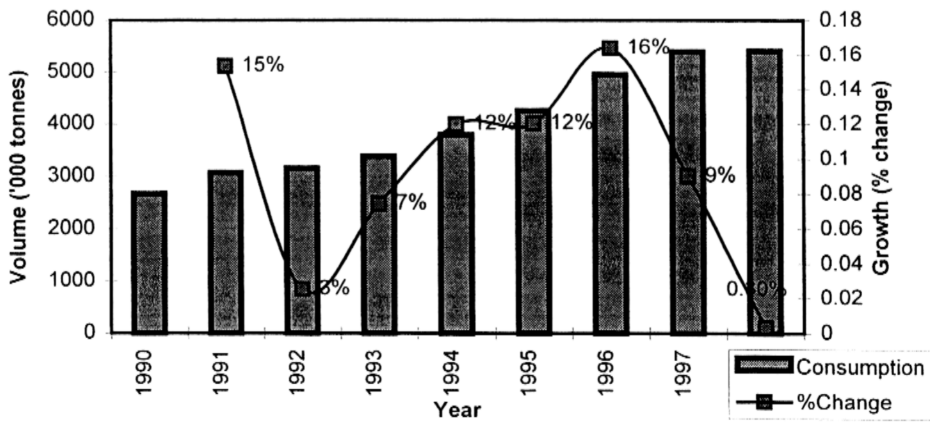
CHAPTER 4
DEMAND FOR GASOLINE

4.1 Introduction

Gasoline is demanded for all gasoline driven vehicles including 2-stroke and 4-stroke motorcycles, motorcars, small portion of commercial vehicles and etc. In Malaysia, most of passenger vehicles are petrol driven (Yearbook of Transport Statistics, 1996). Increase in general income levels have contributed to the growth in passenger car market. These factors are believed to have direct impact on gasoline consumption in this country. The significance of these factors shall be examined in this chapter with the use of demand model developed in Chapter 2.

Figure 9 shows the trend of gasoline demand in Malaysia from 1990 to 1998. Annual consumption of gasoline has been increasing at an annual average rate of 9.37% for the period of 1990-1998. In 1990, the annual consumption of gasoline was 2,667,000 tonnes which then gradually rose to a peak of 5,392,000 tonnes in 1997 and stabilised in 1998. In absolute term, the consumption of gasoline has been increasing from year to year. In terms of percentage change, the growth pattern in gasoline market was very encouraging since 1993 till 1996 when the economy was booming. It started to decrease and stagnated during the economy downturn in 1997/98.

Figure 9 : Gasoline Consumption and Growth Pattern in Malaysia



Source : Euromonitor 1997; MDTCA

4.2 Model of Gasoline Demand

In the theory of economics, demand is normally a function of price, income, price of related products, expectations and tastes (Chrystal and Lipsey 1997). Norling (1980) in the article *"The Demand for Gasoline"* concluded that demand function as follows :

$Q_{demanded}$ = f(retail gasoline price, income and stock of automobile)

This study emphasises on the impact of the above inputs to the gasoline consumption in Malaysia, with an expansion on factors like legislation and socio-environment effects. Hence, the function of gasoline demand in Malaysia can be summarised as :

$$Q_g^d = D(P_g, P_1, \ldots, Y, SPV_g, L_g, CP, E)$$

where Q_g^d is the quantity of gasoline demanded

P_g is the price of gasoline

$P_1, \ldots,$ refers to price of other products - substitutes and compliments

Y is the income level

SPV refers to the stock of passenger vehicles

L_g is the legislation related to environment and taxation

CP refers to consumer preference

E is the environmental and sociological effect

In line with other researches as discussed in Chapter 2, the static model used in this study for quantitative analysis is :

General gasoline demand model :

$$G_t = \alpha_0 + \beta_1 Y_t + \beta_2 P_t + \beta_3 SPV_t, \quad t = 1,2,\ldots T$$

Individual gasoline demand model :

$$LG \text{ or } ULG = \alpha_0 + \beta_1 Y + \beta_2 P_{own\ price} + \beta_3 SPV + \beta_4 P_{substitute}$$

where : G is the per capita gasoline consumption in tonnes per capita;

Y, the real income per capita in Malaysian Ringgit in 1990 prices;
P, the real gasoline price with 1990 as the base year;
SPV, stock of passenger vehicles per capita and
$\alpha_{0,}$ is the constant of the equation
$\beta_{1,2,3,}$ represents elasticity for each of the variable
$\beta_{4,}$ represents cross elasticity
lg, leaded gasoline
ulg, unleaded gasoline

Various equations are developed to study the effects of real and nominal data for income as well as prices, the inclusion of vehicle stock and lastly to develop individual demand model for leaded and unleaded gasoline. These equations are summarised in Table 9 in the following page.

4.3 Empirical Results

The results from quantitative analysis using linear regression method for equations 1(a) to 4(e) are detailed in Appendix II. It is important to note that the definition of demand elasticity used in this study differs from that defined in economic theory. Demand elasticity here is represented by the coefficient of the regression which is consistent with other studies on gasoline demand for example Ramanathan (1999), Baltagi and Griffin (1996), Greening and Puller (1999) and Chee (1981). Comparing the results for models with real data against nominal data, it is found that equation 1(b) with real income and real price yields better results (adjusted R^2 of 0.990 and F value of 277.298). This implies that 99.90% of the variation can be explained by the regression. The results show that all the demand elasticities are below 1 i.e. inelastic but with expected signs for the coefficients. All variables are statistically significant with less than 0.05 significance level (with 95% confidence level) and relatively high t-statistics. The income elasticity is 0.537 whilst own price elasticity is -0.363. Vehicle stock elasticity is 0.827, close to unity. As explained in Chapter 2, the elasticities estimated in equation 1(b)

Table 9 : Equations for Gasoline Demand Model

Case	No	Equation	Remarks
Case I : The effects of nominal versus real data for income and prices (CPI base year = 1990).	1(a)	$G = \alpha_0 + \beta_1 Y_{nominal} + \beta_2 P_{average\ (nominal)} + \beta_3 SPV$	Nominal data. Average nominal price for unleaded and leaded gasoline is used.
	1(b)	$G = \alpha_0 + \beta_1 Y_{real} + \beta_2 P_{average\ (real)} + \beta_3 SPV$	Real data.
Case II : The effects of the inclusion of vehicle stock.	2(a)	$G = \alpha_0 + \beta_1 Y + \beta_2 P_{average} + \beta_3 SPV$	Average gasoline price - the use of nominal or real data depending on results from Case I
	2(b)	$G = \alpha_0 + \beta_1 Y + \beta_2 P_{average}$	As above
Case III : Demand for	3(a)	$ULG = \alpha_0 + \beta_1 Y + \beta_2 P_{ulg} + \beta_3 SPV$	ULG - Unleaded Gasoline. Either nominal or real data depending on the results from Case I
Unleaded gasoline. Case I	3(b)	$ULG = \alpha_0 + \beta_1 Y + \beta_2 P_{ulg}$	
and II are repeated.	3(c)	$ULG = \alpha_0 + \beta_1 Y + \beta_2 P_{ulg} + \beta_4 P_{lg}$	
	3(d)	$ULG = \alpha_0 + \beta_1 Y + \beta_2 P_{ulg} + \beta_3 SPV + \beta_4 P_{lg}$	
Case IV : Demand for	4(a)	$LG = \alpha_0 + \beta_1 Y_{real} + \beta_2 P_{lg\ (real)} + \beta_3 SPV$	As per note 3(a)
Leaded gasoline.	4(b)	$LG = \alpha_0 + \beta_1 Y + \beta_2 P_{lg}$	
	4(c)	$LG = \alpha_0 + \beta_1 Y + \beta_2 P_{lg} + \beta_4 P_{ulg}$	
	4(d)	$LG = \alpha_0 + \beta_1 Y + \beta_2 P_{lg} + \beta_3 SPV + \beta_4 P_{ulg}$	

are represented as short run elasticities due to the inclusion of vehicle stock. As compared to equation 2(b), the results of R^2 improves with the use of vehicle stock in the model. The latter model has an adjusted R^2 of 0.952. This shows that inclusion of vehicle stock improves the adjusted R^2 value hence strengthened its significance in the demand model. Income elasticity is lower in short run than long run whilst own price elasticity is higher with the inclusion of SPV. The long run income elasticity of gasoline has found to be quite low at 0.745, indicating that gasoline demand does not increase as significantly as Gross National Products (GNP) in Malaysia increases. The long run price elasticity is -0.245 indicating that gasoline consumption is relatively inelastic to change in own price in long term.

In examining the demand model for unleaded gasoline, it is found that both income, own price and price of substitute variables are significant within 95% confidence level. The regression rejects vehicle stock variable as its significance level is greater than 0.05 indicates lower confidence level. The income and own price elasticities are less than 1 in all cases i.e. inelastic. The regression are relatively reliable with adjusted R^2 of 0.987-0.991. The results improves with the inclusion of price for other substitute (leaded gasoline). The income elasticities range from 0.717 to 0.76 whilst own price elasticities range from -0.228 to -0.747. Substitution of unleaded gasoline by leaded gasoline is found not elastic as the price for leaded gasoline decreases. The regression suggests that cross price-elasticities for unleaded gasoline is low and inelastic, at 0.082 and 0.434. Every unit increase in price of leaded gasoline will only results in 0.08 to 0.43 unit decrease in quantity demanded for unleaded gasoline. It also suggests that in the long run, change in own price for unleaded gasoline is more elastic than the short run models, with the price elasticities of -0.747 and -0.693 for short and long run, respectively. From the results interpretation, the unleaded gasoline consumers are generally less price conscious as the own price elasticities are low. They use unleaded gasoline instead of leaded gasoline mainly because of reasons like technology requirement and consumer preference which could be related to their higher awareness on environment preservation instead of pricing alone.

For leaded gasoline, the regression also yields high R^2 range from 0.89-0.90 indicates that the models are relatively reliable. However, inclusion of more variables do not improve the adjusted R^2 value. Variables like income, own price and price of substitute (unleaded gasoline) are accepted within confidence level of 95%. Similar to the unleaded gasoline demand model above, stock of vehicle is rejected from the model as the results of significance test is greater than 0.05. The income elasticities for leaded gasoline demand model are less than 1, i.e. inelastic. The long and short run income elasticities are -0.849 and -0.667. Nevertheless, income elasticity for leaded gasoline demand model is higher and carries opposite sign (negative) as compared to the others. This is in line with the theory of Engel Curve that inferior goods have negative income elasticities. As income rises, increase in income can cause reduction in quantity demanded for leaded gasoline. This can possibly be attributed to the increasing environment awareness as the society is more developed and also the rising demand for modern vehicles that encourage the use of more superior gasoline like unleaded petrol.

Nonetheless, own price elasticities for leaded gasoline are high. The short run own price elasticity is inelastic at -0.76 whilst the long run price elasticity is highly elastic at -1.543. In another word, the finding leads to the conclusion that in the short run, any change in price of leaded gasoline would not alter the demand pattern for leaded gasoline. However, the effect has great impact on leaded gasoline consumption in long term. Leaded gasoline consumers are responsive in long run towards change in the price of leaded gasoline.

It is highly interesting to note that though the cross elasticity for unleaded to leaded gasoline is low (inelastic), the cross elasticity for leaded gasoline to unleaded gasoline registers a reverse situation. The cross elasticity for leaded gasoline to unleaded gasoline is high, at 1.839 and 1.452 for equation 4(c) and 4(d) respectively. It shows that cross substitution from leaded gasoline to unleaded gasoline is highly elastic in this country - as the price for unleaded gasoline decreases, quantity demanded for unleaded gasoline increases to substitute for leaded gasoline. This finding helps to explain the success of the use of tax instrument in 1994 to spearhead the conversion to unleaded gasoline in order to preserve the environment. The leaded gasoline users are more prone to tax incentive as the gap between leaded and unleaded gasoline are narrower. Such a piece of finding would help the policy maker to draw an effective leaded gasoline withdrawal plan for the country.

In summary, the results from linear regression analysis are :

Model	Long Run	Short Run
General Gasoline Model		
• Adjusted R^2	0.952	0.990
• Income Elasticity	0.745 (2.846)	0.537 (4.32)
• Own Price Elasticity	-0.245 (-0.935)	-0.363 (2.148)
• Vehicle Stock Elasticity	-	0.827 (4.998)
• D-W Statistics	0.894	2.069
Unleaded Gasoline Model		
• Adjusted R^2	0.991	0.982
• Income Elasticity	0.743 (4.878)	0.717 (3.906)
• Own Price Elasticity	-0.639 (-0.946)	-0.747(-0.908)
• Cross Elasticity (LG)	0.434 (0.627)	0.082 (0.343)
• D-W Statistics	2.008	2.121
Leaded Gasoline Model		
• Adjusted R^2	0.891	0.890
• Income Elasticity	-0.667 (-1.620)	-0.849 (-1.882)
• Own Price Elasticity	-1.543 (-0.824)	-0.76 (-0.374)
• Cross Elasticity (ULG)	1.839 (0.928)	1.452 (0.718)
• D-W Statistics	1.716	2.137

Figure in parentheses shows t-statistics

The findings above accept the null hypothesis of this study that gasoline demand in Malaysia in general is determined by price, income level and passenger vehicle stocks. The gasoline demand models in Malaysia can be presented as :

General gasoline demand model :

$$G_{short\ run} = -0.242 + 0.537Y - 0.363P + 0.827SPV$$

$$G_{long\ run} = -8.919e^{-02} + 0.745Y - 0.245P$$

Unleaded gasoline demand model :

$$ULG_{short\ run} = -0.227 + 0.717Y - 0.747P_{ulg} + 0.082P_{lg}$$

$$ULG_{long\ run} = -0.158 + 0.743Y - 0.639P_{ulg} + 0.434P_{lg}$$

Leaded gasoline demand model :

$$LG_{short\ run} = -1.8e^{-02} - 0.849Y - 0.76P_{lg} + 1.452P_{ulg}$$

$$LG_{long\ run} = 0.252 - 0.667Y - 1.543P_{lg} + 1.839P_{ulg}$$

4.4 A Comparative Analysis

The short run and long run elasticities compiled from various literature are presented in Table 10 for comparison. Two other studies of similar subject on gasoline demand in Malaysia are reported (McRae, 1994; Chee, 1981). Before making comparison of the results reported in these studies, it is important to note the following basic differences among the models. The data used by McRae (1994) pertains to 15years (1973-1987) includes the oil crisis in early 70s and prior to massive development in this country. Chee (1981) only considers data in between 1970 to 1979. McRae(1994) takes gasoline demand per vehicle as the dependent variable whereas Chee (1981) and the

Table 10 : A Comparison of Gasoline Elasticities

Study and Country	Period	Elasticity				Method	R^2	Remarks
		Income	Price	Other Variable	Cross			
1. Ramanathan, India	1972-1994	1.18[a] 2.68[b]	-0.21[a] -0.32[b]	-	-	Cointegration	0.707 0.902	
2. Ramanathan and Geeta (1998), India	1972-1994	1.43	-0.42	0.35	-	Ordinary Least Squares (OLS)	0.92	Other variable is vehicles per capita
3. Bentzen (1994), Denmark	1948-1991	-	-0.32[a] -0.41[b]	0.89[a] 1.04[b]	-	Cointegration	-	Other variable is vehicles per capita
4. Eltony and Al-Mutairi (1995), Kuwait	1970-1987	0.47[a] 0.92[b]	-0.37[a] -0.46[b]	-	-	Cointegration	-	
5. McRae (1994),	1973-1987				-			Other variable used in the study is passenger vehicles per thousand population
Bangladesh		0.016	-0.35	-0.35		OLS	0.138	
Hong Kong		0.22	0.055	-0.001		OLS	0.828	
India		1.38	-0.32	-0.36		OLS	0.938	
Indonesia		1.69	-0.20	-1.11		OLS	0.956	
South Korea		0.72	-0.50	-0.90		Auto	0.963	
Malaysia		0.57	-0.13	-0.20		Auto	0.689	
Pakistan		2.91	0.39	-2.14		OLS	0.880	
Philippines		0.15	-0.39	-0.28		OLS	0.909	
Sri Lanka		0.82	-0.34	-0.50		Auto	0.852	
Taiwan		0.81	0.024	-0.81		Auto	0.995	
Thailand		1.77	-0.30	-1.14		OLS	0.972	

Study and Country	Period	Elasticity				Method	R^2	Remarks
		Income	Price	Other Variable	Cross			
6. Chee (1981), Malaysia	1970-1979	0.006[a] 0.008[b]	-0.11[a] -0.14[b]	0.84		OLS	0.980	Other variable is vehicle stock per capita
7. Wasserfallen and Guntensperger (1988), Switzerland	1962-1985	-	0.55-0.66	0.26-0.06	0.006	OLS	0.58-0.67	Ranges show the results of 3 different models. Price for public transport is used as the other variable
8. Blum et al. (1988) West Germany	1968-1983 (monthly)	0.247	-0.283	See remarks 0.113	-	Box-Cox	0.971	Other variables are vehicles stock, infrastructure, weather, employees, tax, etc. have been included. A total of 6 models have been used. Only the first model is reported here
9. Baltagi and Griffin (1997) 18 OECD countries	1960-1990	0.55[a] - -0.46[b]	-0.07[a] -1.42[b]	-0.66[a] -0.38[b]	-	OLS	-	Other variable is vehicle per capita. A total of 10 estimators are used. Only results from OLS is reported .

Study and Country	Period	Elasticity				Method	R^2	Remarks
		Income	Price	Other Variable	Cross			
10. Present study (2000), Malaysia	1990-1998	0.537[a] 0.745[b]	-0.363[a] -0.245[b]	-	0.082[a,d] to 0.434[b,d] 1.452[a,e]- to 1.839[b,e]	Linear Regression	0.990 0.952	Cross elasticities are obtained from individual ULG and LG models

a - short run,
b - long run,
c - cross substitute from Regular Motor Gasoline (RON85) to Premium Gasoline (RON95) in 1978/79 using simple calculation
d - cross elasticity from ULG to LG for every percent change in price of LG
e - cross elasticity from LG to ULG for every percent change in price of ULG

Source : Baltagi and Griffin (1997), Ramanathan (1999), Chee (1981) present study consider per capita gasoline as the dependent variable. However, Chee (1981) has also included price of alternative fuels and the number of vehicle stock per capita as other variables. The estimators used by all the said studies are also different - the present study uses linear regression, McRae (1994) with autoregression and Chee (1981) applies OLS and 2SLS in the gasoline demand model analysis. Each statistic estimator has its advantages and disadvantages and there is no intention for comparison in this area. However, it is realised that among the three models, the present study yields the highest R^2 results of 0.990. This means that the model developed in this study is able to explain 99% of the variation as compared to only 69% and 98% explainability of the models developed by McRae(1994) and Chee(1981) respectively.

From the comparison, it is found that the present study has higher income and own price elasticities than those reported in the previous studies, in both long and short run. However, they are consistent in terms of the sign for both income and own price coefficients of which the former variable is positive and the latter one is negative. This indicates that as the income level increases, the demand for gasoline also increases in all three studies. Own price has a reverse relationship to gasoline consumption - the lower the price level, the more quantity of gasoline is demanded. The present study is also consistent to the other literature in the aspect of inelasticity of income and own price. All the results show that the gasoline consumption in Malaysia does not respond to the change in income level and own price proportionately. For every unit change in income level and own price, we can only expect less than unit increase or decrease in gasoline demand. Similarly, the stock of passenger vehicles elasticities from all three researches are inelastic, except that results from McRae (1994)'s study is of opposite sign (negative).

Finally, an international comparison of price and income elasticities can also be made. Table 10 earlier reports some recent estimations made for various countries. Note that the elasticities reported in the studies vary quite widely preventing any meaningful conclusion. However, some inferences are possible with the elasticities estimated from various countries of different stages of development. Note that for low income developing countries like India, Indonesia and Pakistan, the income elasticities are highly elastic. This may be attributed to the low level of gasoline consumption and economic growth in these countries. Comparing to the medium-income developing countries including Malaysia as well as developed countries like Hong Kong and West Germany, the income elasticities are below 1 i.e. inelastic. As the gasoline consumption levels are relatively high, changes in income levels do not contribute significantly to percentage change in gasoline demand. In terms of price elasticities, all the results compiled from various countries show inelasticity to gasoline consumption, except for the study conducted by Baltagi and Griffin (1997).

4.5 Other Determinants of Gasoline Demand in Malaysia

4.5.1 Price of Alternative Fuels

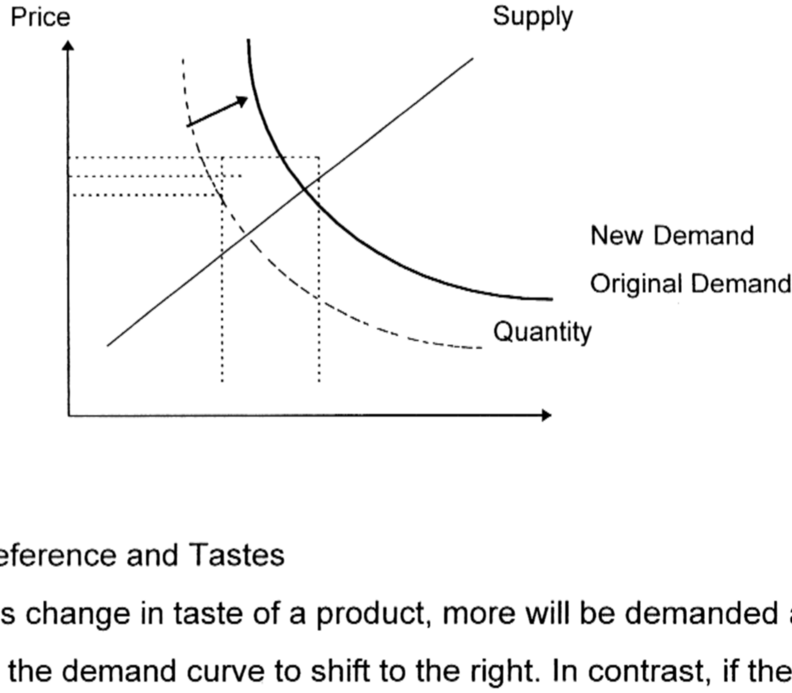
The prices of gasoline substitutes like automotive LPG, compressed natural gas (CNG) and etc. also influence the demand for gasoline in theory. In general, a rise in the price of gasoline substitute shifts the demand curve for gasoline to the right, i.e. more will be purchased at each price. In Malaysia, only automotive LPG and CNG are available as alternative fuels for gasoline. Petronas is the sole supplier for these alternative fuels in her move to promote cleaner environment. The availability and demand of these alternative fuels are complicated - it depends on factors like gasoline prices, engine compatibility and equivalent heat to gasoline. Pricing of CNG is typical around RM0.50 per equivalent British Thermal Unit (BTU) (whereas automotive LPG is controlled at RM0.64/litre or RM1.16/BTU equivalent). Hence in Malaysia, there is no economic incentive to increase the usage of gasoline substitution as the price differential are not significant enough especially for LPG. Although there is some savings for every equivalent heat of CNG against gasoline, lacking of consumer preference owing to bulky fuel tank and drive-ability problems of CNG is the main obstacle to the growth in consumption of CNG. However, if the gasoline prices were to rise significantly, in the long run demand of other substitutes will definitely increase hence shift the demand curve for gasoline downwards.

4.5.2 Environmental Legislation

In terms of environmental regulations, the Environmental Quality Act (Control of Lead Concentration in Motor Gasoline) 1985 and Environmental Quality (Control of Emission From Petrol Engines) Regulations 1996 did not make much of impact in influencing the supply and demand for gasoline in overall as these regulations have no legal enforcement. The former regulation succeeded in tightening the lead content in gasoline but failed to promote the use of unleaded gasoline as desired. The moves to total unleaded gasoline in the country is rather on volunteer instead of legislated. In the latter regulation, the absence of the mandatory use of catalytic converter for vehicles to meet the emissions standard, made no impact on the demand of gasoline. As known, only unleaded gasoline is permissible in cars fitted with catalytic converters. Therefore the use of such emission control equipment will shift the demand curve of unleaded gasoline upwards as what experienced in developed countries like Japan and USA. Unfortunately in Malaysia, there is no influence of environmental regulations in any way, on the demand pattern of gasoline. It is also tested that till today, although there is an environmental regulation concerns on exhaust emissions but there is no limits put to it and hence no enforcement by the authority to reduce pollutants from gasoline. As such, these regulations do not influence gasoline demand in the country.

In terms of taxation, gasoline tax is one of the determinants that influence gasoline consumption. As discussed in earlier sections, tax incentive that change the price of gasoline, are all statistically significant. In Great Britain for example, a US5cent reduction in gasoline tax had shifted the demand curve of unleaded gasoline to the right and leaded gasoline to the left. The market share of unleaded gasoline grew by 25% within 6 months of implementation. Similarly in Malaysia, the tax incentive of 3 Malaysian sen in 1994 had shifted the unleaded gasoline demand in the same direction as experienced in Britain. This can be illustrated in Figure 10 below. PB represents price that buyers pay, P1 is the price without tax and Ps is the price seller receive. Therefore, reduction in tax will reduce the price paid by the buyers. In another words, more quantity can be purchased at the same price level henceforth shift the demand curve to the right, as the results from regression suggest that cross elasticity for leaded gasoline to unleaded gasoline is highly elastic.

Figure 10: The Effect of Tax Reduction on Gasoline Demand



4.5.3 Consumer Preference and Tastes

When there is change in taste of a product, more will be demanded at each price, causing the demand curve to shift to the right. In contrast, if there is change in tastes away from a product, less will be demanded at each price causing the entire demand curve to shift left (Chrystal and Lipsey 1997). In the context of gasoline market in Malaysia, the effect of advertising and rising environmental awareness have influenced the choice of gasoline to a certain extent. As observed, unleaded gasoline reached its market share of 25% in the first two years of introduction. This can be attributed to the preference of consumers to use ULG instead of leaded gasoline as a result of environmental campaign in the country. More quantity is demanded for unleaded gasoline and less for leaded one even at the same price level of 113sen/litre. This has caused a shift in demand for unleaded gasoline to shift to the right and vice versa. Consumer preference also made a different in terms of choice of vehicle either gasoline-driven, diesel driven or on other alternative fuels. Therefore, more gasoline will be demanded and hence shifted up the demand for gasoline if petrol-driven cars are more preferred by the motorists in this country.

4.5.4 Sociological Effect

In urban living nowadays, as property prices in urban areas are increasing tremendously, more and more household have shifted to out-skirt of the city to enjoy lower cost on houses. This has expanded the boundary of the city. For instance, with the rise in property prices in Kuala Lumpur, more housing development can be found in sub-urban areas within Selangor and Negeri Sembilan states. It is reported that more than 50% of housing development in country concentrates in the state of Selangor since 1998 (The Star, April 2000). Coupled with the increasing number of inter-urban highways, more mileage have been accumulated by the motorist as a results of change in property price and upgrade of road infrastructure. This has caused an upward shift in the demand for petrol especially in cities like Kuala Lumpur, Johor Bharu and Penang. Consequently, more quantity is demanded for gasoline at the same price level.

From the above qualitative analysis, we can conclude that the soft factors that influence gasoline demand in Malaysia are consumer preference and sociological effect e.g. housing and infrastructure. Other factors for example price of gasoline substitutes and environmental legislation are yet to make an impact on gasoline consumption mainly due to lack of development and implementation. From all the tests above, the demand for gasoline in Malaysia is a function of :

$$Q_g^d = D(P_g, Y, SPV, CP, E)$$

where Q_g^d is the quantity of gasoline demanded

P_g is the price of gasoline

Y is the income level

SPV represents the stock of passenger vehicles

CP refers to consumer preference

E is the environmental and sociological effect