768 (−0.120)
R-squared	0.010	0.107	0.109
Durbin Watson	1.104	2.63	1.342
No. of Observations	64	64	64

Notes:

1. The figures in parentheses are the t-statistics.

2. As Categories 1 and 2 were merged to form Category A in April 1999, an index of the quota license premiums for Categories 1 and 2, weighted by the number of quota licenses in each category, is constructed to proxy for a “Category A” license premium over the period January 1996 to April 1999,. A similar index is constructed for Categories 3 and 4 over the same period for a “Category B” license premium.

TABLE 4:

Forecast Errors in Quota License Premiums: May 2002 to March 2003

	Forecast Errors of Quota License Premiums (in Singapore dollars)		
	Category A	**Category B**	**Category E**
May 2002	-1,913 -2,311	-5,200 -9,792	-2,605 -5,249
Jun 2002	-1,814 -2,943	-10,419 -8,921	-6,894 -7,178
Jul 2002	-1,915 203	-1,509 -2,582	-3,389 -3,358
Aug 2002	-1,064 546	-1,945 -258	-2,040 -83
Sep 2002	464 -2,628	-2,554 -6,274	-2,011 -4,107
Oct 2002	877 2,393	162 2,786	-1,874 -68
Nov 2003	-2,309 -1,838	-4,005 -2,687	-4,454 -4,260
Dec 2003	230 -1,173	-7,804 -11,537	-1,448 -2,822
Jan 2003	-309 -791	3,989 3,317	-903 -1,120
Feb 2003	3,022 4,008	2,442 3,555	2,840 624
Mar 2003	-2,744 -3,049	-7,494 -6,534	-8,355 -6,053
Mean	-685	-3,330	-2,946
Standard Deviation	1,979.525	4,856.062	2,750.370
t-Statistics	-1.62308	-3.21641	-5.02404

Note:

The forecast error in quota license premium is calculated by comparing the predicted quota license premiums and the actual license premiums. If revenue equivalence holds, the forecast errors should be statistically insignificant.

TABLE 5:

Estimated Impact on Auction Revenue following the switch to an Open Auction Format: May 2002 to March 2003

	Estimated impact on auction revenue (in Singapore dollars)		
	Category A	**Category B**	**Category E**
May 2002	-2,155,625 -2,495,568	-2,693,379 -5,297,241	-2,422,322 -4,603,063
Jun 2002	-2,004,973 -3,334,935	-5,928,495 -4,942,316	-6,466,709 -6,747,457
Jul 2002	-2,122,155 226,616	-840,424 -1,427,757	-3,060,244 -3,035,609
Aug 2002	-1,186,609 600,355	-1,079,361 -139,983	-1,834,167 -73,742
Sep 2002	514,137 -2,938,079	-1,412,482 -3,570,030	-1,846,140 -3,835,981
Oct 2002	965,600 2,656,254	89,685 1,535,184	-1,707,646 -61,969
Nov 2003	-3,108,196 -2,441,142	-2,655,529 -1,604,332	-4,823,565 -4,660,322
Dec 2003	304,294 -1,568,064	-4,830,966 -8,399,277	-1,594,777 -3,053,923
Jan 2003	-412,621 -1,048,181	2,820,195 2,192,511	-988,167 -1,231,166
Feb 2003	4,046,460 5,350,682	1,602,221 2,343,016	3,095,622 676,438
Mar 2003	-5,461,108 -2,155,625	-4,968,576 -2,693,379	-8,614,457 -2,422,322
Cumulative Impact	-21,476,615	-43,389,148	-63,457,345

Note:

The estimated revenue impact is calculated by taking the forecast error and multiplying it by the number of vehicle licenses allocated each month.

FIGURE 1:
Quota License Premiums May 1990 to June 2003

(Singapore dollars)