Determinants of Certificate of Entitlement Premium for Cars under Vehicle Quota System in Singapore

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Abstract: Confronted with the general dilemmas besieged by limited land resource and traffic congestion, land transport authority of Singapore has successfully implemented the Vehicle Quota System (VQS) to control the vehicle population. The VQS requires each new vehicle buyer to bid for a license, called Certificate of Entitle (COE), for the registration of her/his new vehicles. This study will examine the quantifiable and unquantifiable determinants of the COE premium for cars in Singapore firstly, based on a revealed reference (RP) survey and some related literature reviews. Through the collected real data, the impacts of these determinants are further analyzed by formulating an autoregressive model with exogenous variables, which is verified to well fit the trend of the COE premium. Thus, the autoregressive model can be used by the authority or bidders to understand the feasibility of VQS and to estimate COE premium changing trend more reasonably.

Keywords: Certificate of entitle; COE Premium; Vehicle Quota System; Autoregressive model; RP survey.

1. INTRODUCTION

Singapore is a sovereign city-state and island country in Southeast Asia, with a total land area of only 716.1 square kilometers and a population of 5.40 million in June 2013 (Department of Statistics Singapore, 2014). With respects to economic development, Singapore has been one of the most rapidly growing economies in the world since obtaining independence in 1965, which is classified in the “high-income” group of economies by the World Bank. The rapid increase in the number of vehicles in the 1970s, in tandem with Singapore’s economic development and population growth, called for the implementation of some form of travel demand measure. However, due to the limited land space for roads and high population density, traffic congestion in Singapore have been increased and reinforced by the higher level of car ownership. Therefore, land transport authority (LTA) of Singapore has recognized traffic congestion since 1970s and introduced a variety of vehicle population control strategies to discourage private car ownership (Toh and Phang, 1997). The major traffic demand control policies are summarized below:

(i) Area License Scheme and Electronic Road Pricing Scheme
Singapore’s first traffic congestion management strategy was the Area Licensing Scheme (ALS), which was introduced in 1975 to address the burgeoning traffic congestion. It requires vehicles entering or leaving the central business district (CBD) to display an area license in peak period.
The license could be purchased daily or monthly (Land Transport Authority, 2011). In September 1988, the ALS was replaced by the fully automated electronic road pricing (ERP) system, which utilized the dedicated short range radio communication technology to deduct charges from each vehicle passing through an EPR gantry.

(ii) High Additional Registration Fee for vehicles
The additional registration fee (ARF) is a high tax imposed upon registration of a vehicle from 1975, which is calculated based on a percentage of the open market value (OMV) of the vehicle. For example, according the LTA policy, a car with an “open market value” of S$30,000, will have an ARF of 140% for S$42,000 (Land Transport Authority, 2014a). Another example in 1990, a Toyota Starlet XL, having an open market value of S$11,351 in May 1990, would eventually sell retail at S$42,630 (Smith, 1992).

Although the government has imposed ARF on buying a new car and ERP on using the CBD area, the vehicle population still increased very fast from 135,499 to 257,371 during the period of 1976-1989. Singapore authority began to realize that the curb on usage would not enough to control traffic congestion in the long run. Land scarcity makes it impossible to increase the road supply to adopt more traffic demand, except at high marginal cost. Therefore, the authority’s attention has switched towards the more direct regulation and begins to control the car population by using the vehicle quota system.

(iii) Vehicle Quota System and Certificate of Entitlement:
Moreover, Vehicle Quota System (VQS) has played an important role on the control of vehicle population in Singapore. The LTA of Singapore makes use of VQS to limit the purchase of new vehicle by Singapore residents since April 1990. The individuals must obtain a “certificate of entitlement” (COE) before purchase a new vehicle. The main procedure is that a set quota of COEs would be issued each month, individuals could enter bids for a COE; the price would be set at the lowest accepted bid following the quota number. “Since the introduction of the COE system in 1990, the vehicle population has grown at a Compound Annual Growth Rate (CAGR) of 2.7% from 1990 to 2007, which is within the prescribed rate of 3%. The vehicle population at the end of 2007 is therefore not larger than what it should be, based on the allowable growth rate of 3%; in fact, it is smaller.” (Land Transport Authority, 2014b) So the COE system is one of the most effective way in keeping the vehicle population’s growth within the prescribed limit, even though the growth rate on a year-to-year basis may fluctuate.

<table>
<thead>
<tr>
<th>Category</th>
<th>Previous Category*</th>
<th>Highest</th>
<th>Lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cat A</td>
<td>Cat 1 (1000 cc &amp; below)</td>
<td>92100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cat 2 (1001 - 1600 cc) &amp; taxi</td>
<td>Jan 2013</td>
</tr>
<tr>
<td></td>
<td>Cat B</td>
<td>Cat 3 (1601 - 2000 cc)</td>
<td>96210</td>
</tr>
<tr>
<td></td>
<td>Cat C</td>
<td>Cat 5 (Goods Vehicle &amp; Bus)</td>
<td>63035</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cat 6 (Motorcycle)</td>
<td>2704</td>
</tr>
<tr>
<td></td>
<td>Cat E</td>
<td>Cat 7 (Open)</td>
<td>97889</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jan 2013</td>
</tr>
</tbody>
</table>
The COE premium is determined by the market force through bidding rounds which are held twice a month in recent years. Then the bidding are collated and the results for different vehicle types will be announced two days after the closure of a particular bidding exercise. The vehicles are separated into five categories as shown in Table 1, and the COE premium changes trend is illustrated in Figure 1. It can be seen that the COE prices are dramatically changed. In this study, we will investigate the trend of car COE premium (category A and B) and identify the significance of their determinants based on the actual data analysis.

1.1 Relevant Studies

There are two ways to alleviate traffic congestion in general: increasing road supply or reducing traffic demand. For the limitation of land space and fund, just as the cliché says “you cannot pave your way out of traffic congestion”, the increased capacity cannot catch the traffic increase speed always. Many transportation managers and researchers turn to demand management as a tool to address the traffic congestion issue.

Since the influential work on congestion price by Pigou (1920), a large body of researches has been developed on extra economical control on vehicles (Liu et al., 2011; Lu et al., 2011; Meng and Liu, 2010; Tan, 2012; Zhang and Yang, 2004). However, as Yang and Wang (2011) said, “one of the major concerns with road pricing is that it is perceived as unfair or just another flat tax”, and the congestion pricing cannot control the increasing vehicle population effectively with the political resistance consideration. The equality debates may explain the reason why its application on urban roads is still limited to a small number of cities worldwide. Given these limitations to traffic congestion pricing, more and more researchers have turned to vehicle number control and some methods have been put into practice (Chin and Smith, 1997; D. Wu et al., 2012; Yang and Wang, 2011). The straightforward vehicle number control method, plate-number-based road space rationing, have been used in many Latin American cities like Sao Paulo and Mexico City, and been tried in a few large cities in China (e.g. Beijing ,Guangzhou) in recent
years (BARTER et al., 2003). But it is also known this method may lose its effective over long-time as it promotes the undesirable second-car ownership to circumvent the restriction. In addition, the more effective vehicle population control method- the vehicle quota system implemented in Singapore, are proposed and interested by a few researchers at its mechanics, equity and efficiency (Chin and Smith, 1997; Phang, 1993; Smith, 1992).

With implementation of VQS in Singapore in May 1990, the COE quota and premium has undergone changes, and several studies have tried to find its theoretical base and change rule. Olszewski and Turner (1993) have made an analysis of the influence of the people income growth and “Weekend Car Scheme” on COE premium. Phang et al.(1996) have examined the policy processes behind Singapore’ car quotas, including the “Discourage of Transfer” and “Weekend Car Scheme”. Chin and Smith (1997) examined the theoretical basis for VQS and presented an econometric investigation on the program in controlling the vehicle population. Hon and Yong (2004) studied the price of owning a car in Singapore, especially the effects of economic factor and seasonality on COE premium. Chu (2011) used a regression model to investigate influence of policy shift from sealed bids to open bids on COE premium. However, although the COE premium are affected and determinate by many factors and will changed with time, most of the previous studies have focus on one or two determinants. Thus, this paper intends to take a multiple determinants regression and analysis on the changing trend of COE premium.

1.2 Objective and Contributions

This study will analyze the change trend of the car COE premiums under Singapore VQS using data in Categories A and B. The primary focus of this analysis is to extract determinants of COE premium through revealed preference survey (RP) and literature review first. And then an autoregressive model with exogenous variables (ARX) will be chosen to analyze both the quantifiable and determinants on the car COE premium. For non-quantifiable determinants, dummy variables and before-after trend effect will be studied to recognize impacts of these determinants on COE Premiums. Next the determinants and their influences of different category vehicles will be compared based on the four regression models. Finally, the extrapolated values will be checked against the true value of COE Premiums of certain rounds to validate the model robustness.

The contribution of this study can be concluded in the following aspects. Firstly, determinants of COE premium are identified through both RP survey and literatures review, and the influence and significance of these determinants are identified by ARX models. Secondly, the ARX model is used to analyze the COE trend, which is not only flexible with time-related parameters but also is multi-faceted by allowing the considerations of all the salient determinants of COE Premiums. Thirdly, some government policies and uncountable variables are added in the regression analysis, in which the variables are divided into two categories: quantifiable and unquantifiable determinants. Fourthly, by restricting the analysis to these categories A and B, the authority and vehicle dealers could analyze the COE premium change trend, and the preference and interest of other bidders.

2. IDENTIFICATION OF DETERMINANTS
To analyze the trend of the COE premium, the first step is to find out its determinants. The influence variables of the COE premium are probably many under various situations, but some must play the main role. In general, the COE premium determinants are chosen through the three main sieving processes: (i) Through studies from various literatures, some academicians have stated a list of various factors that influence the car COE premium; (ii) After a RP survey, these factors will be checked again with the response from local car dealers; (iii) The data of these variables must be available to us. With these three steps, we can obtain those important determinants.

2.1 Determinants Identification from Reveal Preference Survey

Revealed Preference (RP) survey is the most straightforward way to acquire data and it utilizes actual choices made by commuters in real transport situations (Lam and Small, 2001). In the COE bidding processes, automobile dealers are the real players because car buyers will hand over the COE matter to the car dealers who bid on the behalf of them. There is meaningless by just guessing the determinant of COE premium by literatures without seeking the advice of Singaporeans who deal with COE daily. To understand the COE “game” from the automobile dealers, the blind review interview sessions with a group of 50 automobile dealers were conducted on 1st March 2013 and 15th April 2013. To get the unbiased and neutral answer, we, as the interviewer, took the step of an interested car buyer and asked them a list of questions related to the COE bidding.

According to the answers gathered during the RP survey, the frequencies of the COE premium determinants mentioned by these dealers are put into Figure 2. It can be seen that 100% of the responders agreed that the quota (supply), number of bidders (demand), the previous bidding results, and government policy will have direct effects on the quota premium. Demand strength factor and festival seasons are also mentioned by 75% and 65% of these respondents. For nation affluence, 70% of these responders mentioned about the economy but without stating the criterion of these judgments (GDP, GNP or STI). Some other determinants, such as company sale package, subsidy or discount are also mentioned by 20% of the responders.

Figure 2. Particular determinant percentages taken from all respondents
2.2 Determinants Identification from Academic Papers

In this section, we will provide seven determinants based on our literature reviews, which are classified into quantifiable determinants, including lagged COE premium, quota, bidding received, nation affluence, demand strength factor, and the unquantifiable determinants, including government policies, seasonal demand peaks in our analysis, as Figure 3 shown.

![Figure 3. Choice of determinants for vehicle COE premium](image)

2.2.1 Quantifiable determinants

Identifying and analyzing quantifiable determinants of a particular phenomenon will enable a statistical analysis of it. As one objective of this study is to develop a model for car COE Premium, the measurable factors need to be used as its predictors. In this section, we will examine these quantifiable determinants with reference to the existing academic findings.

As the supply and demand factors to the COE price, the relationship between COE quota and number of bids received plays an important role on the COE premium. As the supply factor, the COE quota is mainly determined by the yearly target growth rate of vehicle population. And Singapore LTA will estimate the allowable growth rate of vehicle population factored by road capacity and infrastructure. Many existing literatures have highlighted importance of the quota to the COE premium (Chu, 2011; Smith, 1992). On the other hands, the number of biddings received in each round can be used to measure demand of the vehicle in each category. Of course, this demand is mainly determined by the individual’s motivation and economic capacity, and also influenced by some other regulators of COE premiums, such as previous bidding results, human behavior. Phang et al. (1996) have used the number of bids received as one determinants to COE premium. In our analysis, we choose Quota/Number of bids received as one determinant, to show the influence of the relationship between supply and demand on COE premium. As examples in Figure 4-(a), the coefficient of Quota/Number of bids indicates to be negative for vehicle category 1-A, which have an indication that the COE premium will increase if the quota decrease or the number of bids received increase.

The previous COE premium is highly correlated with the current COE premium since the previous results provide a good reference for the car dealers on their new biddings. Supported by the RP survey interview with car dealers, they emphasize on the amount they bid in each round mainly refer on the previous round COE premium for the same category. In the other hand, the COE premium, as data fluctuates over time, is highly correlated with its lagged values, which suit for time series analysis (Chen and Tsay, 1993; Quintos, 1998). To confirm this, Figure 4-(b) illustrates the relation between the current COE premiums and the he previous one. The trend line
shows positive gradient, which means the higher the previous COE premium, the higher the following premium will be.

![Graphs showing COE premium over quantifiable determinants for category 1-A (June 1991-Feb 2013)](image)

**Figure 4. COE premium over quantifiable determinants for category 1-A (June 1991-Feb 2013)**

Many researchers and our RP survey all have emphasized that the factor of nation affluence have a direct influence on the demand and COE premium of cars. Tay (1994) showed that every 1% economic increase will lead to 1.93% increase in the car population. In general, Cross Domestic Product (GDP), Gross National Income (GNP), and STI (Straits Times Index) are the most general benchmarks for country economy. STI is a capitalization-weighted stock market index that is regarded as the benchmark index for the Singapore stock market (Y. Wu, 2000). Among them, the STI are measured almost daily and fluctuate in every COE round, but both the values of GDP and GNP are only available on a quarter-yearly base. Since regression is sensitive to the fluctuated data, the monthly average STI is better to be the proxy for national economic condition. From Figure 4-(c), it can be seen that STI have a direct positive effect on vehicle premium of category 1-A, as expected.

The last salient quantifiable determinant is demand strength factor, which equals to the number of bidding received over the number of successful bids. The rationale for this factor is that unsuccessful bidders will bid again in the following round. For some urgent need vehicles, they may bid with a higher and more competitive value. This will have effects on the COE premium, because the system allows the other bidder to look at the value of other bidders. Figure 4-(d) illustrates that the demand strength factor has an unobvious negative effects on the COE premium, which indicates the COE premium will decrease with the increase of number of
bidding received or the decrease of the number of successful bids. But this factor seems play the inverse effect on Category B vehicles. Anyway, the demand factor is chosen as one of the COE premium determinants at first.

2.2.2 Unquantifiable determinants

Some unquantifiable determinants mentioned by the RP survey respondents and existing literatures, are also taken into consideration, such as the government policies and the seasonal demand peaks. As these determinants can be measured by quantifiable ways, the unquantifiable determinants will be analyzed by using dummy variables.

Through our investigation, there are mainly three relevant policies that many have influence on COE premium: Weekend Car Scheme (WEC), Green Vehicle Rebate (GVR), and Sealed v/s open bids. The step dummies are used to represent the government policies, which take 0 before the policy and 1 after the policy. Firstly, in May 1991, the “Weekend Car Scheme” was introduced to enable more people to own car without contributing to road congestion. Existing vehicle owners could convert their car into “weekend car”, which will take the car owners 95% tax reduction (Singapore, 1992). However, since this policy begins at 1991, and the VQS only start a year ago, we will make the regression by using the VQS data after April 1991 in this paper, to exclude this WEC policies’ influence. Secondly, the GVR policy started in January 2001 and now is replaced by Carbon Emission Vehicle Scheme (CEVS). To encourage Singaporean purchase environmental friendly car, the government offered attractive rebates to light the economic burden of owning a car, especially for the middle class (Singapore Government, 2014). Thirdly, the COE auction format started out as sealed bids in May 1990 and are changed to open bids, that every bidder can see others’ bidding price since July 2001. As an example, Figure 5 shows the sealed/open COE quota and premium for Category 1-A. It can be seen that the COE premiums were distributed more or less equally through biweekly open auctions from 2002 to 2008, than monthly sealed bid auctions. Since 2009, the growth factor of vehicle population was changed to 1.5% due to some worsening traffic condition from 3% at 1990. As a result, the COE premiums have shot up obviously from 2009. The other vehicle categories have similar results.
Another unquantifiable factor is the seasonal demand peaks of cars. Seasonality may stem from festival seasons and periods when companies reward employees with bonus wage payments. During festivals, the urge of owning a car is higher than usual. One reason is that when celebrating festivals, people will feel owning a car is necessity to commute their family around for visiting relatives or religious obligations. The other reason is that employees may get their ability to bid for a car using their bonus wage payments. According to the research of Hon and Yong (2004), the COE premium is higher in the months of June, July, and December, which coincides with period when companies issue mid-year and year-end salary bonuses, in addition to Christmas, New Year and School holidays. Following Hon and Yong (2004), we choose June, July and December as the festival seasons. In this paper, we use the impulse dummies to handle the seasonality variable, by using 1 at the time of festival seasons, 0 at the time of non-festival seasons.

2.3 Data and Summary of Determinants

Data for COE premium comes from Singapore Land Transport Authority (2013) and Yahoo Finance (2014) and span the time period from 1991 to 2013. Table 2 displays the determinant definitions and their expected signs. Table 3 presents the summary statistics and provides data sources for the quantifiable determinants.

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Definition</th>
<th>Expected Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>COE_j</td>
<td>COE premium for particular category vehicles;</td>
<td>NIL</td>
</tr>
</tbody>
</table>

Table 2. Descriptions of determinants for COE premium
The lagged value of COE premium; +
(Quota/No. Bids), Quota (supply) over number of bids received (demand); -
STI, Monthly average straits time index; +
Demand SF, Number of bids received over number of successful bids; /

Unquantifiable (Dummy) Determinants

GVR, Policy step dummy variables, 0 before the GVR/CEVS policy, 1 denote after the policy; +
Open Bids, Policy step dummy variables, 0 before the Open bids policy, 1 denote after the policy; /
Season, Seasonal demand or festival demand, 1 denote the festival month, 0 denote the rest. +

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium</td>
<td>26751</td>
<td>16090</td>
<td>2</td>
<td>92100</td>
</tr>
<tr>
<td>Quota/No. bids</td>
<td>0.654</td>
<td>0.19</td>
<td>0.15</td>
<td>1.02</td>
</tr>
<tr>
<td>STI</td>
<td>2251.8</td>
<td>646.6</td>
<td>856.4</td>
<td>3805.7</td>
</tr>
<tr>
<td>Demand SF</td>
<td>1.79</td>
<td>0.9824</td>
<td>0.635</td>
<td>10.06</td>
</tr>
</tbody>
</table>

Notes: The data span the years 1991-2013, and come from Singapore Land Transport Authority and Yahoo Finance.

3. MODEL BUILDING FOR CAR COE PREMIUM ESTIMATION

The ARX models are used to extract the trend and determinants of COE premium series. In this approach, the model is constructed directly in terms of the underlying quantifiable and unquantifiable components, such as Quota, Number of bids received, STI, seasons, and so on. The ARX model is prior than the general time series model and the classical regression model in the following aspects:

(i) Time series model: With the nature of a time series, the initial analysis of data is critical in Box-Jenkins methods. It is necessary to include a trend in the empirical model to avoid spurious results.

(ii) Classical regression models: It is necessary to check that the parameters have no relations with time; Goodness of fit for the classical regression model is unsatisfactory.

In comparison of the time series models and classical regression model, the autoregressive model is limited to study COE premium and its previous values but no other determinants. To examine the relationships and significance of the determinants to the COE premium, the ARX model is suitable for our analysis, which not only has the flexibility to include time-related parameters, but also can take the exogenous variables into the regression model (Chen and Tsay, 1993; Quintos, 1998). The ARX model for COE premium is built as:

\[ COE_t = b_0 + \sum_{i=1}^{p} b_{ui} COE_{t-i} + \sum_{i=0}^{q} b_{ui} (Quota / No.Bids)_{t-i} + b_2 STI_t + b_4 Demand SF_t + b_5 GVR_t + b_6 Open Bids_t + b_7 Season_t \]  

(1)

where the variable’s definitions and explanations are explained by Table 2, and the parameters to
be estimated are $b_0, b_1, b_2 - b_s$. We begin with one lags for all variables, and then some variables’ lags show insignificant after regression. In the end, only lags of COE premium and Quota / No.Bids are included in our model.

In total, 4 models are built for the car premium of Category A and B based on the collected data. In April 1999, the government reshuffle the vehicle category to provide greater liquidity and reduce price distortions, by merging Category 1 and 2 into Category A, and merging Category 3 and 4 into Category B, as illustrated at Table 1. To make use of a large pool of 24 years’ data and enhance the model validity, we studied two regression models for each category. All the parameters involved in the four models are estimated using data from May 1991 to December 2013. The results of Category 1-A, 2-A, 3-B and 4-B are shown at Table 4. By the way, the essential statistics for evaluating these models are also presented in this table.

From Table 4, it can be seen that for all the coefficient of determination, adjusted $R^2$, of the four models are larger than 90%, which indicates that the adequacy of all the four ARX models are high. In addition, at the 90% significance level, all these determinants are significant in the four models expect Open Bids, and all the coefficient sign agree with our expectation in Table 2. The estimates of coefficients for $COE_{t-1}$, $STI_t$, $GVR_t$, $Season_t$ also illustrate a positive relationship with the COE premium, which are all statistically significant in the four models. Moreover, the estimates for Quota/No. Bids, turn to be negative as expected, which proves that the COE premium will go up, with the increase of the quota number or decrease of the bidding number. The sign of Demand $SF_t$ is also negative for Category A but positive for Category B. This may be explained by the different economic ability of different car owners. For example, with the engine capacity increase, the price of vehicles will increase. The phenomenon shows when the car owner’s economic ability is better, and they will prefer to pay higher premium in their next bidding round to obtain COE for their cars. Actually it is hard to find the exact reasons, but it does be significant for Category A and B models.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1-A</th>
<th>Model 2-A</th>
<th>Model 3-B</th>
<th>Model 4-B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef</td>
<td>P-value</td>
<td>Coef</td>
<td>P-value</td>
</tr>
<tr>
<td>$b_0$</td>
<td>7358</td>
<td>0</td>
<td>7120</td>
<td>0</td>
</tr>
<tr>
<td>$COE_{t-1}$</td>
<td>0.9538</td>
<td>0</td>
<td>0.9603</td>
<td>0</td>
</tr>
<tr>
<td>(Quota/No. Bids)$_i$</td>
<td>-12760</td>
<td>0</td>
<td>-16965</td>
<td>0</td>
</tr>
<tr>
<td>(Quota/No. Bids)$_{t-1}$</td>
<td>-</td>
<td>-</td>
<td>6162</td>
<td>0</td>
</tr>
<tr>
<td>$STI_t$</td>
<td>0.91</td>
<td>0.002</td>
<td>0.8518</td>
<td>0.005</td>
</tr>
<tr>
<td>Demand $SF_t$</td>
<td>-667.8</td>
<td>0.002</td>
<td>-811.7</td>
<td>0.011</td>
</tr>
<tr>
<td>$GVR_t$</td>
<td>811.5</td>
<td>0</td>
<td>943.7</td>
<td>0.041</td>
</tr>
<tr>
<td>Open Bids$_i$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$Season_t$</td>
<td>871.2</td>
<td>0.023</td>
<td>660.9</td>
<td>0.082</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>96.70%</td>
<td>96.9%</td>
<td>93.2%</td>
<td>95.9%</td>
</tr>
</tbody>
</table>

As we have mentioned that the coefficient estimates for Open Bids seems to show no relations with the COE premium, which is in contract with our analysis that the open bids may affect COE premiums. The main reason may be that it is hard to tell the effects of GVR/CEVS and Open Bins since the two policies are announced and put into practice in similar time. The
GVR policy started in January 2001, while the COE auction format is changed to open bids in July 2001, and put into practice by biweekly in November 2001. Therefore, we believe that the coefficients of GVR/CEVS also include the influence of the Open bids policy, as it is hard to identify their differences in less than a year.

Additionally, it can be found that both GVR and Open Bids policies show no significance for Category B. It may be explained by the higher economic ability of Category B, with its car prices and COE premiums are both higher, and the higher income group may not care so much about the money rebate policies. Furthermore, the seasonality is proved to have effects on COE premium, which is coincide with the results of Hon and Yong (2004). Though its p-value is higher than other determinants, but it still can prove the seasonality is significant for the four models at the 90% significance level.

4. MODEL ROBUSTNESS AND VALIDITY

After obtaining the four ARX models, the validity and robustness of these models have been studied, through forecasting the value of new COE premiums and comparing them with the actual values. We used the first two month of COE premium data in 2014 to check the four model’s validity, and the results turned out that the ARX models are robust and validated in predicting new observations. The following Table 5 lists an example of our model validity test for Category A and B respectively.

<table>
<thead>
<tr>
<th>Bidding Round</th>
<th>Actual COE</th>
<th>Fit COE</th>
<th>SEs Fit</th>
<th>95% CI</th>
<th>95% PI</th>
<th>Diffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1-A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 2014 (1st)</td>
<td>74002</td>
<td>74129</td>
<td>459</td>
<td>(73227, 75030)</td>
<td>(67466, 80792)</td>
<td>0.17%</td>
</tr>
<tr>
<td>Jan 2014 (2nd)</td>
<td>72369</td>
<td>73447</td>
<td>467</td>
<td>(72529, 74364)</td>
<td>(66781, 80112)</td>
<td>1.49%</td>
</tr>
<tr>
<td>Feb 2014 (1st)</td>
<td>72290</td>
<td>73406</td>
<td>457</td>
<td>(72507, 74305)</td>
<td>(66743, 80069)</td>
<td>1.54%</td>
</tr>
<tr>
<td>Feb 2014 (2st)</td>
<td>71564</td>
<td>72256</td>
<td>450</td>
<td>(71372, 73140)</td>
<td>(65595, 78917)</td>
<td>0.97%</td>
</tr>
<tr>
<td>Category 3-B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 2014 (1st)</td>
<td>78700</td>
<td>74480</td>
<td>666</td>
<td>(73171, 75789)</td>
<td>(61975, 86985)</td>
<td>-5.36%</td>
</tr>
<tr>
<td>Jan 2014 (2nd)</td>
<td>79000</td>
<td>76753</td>
<td>696</td>
<td>(75384, 78122)</td>
<td>(64242, 89265)</td>
<td>-2.84%</td>
</tr>
<tr>
<td>Feb 2014 (1st)</td>
<td>75300</td>
<td>77001</td>
<td>672</td>
<td>(75679, 78322)</td>
<td>(64494, 89507)</td>
<td>2.26%</td>
</tr>
<tr>
<td>Feb 2014 (2st)</td>
<td>78604</td>
<td>73569</td>
<td>638</td>
<td>(72316, 74823)</td>
<td>(61070, 86068)</td>
<td>-6.41%</td>
</tr>
</tbody>
</table>

According to Table 5, it can be found that all the predicted values are in the prediction intervals at 95% confident level for both Category 1-A and 3-B. Moreover, all the differences between the actual COE premium and the predicted COE premium are under 10%, which means they are reasonable predictions.

5. MODEL APPLICATIONS

Through our analysis, the COE premium trend model and its determinant are derived. Then what
are the benefits and possible applications for these models? Does it make sense to do this research? In this section, the benefits and possible applications of these models are concluded in the following aspects:

(i) Understanding the VQS Feasibility
Singapore has gone through a valiant journey for the past 24 years with the VQS implemented. Although many objections were there, many supports can still see its benefits. For the other countries that are facing traffic congestions, a feasibility study can be done through our model and analysis. The determinants of the COE premium should be examined first before they want to implement a similar system in their countries. One of the questions that will race to their mind is whether the people of their country will be able to fork out the money of such forecasted COE Premium. This may be especially important to countries whose economy depends on car production such as Malaysia and Japan. Should the COE Premium be something that is impossible for the people to buy? People may forgo the idea of owning a car and this consequently affects their car production market and country’s economy.

(ii) Understanding of Vehicle COE premium Change Trend
Recently, there are an influx of complaints and outcry in the local newspaper regarding the expensive COE Premiums. When it was first started, COE Premiums for Category 1 was only S$1004 but 24 years later, the premium increase by a multiple of about 80 times. Will the government allow it to continue to increase to a point where almost no one can afford to own a car? Or will the government not do anything to the COE Premiums and forgetting the need to fulfil their obligations in addressing the public needs? The premiums are uncertain for both government and bidder before bidding. Therefore, the COE premium ARX regression models can help them understand the COE premium change trend and its determinants. In addition, after known the influence of these determinants, the car bidders can choose their bidding price more reasonably or can avoid some peak premium. Even though the COE Premiums extrapolated from these models may not be entirely accurate, it can still be used as a benchmark to determine the reasonable timely market price of COE.

(iii) Estimating Proxies of Car Market
One of the benefits of studying the trends of COE is able to get a feel of the other factors of the automobile market, either locally or globally. In this study, several determinants have been studied and they are used to explain the highs and the lows of COE Premiums. With the models, these determinants’ proxies can be estimated too. Given the model, the other determinants’ proxies can also be made as a function of the COE Premium. Through the COE Premium, authority or any market players can actually reflect a lot of indicators such as the economic performance of the country. COE Premiums may be used as a gauge for macroeconomics health (Yong, 2004). In other cases, the COE Premium can also be used to study and estimate the car demand. Therefore, the models are not only flexible and robust, but also can contribute in many areas of studies.

6. CONCLUSIONS
In this study, several salient determinants of COE Premium of cars have been identified. Studies
of their relationships with COE Premiums have not only been rationalized and discussed, statistical analysis has also been provided. Through the ARX model analysis, we not only study and capture the timely and periodic effects of these determinants, but also the variation of other variables. To check for its robustness, extrapolated values are checked against the true value of COE Premiums of certain rounds. Other than robustness, its relevance to today’s context is important too and some latest round results are used for this purpose.

After studying the determinants, we realized that there is a room for improvement in the COE system. For example, categorization of the vehicles may be changed in terms of its categorizing criteria. Instead of engine capacity, price of car in terms of OMV or engine horsepower may be used. With this, issue such as social equity in car-owning can be readdressed. Future studies can model a new categorization method upon understanding the current COE Premium determinants. If COE categorization is done based on the OMV, determinants such as nation affluence may even change the trend totally. Thus, improvisation of the current COE system should be the next step after examining the determinants and understanding problems it encompasses.

REFERENCES


