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Consumer Preferences for Fuel Choice

A Study of Swedish Flexi-fuel Drivers

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Our study investigates the behavior of flexi-fuel vehicle (FFV) drivers in the choice between ethanol and gasoline, in order to understand if preferences are driven by other factors than the cost of fuelling. Furthermore, we investigate if individual characteristics affect preferences. To address these questions, we conduct a survey with FFV drivers at gas stations in the Stockholm area, and use ready market-level data for comparative purposes. Applying the probit regression model to our data, we find that fuel preference is not only price-driven, though both gasoline and ethanol prices have substantial effect on ethanol choice – the former significantly more than the latter. The impact of relative prices is however inconclusive. Our field study reveals that some respondents choose ethanol for its perceived environmental advantages over gasoline, even if this choice incurs a financial loss. Besides price and environmental concern, autonomy preference and habit are identified as main reasons behind fuel choice, and we identify specific characteristics of each of these four decision-making groups.

Keywords: ethanol, flexi-fuel, alternative fuels, subsidies, probit

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1 Introduction

The market for alternatively fuelled cars has grown tremendously for the past few decades. From being virtually non-existent, cars running on fuels other than gasoline have today come to represent a noteworthy portion of total new car sales. This change, happening mainly in Europe and the Americas, is induced by several different factors. Increased consumer demand is one probable factor, since it generates an increased environmental focus among car producers, but government action is also likely to have been a powerful driver. Several countries and supranational institutions have set targets and passed bills promoting a more environmentally focused transport sector. The European Union has set the goal that biofuels, including bioethanol, biodiesel and biogas, would make up at least 5.75% of the energy consumed by the transport sector by December 31, 2010 (European Commission). Out of the existing alternative fuels, bioethanol is the largest to date when looking at the amount of production and consumption. Ethanol is used as a fuel in flexible-fuel vehicles (FFVs), which can run on either ethanol, gasoline or a mixture of the two. FFVs are popular in Sweden, new FFV registrations were at 21% of total in 2008 (Trafikanalys). The popularity of this type of vehicles is likely to come partially from favorable government policies – ethanol is tax exempt in Sweden when sold, in contrast to gasoline and diesel fuels.

A number of countries, including Sweden, are clearly investing a significant amount of resources in developing and promoting ethanol and other biofuels. It is therefore very useful to understand consumer preferences for ethanol contra gasoline and what it is that affects choice in this question. Government entities as well as many researchers appear to make the assumption that human beings act rationally and strive for cost-minimization. Ethanol is promoted in Sweden through tax exemption, which is assumed to make people switch fuel. The underlying assumption seems hence to be that consumers strive to minimize costs when choosing fuels. Though costs are likely to be important to a majority of people, it can not be assumed to be all that matters. Ethanol is considered to have environmental benefits contra gasoline, which may affect consumer attitudes and skew the effect of attempting to control volumes through controlling prices. Another aspect that may affect consumer preferences is the fact that driving on ethanol requires more fuelling stops since it has lower energy content per liter. It is therefore necessary to control for these and any other influential factors. Understanding the motivation behind this choice is not only interesting for the world of science, but can help countries achieve more efficient policies, realize environmental improvements and find other benefits for society. *In our study we will investigate the behavior of flexi-fuel vehicle drivers in the choice between ethanol and gasoline. Our first hypothesis is that this choice is not motivated by other objectives than cost-minimization. Our second hypothesis is that all FFV-motorists have homogeneous preferences, not affected by individual characteristics.*

2 Background

This section starts out with a paragraph on how we envisage our work to contribute to existing research within the field. Further, we will provide background information on the topic, describing factors which we believe are important to grasp in order to comprehend our results and analysis. The functionalities of flexible-fuel cars, composition of gasoline and ethanol fuels, fuel prices, accessibility and environmental impact will be examined in this section.

2.1 Contribution to Existing Research

Gaining a better understanding of the factors that affect individual behavior in the choice between ethanol and gasoline would improve decision-making on policies that regulate fuel choice and promote ethanol and other biofuels. Biofuel-powered cars have since their introduction quickly grown to represent a significant portion of new car sales, making research on the topic even more beneficial. The conclusions might also be used as a basis for research as well as for decision-making in other issues regarding subsidies and environmental incentives. Through conducting a field study, we achieve more detailed results than we would have obtained by only looking at fuel sales statistics. The data generated is unique, but has the disadvantage of taking longer to compile than ready statistics. Another benefit of making face-to-face interviews is being able to capture opinions and attitudes that are not always pronounced, and being able to ask follow-up questions where necessary to improve the quality of the data. To the best of our knowledge, this type of survey has not previously been conducted in Sweden. Therefore, we see this as a unique opportunity to contribute to the research in the area. As a complement we will also analyze fuel sales statistics compiled by Svenska Petroleum Institutet (SPI), a government institution whose database we have used to gain information and data for our analysis. Our ambition is to produce a paper that will facilitate future studies on subsidies, as well as human economic behavior within the area of behavioral economics.

2.2 General Description of FFVs

This thesis will focus on the choice between ethanol and gasoline as fuels, and hence on drivers of flexible-fuel vehicles. A flexible-fuel vehicle, colloquially referred to as a “flex-fuel” vehicle or multi-fuel vehicle, has an engine that is designed to be able to run on several different kinds of fuel. The most common mixture is gasoline and ethanol, which are combined in the same tank. The vehicles can run on gasoline alone, ethanol alone, or any combination of the two fuels. At gas stations, the “ethanol” sold to consumers contains 15-25% other substances, and we will in this thesis use the word as referring to the ethanol-based fuel that is available at gas stations. A more detailed description of the two types of fuels will be provided later in this section. Throughout this paper, a flexi-fuel vehicle, or FFV, is used for describing a vehicle designed to run on no other fuel types than ethanol and gasoline. Flexible-fuel vehicles are in general identical to "standard", gasoline-only, cars in design and appearance – the only things that differ are parts of the engine and the fuel system. They do not perform any different from standard cars even when running on ethanol only, though more fuel is consumed as ethanol is less energy efficient. Newly produced, FFVs cost slightly more than comparable gasoline-only vehicles, but second hand prices of the two types converge. Since the introduction in the first few years of the 2000s, FFVs have quickly come to represent a significant portion of new car registrations, although it has declined somewhat in the last two years. According to the Swedish Environmental Protection Agency (Naturvårdsverket), the percentage of FFVs of total new cars sold 2008 varies with geographical area, from 31% in Stockholm County to 16% in the County of Dalarna (2009, p. 34).

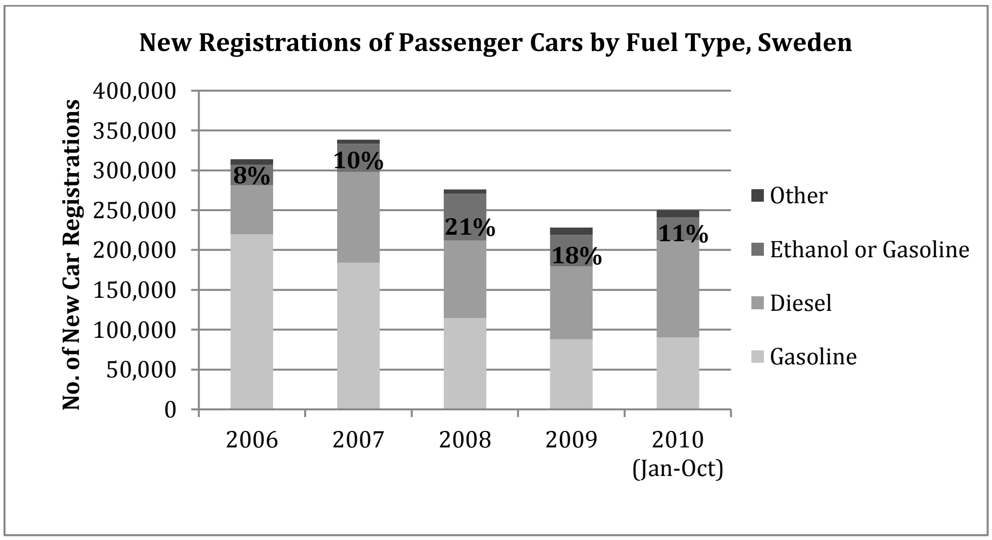

Figure 1. Split of new passenger car registrations in Sweden 2006-2010 (Jan-Oct). Source: Trafikanalys

2.3 Fuel Properties

2.3.1 Ethanol and Gasoline-based Fuel Composition

Ethanol that is sold in pumps at gas stations is already mixed with some gasoline and labeled E85. E85 is short for "Ethanol 85" as the mix contains 85% ethanol. More specifically, Swedish E85 constitutes of 85% absolutized ethanol, 12.5% gasoline, 2.1% Methyl tert-butyl ether ("MTBE") and 0.4% isobutanol. Gasoline is added to make the engine run smoother, MTBE for purposes of oxygenation and to raise the octane number, and isobutanol to reduce carburetor icing. In comparison, regular 95-octane gasoline constitutes of 95% gasoline and 5% ethanol. The winter blend of the ethanol fuel, E75, contains only c. 75% ethanol and consequently more gasoline, to facilitate engine starting and utilization at lower temperatures. (OKQ8) This difference between summer and winter blend will be described further in the next section.

The energy content of ethanol is lower than for gasoline. More precisely, the consumption of ethanol per kilometer driven is higher with about 34% for E75 and 42% for of E85, according to SPI's information on energy content. Households that care only about minimizing fuel costs should therefore choose ethanol when gasoline costs at least 42% more per liter in the summer (E85), and 34% more in the winter (E75). Looking at actual prices, ethanol does sell at a lower liter price than gasoline, but not always enough to compensate for the lower energy content.

2.3.2 The Switch between E75 and E85

The reason that the ethanol composition differs between seasons is the cold Swedish winters. The mixture is modified during the winter to provide more reliable cold starting, as a higher ethanol percentage can cause starting problems at lower temperatures, according to SEKAB (Svensk Etanolkemi AB). Even though the winter mixture only contains roughly 75% ethanol, the fuel is in general labeled E85 at gas stations all year round. In this paper, we refer to the fuel as "ethanol", alternatively use the terms E75 and E85 when there is need to emphasize the difference between the summer and winter quality.

Since the winter of 2006-2007 the winter grade of ethanol is introduced in late October and kept through the end of March (SEKAB). Customers visiting gas stations get the impression that standard E85 is changed to E75 on November 1. Similarly, it is announced on April 1 that the blend has been changed back to E85. However, after talking to the person responsible for the E85 switch at OKQ8, we understand that the process is somewhat more complex. In 2010, OKQ8 started the switch process already on March 15, as planned and announced on their website. Since each station receives a delivery at least once per week, they should have a mix in the tanks (of both summer- and winter-E85) by the following Monday. After the second delivery, so by c. April 1, the mix is sufficiently high in the summer blend that they can start charging the lower summer-E85 price. After six weeks, by around May 1, the transition is complete and all stations have 100% summer blend in their pumps. However, studying fuel price development for the different gas companies, the price drop in E85 in the spring of 2010 occurred on March 26 for Shell and on March 31 for Statoil, OKQ8, Preem and JET. This exogenous event which induces a change in ethanol price also alters the price relationship between ethanol and gasoline.

2.4 Fuel Prices and Accessibility

2.4.1 Price Drivers and Retailers

The retail price of gasoline is affected by the price of crude oil, the production cost of gasoline and the dollar exchange rate. Prices vary over time by supply and demand and are affected by local competition. Svenska Shell's retailers are free to set prices as they like and do not have to abide to a local or company-wide pricing strategy. Hence, there is a possibility that different prices are charged across gas companies but also across each company's different gas stations. The companies themselves are open with the fact that their prices vary across regions. (Shell) However, due to intense competition on a market where companies sell an identical product of commodity type, the prices are likely to converge and differences likely to be negligible. This is consistent with our observations during the survey rounds. The only difference worth mentioning is between manned and unmanned stations, unmanned being stations where there is no service personnel or vending of anything other than fuel. In general, these unmanned stations have somewhat lower prices. Furthermore, gasoline is heavily taxed in Sweden. The three components of the government charge are energy tax, carbon dioxide emission tax and VAT, and we will from here on refer to all these three together as "gasoline tax". In general, for each 1.00 SEK that a customer pays for gasoline, 0.60 SEK or 60% is gasoline tax. (Statoil I)

The retail price of E75/E85 is dependent on the price of ethanol and exchange rates, as well as the small gasoline component which is exposed to the same factors as discussed above (Statoil II). Most major producers import sugar-cane based ethanol from Brazil. One main difference from gasoline is that pure ethanol is not taxed in Sweden. In the winter, when the gasoline percentage of ethanol increases from the "standard" 15%, to 25%, the taxable part of ethanol increases and subsequently also the price of the fuel (see Figure 2 below).

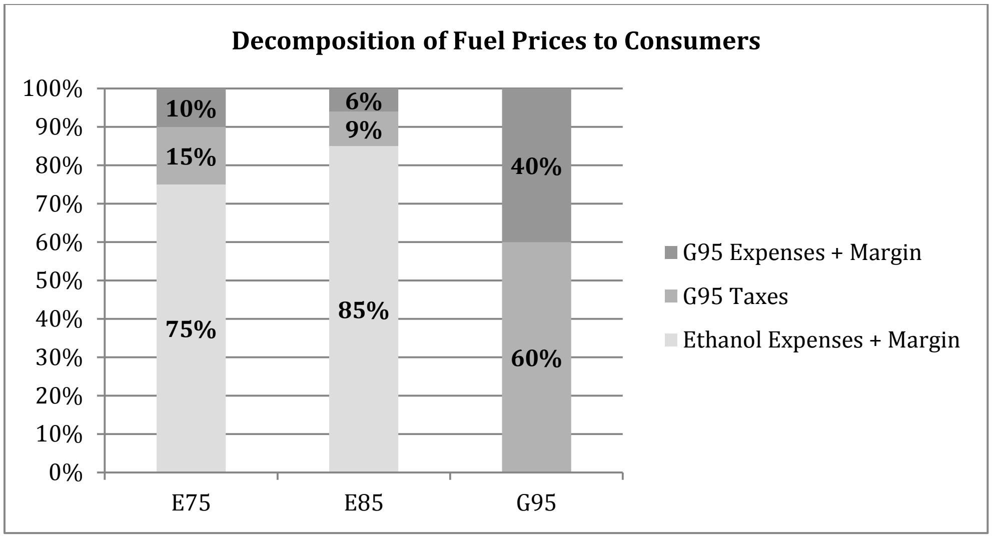

Figure 2. Decomposition of E85, E75 and G95 prices to consumers. Source: Statoil I

As of 2009, there are approximately 1,500 pump stations around Sweden, where cars can be fuelled with ethanol. 224 of these stations are located within Stockholm County. In 2009, the distribution of stations offering ethanol was as follows: 58 Statoil, 53 OKQ8, 39 Shell, 20 JET, 20 St-1, 19 Preem, 13 Tanka and 2 Q Star. (Government of Sweden)

2.4.2 Parity Relations

To find the break-even price relationship between gasoline and ethanol, it is essential to know the energy content of each of the two fuels. We have obtained this information from the website of SPI (see Appendix 1). Subsequently we calculated the break-even point for relative energy consumption, which should be equal to the break-even point for relative fuel prices. For E85, the summer mixture, the driver needs c. 42% more fuel measured by volume, compared to G95, to drive the same distance. For E75, the winter mixture, she needs c. 34% more fuel to travel the same distance.

Our own calculations based on SPI data are compared to the information on energy parity relations obtained from car makers in Figure 3 below. The numbers in the figure are based on consumption from mixed driving and ethanol is assumed to be summer mixed, E85.

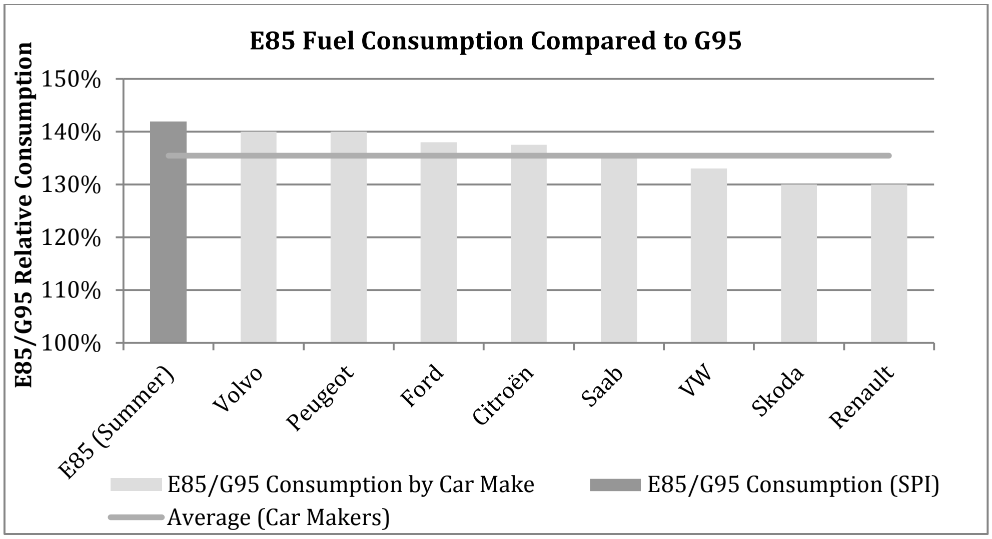

Figure 3. E85 fuel consumption compared to G95 by car make.[1]*Source: Interviews with customer service units*

The relationship between fuel consumption of gasoline and ethanol as a percentage is reported to be the same for all engine types of the same car maker, even though there is of course a difference in absolute amounts of fuel consumed, liters per metric mile.

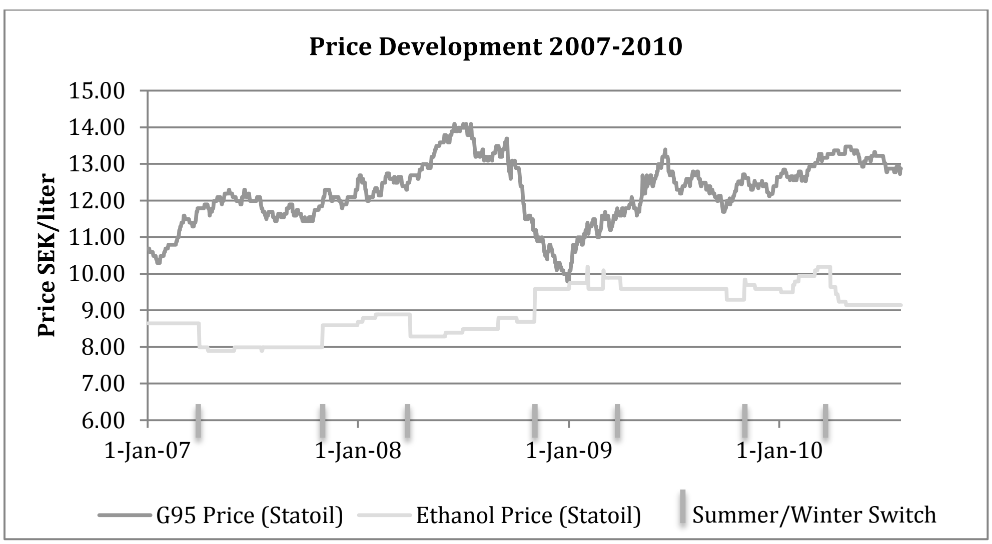

Figure 4. Ethanol and G95 price time series. Source: Statoil III

Figure 4 above shows the historical fluctuations in ethanol and G95 prices. Each E75/E85 switch is indicated by thick marks, occurring around April 1 and November 1 every year.

[1] Average of 37-38% for Citroën and 30-40% for Saab
[2] Exception: The fuel corporation St-1 which uses a patented technique for extracting ethanol from waste products

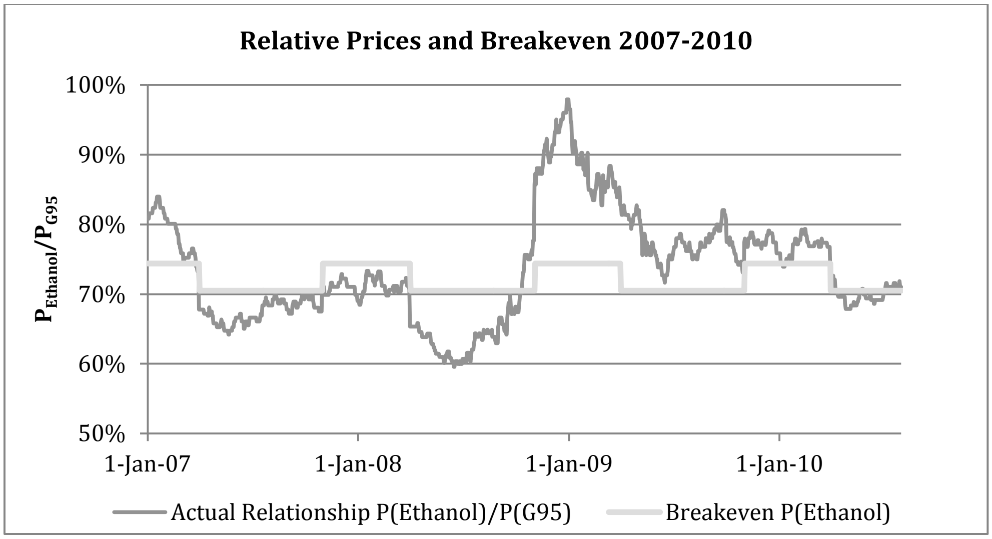

Figure 5. Ethanol and G95 price relationship time series. Source: Statoil III and SPI I

In recent time, the price discount on ethanol relative to gasoline has been higher during summers than winters, as seen in Figure 5. The interpretation of Figure 5 is as follows: when the actual relationship curve for ethanol is below the breakeven curve for ethanol, ethanol is the cheaper fuel. When the actual curve is above the ethanol breakeven curve, gasoline is cheaper.

2.5 Environmental Aspects

Ethanol is often portrayed as having more environmental benefits than gasoline. Unlike gasoline, bioethanol is a form of renewable energy that can be produced from agricultural feedstock, most commonly sugar cane (Brazil) or corn (USA). Its benefits have however been debated on several levels. One major point of criticism has been the fact that a possible source of food is transformed into fuel. This critique is versed mainly towards corn-based ethanol. The Swedish fuel corporations import Brazilian sugar cane ethanol[2], which is exempt from this problem. Brazilian sugar cane production on the other hand has been accused of cutting down parts of the rainforest to obtain land for cultivation. This argument is false, as sugar cane is mostly grown in the south whereas the Brazilian rainforest is found in the northern part of the country. Several studies, including one by the Swedish EPA, have proven that sugar cane production has had no effect on the Brazilian rainforest. (Dagens Industri)

We are not able to answer yes or no as to whether ethanol-based fuels are better or worse than gasoline from an environmental point of view, but consensus appears to be that as long as the fuel is sugar cane-based it has somewhat milder effects than gasoline. The Swedish Department of Motor Vehicles (Vägverket) estimates that an ethanol-fueled car has 56% less of a negative effect on the environment

[2] Exception: The fuel corporation St-1 which uses a patented technique for extracting ethanol from waste products

than a comparable gasoline car. (Dagens Industri) In this thesis, we control for the fact that not everyone may view ethanol-based fuels as better than standard gasoline by asking a question on the perceived relative environmental benefits of the two fuels.

3 Previous Research

The following section summarizes relevant literature on the topic of our thesis; namely utility-maximization/cost-minimization as basis for decision-making, incentives for pro-social and pro-environmental behavior and previous research on vehicles and fuel choice.

3.1 Cost-minimization as Basis for Decision-making

Utility can be defined as gains minus losses, and choice is based on preferences which are expressed by a utility function. Classic economic decision-making theory assumes that people make decisions based solely on the expected effect on their private wealth; utility is maximized by minimizing costs. People are hence assumed to be fully rational, acting as self-interested cost-minimizers, have well-defined preferences, perfect recall and planning ability etc. If given a choice between 1 unit of wealth and 0 units of wealth, a human being should always choose the former if the required effort to obtain the two is equal. These assumptions have come in handy when developing economic models. However, an increasing part of literature on the subject shows that people often behave differently and are in fact not completely rational in this sense. Many economists agree that complete rationality is a difficult assumption to make, in some settings particularly, and argue that also psychological theory should be incorporated to better understand economic behavior. (Leiser and Azar, 2008) In recent years, empirical research has proven that people will consider the interests of others and are also sensitive to social norms of cooperation and fairness when they make decisions. One of the most common and successful tests examining sensitivity to fairness and other-regarding preferences is the ultimatum game. In such a game, individuals will reject a proposed division of a monetary sum, at a cost to themselves, if they perceive it as unfair. Jensen, et al. (2007) carried out an ultimatum game with humans and chimpanzees, which are the closest living relative of humans. They found that chimpanzees are rational maximizers who are not taking fairness into account in their decision-making, contradicting the results in the human participation group. In the mentioned experiment, the rational choice is to accept any split where the sum offered is greater than 0, as even 1 unit leaves the respondent better off than if rejecting the proposal and receiving 0. Humans on the other hand, chose to reject such offers if they were perceived as “unfair”, i.e. they punished the proposer for wanting a too large share. This outcome is consistent with the theory that humans are not fully rational when facing economic decisions.

There have also been experiments where stakes are raised, to see if this changes the respondent's behavior. When performing the same ultimatum game experiment in Indonesia, while increasing the stakes to up to three times the monthly expenditure of a participant, results show that a higher stake makes respondents more willing to accept a given offer. (Cameron, 1999) A similar experiment was conducted in the Slovak Republic where stakes were varied by a factor of 25. The outcome showed, among other things, that the higher the stake, the less likely that the respondent rejects the offer, regardless of its "fairness". (Slonim and Roth, 1998) However, neither of the tests showed 100% "rational" outcomes at any stakes level.

In conclusion, the fundamental assumption of rational maximization as the basis for economic decision-making requires further examination. Larger stakes may make rationality more likely, but not even with hefty stakes have humans been shown to be perfectly rational.

3.2 Pro-social and Pro-environmental Behavior

3.2.1 Findings on Pro-social Behavior

Pro-social behavior is characterized by people who engage in activities that primarily benefit others and that are costly to themselves. For example, people commonly volunteer, help strangers, vote, donate blood, contribute to a public good or worthy cause etc. Apart from this, there is also a wider set of motives that shape people's social conduct and that interact with each other and the economic environment. Motivation to act in a certain way comes from two main sources; oneself and other people. These two sources are called intrinsic motivation and extrinsic motivation respectively. Individuals assign an intrinsic value to performing pro-social activities, which mean that their motivation is driven by an interest or enjoyment in the task itself, and exists within the individual rather than relying on any external pressure. A puzzle related to motivation in raising social conduct is that providing rewards and punishments to encourage pro-social behavior can have a negative effect, reducing the total contribution by the agent. For example, external monetary compensation can reduce the intrinsic value, also known as a "crowding out effect", and has been observed in a plethora of social interactions. Looking at effects of rewards, Gneezy and Rustichini (2000) found that schoolchildren collecting donations for charity returned with less money after performance incentives were introduced than before. These results are also in line with those of Titmuss (1970), who claimed that economic compensation to blood donors could actually reduce supply. These findings all imply that imposing incentives can lead to decreased motivation and unchanged or reduced task performance. However, this does not hold true for all areas of study. For example, there is much evidence to support the basic premise of economics that incentives work, particularly in workplace environments where performance-based financial incentives are used as extrinsic motivation, by functioning as a credible feedback mechanism. (Bénabou and Tirole, 2006)

Bénabou and Tirole (2006) try to explain pro-social behavior through a model that combines heterogeneity in individuals' degrees of altruism and greed with a concern for social reputation or self-respect. The model is trying to explain agents' pro-social or antisocial behavior by using an endogenous and unobservable mix of three types of motivation: intrinsic, extrinsic, and reputational, which must be inferred from agents' choices and the context. Their results confirm that the presence of extrinsic incentives is crowding out the reputational value of good deeds, rising doubt about the extent to which they were performed for the incentives rather than for themselves. This is in line with an explanation provided by Frey and Jegen (2001): "An intrinsically motivated person is deprived of the chance of displaying his or her own interest and involvement in an activity when someone else offers a reward, or orders him/her to do it." In conclusion, Bénabou and Tirole (2006) as well as Lepper et al. (1973) found that rewards create doubt about the true motive for which good deeds are performed, and that this "overjustification effect" can induce a partial or even net crowding out of pro-social behavior by extrinsic incentives. The pro-social activity is undertaken partially for signaling purposes to increase social esteem, and material incentives decrease the signaling value of the pro-social activity.

3.2.2 Findings on Pro-environmental Behavior

Understanding why people act pro-environmentally is key for policy makers and researchers who wish to fight environmental issues by changing the behaviour of the general public. Neoclassical economic theory and its assumptions of rational self-interest as a basis for decision-making has worked as guidance for economists, whose focus has been on the influence of external factors such as income, price and socio-economic characteristics, upon behavior (Clark et al., 2003). Still, these completely rational and self-interested utility maximizers do recycle, they do drive environmentally friendly vehicles, they do purchase ecologically produced groceries and so on. According to Clark et al. (2003), models that reward, penalize or regulate behavior as means of dealing with environmental issues are the most likely outcomes of the "economic approach" to pro-environmental behavior. They reported that, in contrary to economists, psychologists focus on the links between internal psychological variables and behavior. Moreover, they argued that variables such as values, beliefs and attitudes guide people in the direction of pro-environmental behavior. Consequently, psychologists find that awareness, education, guilt, and persuasion are successful methods for influencing pro-environmental behavior. Gutierrez Karp (1996) argued already 14 years ago that the impact of personal values on influencing pro-environmental behavior was gaining more attention, compared to other resolutions such as monetary incentives and penalizing sanctions. Turaga et al. (2010) report that the two disciplines now seem to be converging.

Several theoretical frameworks try to explain why environmental knowledge and environmental awareness does not necessarily lead to pro-environmental behavior. Much research has been conducted but still no definite explanation has been found. However, the most accepted frameworks, according to Kollmuss and Agyeman (2002), are early US linear progression models including altruism, empathy and pro-social behavior models, and sociological models. In their paper, they analyze the variables which have been proved to have some influence on pro-environmental behavior; demographic factors, external factors and internal factors. External factors are for example institutional, economic, social and cultural factors, while internal are motivation, environmental knowledge, awareness, values, attitudes, emotion, locus of control, responsibilities and priorities. Some of the factors are positive and some are negative – years of education is a factor that particularly appears to influence environmental attitude and pro-environmental behavior. Further, the authors report that the length of education and the extensiveness of knowledge about environmental issues are positively correlated. Still, longer education does not automatically mean a higher degree of pro-environmental behavior.

Many researchers have tried to explain behavior with economic models, thus disregarding preferences and concerns for social approval (e.g. Andreoni 1990, Frey 1997, Brekke et al. 2003a and 2003b). Green consumerism can be explained by economic models assuming that contributions to public goods also produce some kind of private benefit in the form of social approval to the contributor (Nyborg et al., 2006). Though, one should bear in mind that a flaw of such models are that they often make simplified assumptions about the psychological concerns that motivate people to engage in other-regarding deeds. Surveys indicate that people do not engage in pro-environmental behavior just to gain social approval. For example, Bruvoll et al. (2002) found that while 41% of those who engaged in recycling agreed fully with the statement “I recycle partly because I want others to think of me as a responsible person”, as much as 88% agreed that they recycled partly because “I should do what I want others to do”. The authors can conclude that although social approval may be important to most people, it seems unlikely that this should be the only factor influencing pro-environmental behavior.

3.3 Fuel Demand and Price Elasticity

There is little previous research on demand for biofuels. Although gasoline demand has been studied extensively, this research seems to focus on how demand interacts with fuel price only, without taking into account other variables that may affect the decision. Seeing that there is no perfect substitute for cars – taxis are expensive and may be difficult to locate, public transport only takes you between specific stations and walking/cycling takes far more time – the demand for automobile utilization and thus fuel quantity can be seen as inelastic in the short run. Previous research on the topic supports this fact, and studies that use disaggregate data have found gasoline demand as rather inelastic. The first major studies of gasoline using disaggregate household data were conducted by Archibald and Gillingham (1980, 1981). They found that the overall short-run price elasticity of gasoline was −0.43, and that around 75% of the adjustment was to miles traveled while 25% was to household gasoline efficiency. Following research on the topic have yielded numbers around -0.50. Dahl and Sterner (1991) investigated both short- and long-run elasticities to find the elasticity of gasoline demand to be -0.26 in the short run and -0.86 in the long-run.

For FFVs on the other hand, there are very few costs in switching between ethanol and gasoline as the fuels can be found in the same gas station and go into the same tank. The demand for ethanol can thus be considered price elastic, as the two fuels are very close substitutes. As mentioned earlier, second-hand prices of FFVs and standard gasoline cars converge, though a brand new FFV tends to be somewhat more pricy. This means that the second-hand market sells the two variations as close substitutes. Anderson (2010) examined the demand of ethanol as a gasoline substitute through a model linking the shape of the ethanol demand curve to the relative price levels where different households make the decision to switch fuels. The study found that the demand has a mean elasticity of 2.5-3.0 and is thus quite sensitive to relative prices. However, the author states that “[p]rice responses are substantially smaller and less variable, however, than they would be if fuel-switching behavior were focused around a single price. Rather, fuel-switching behavior extends over a wide range of relative prices where ethanol is discounted 0%-25% below gasoline, which implies that preferences for ethanol are diffuse.” Anderson reached the conclusion that preferences are heterogeneous and other factors than price affect fuel choice. Some households are pro-environmental and do not mind paying a premium for an eco-friendly fuel. If his results are correct, this has important implications for policymakers, among others. For this reason, it is important to develop this reasoning and look at what factors affect fuel choice for FFV drivers under different circumstances and in other regions than the United States.

Another study on the factors influencing consumer use of E85, conducted by Bromiley et al. (2008) in Minnesota, USA, shows that “[t]he price difference between E85 and regular gasoline has a substantial effect on E85 sales. Declining E85 prices and increasing gasoline prices both increase the volume of E85 sold at a station, although, the latter has a greater influence and the price difference has a greater effect at higher relative prices.”

4 Data

In this section we will describe our data set and method of data collection, which we later aim to analyze.

4.1 Data Description and Restrictions

This paper combines different types of data. Our main data set is collected by ourselves through a field study. It comprises one-on-one interviews with FFV drivers at various gas stations in the Stockholm area, before and after the switch from ethanol E75 (winter quality) to E85 (summer quality) in the spring of 2010. In addition, we use market-level data obtained from SPI which includes total delivered volume of ethanol to gas stations in Sweden over time, historical prices of ethanol and gasoline as well as energy content of the two fuels.

We will limit the scope of our study to comparing E75/E85 with 95-octane gasoline, as these are by far the two most commonly chosen fuels among FFV drivers. We have therefore disregarded interviewees who choose to fuel a mix of E75/E85 and G95, or use any other gasoline-based fuel (G96, G98, Shell V-power etc.). In the same fashion, we have only selected data on the two above mentioned fuels from SPI's database.

To understand the drivers' revealed preference we have only interviewed drivers who pay for their own fuel, whether by owning the car as physical persons or, if it is a company car, we only include cases where the driver herself pays for fuel. This means that we exclude taxi drivers, drivers of rental cars and company cars when fuel is paid for by the company, as these categories most likely have different incentives to choose a certain fuel and are in general not affected by price changes. The negative aspect of this choice is that it limits our data – many FFVs are purchased by corporate bodies, and a significant portion of these reimburses fuel expenses. As the negative aspect only concerns the quantity of survey results, while the positive is regarding the quality of our paper, we consider this choice appropriate. We also exclude certain respondents based on their answers on reason for fuelling. A detailed description will follow in the Survey Execution section below.

4.2 Survey Data

4.2.1 Survey Design

Our survey design started with the construction of a questionnaire (see Appendix 2). The questionnaire contains 23 questions and a typical interview takes less than five minutes. In order to construct a questionnaire that minimizes the risk of framing and biases while supporting quantitative analysis, we consulted finance papers on behavioral finance, attended classes in a PhD-course in Behavioral

Economics at SSE as well as talked to teaching Professor Magnus Johannesson at the Department of Economics at SSE.

We have chosen to conduct face-to-face interviews over letting the subjects fill out forms as this gives us the advantage of being able to ask follow-up questions on unclear answers, listen to any additional comments the subjects may have and interpret the way the answers are given. This provides us with a strong dataset and a deeper understanding of consumer attitudes. A downside is that this is a more time-consuming method given that it requires us to remain at each gas station for a full day in order to get a handful of answers.

Stockholm has a well-developed and high-quality metro and bus system and although Stockholm County is not a small region, Central Stockholm is relatively compact. The compactness also results in a shortage of parking spaces and thus higher parking prices. This may be some of the reasons for why inhabitants in general travel within the city by foot or using public transport. As a result, traffic flow in general goes from the suburbs to the center in the morning and the other way round in the afternoon/evening, and to some extent vice versa. We therefore selected gas stations on major routes leading to/from the city center. To identify suitable interview venues, we set up a list identifying all gas stations in Stockholm County which sell both gasoline and ethanol – in total there are 224 such stations. To capture differences in geographical locations we divided the sample of gas stations into northern, southern and centrally located stations. We were able to stay longer at each station by restricting the number of stations visited to one to two per day per person, minimizing transport time and maximizing interview time. During interview round I, we conducted 24 station visits and during round II, we conducted 26 visits. This includes repeated visits to some of the most well-trafficked stations in order to maximize sample size, yielding a total of 30 unique stations visited.

Figure 6. A Stockholm map with the gas stations visited

When arriving at each station, we consulted the staff or owner for consent before commencing the interviews with car owners at the pumps. As for the different gas station brands, we attempted to make the sample representative of their relative market shares, where Statoil, OKQ8 and Shell are the largest while Preem and JET are minor players. Splitting up ethanol stations per brand name, the distribution is as illustrated in Figure 7 below.

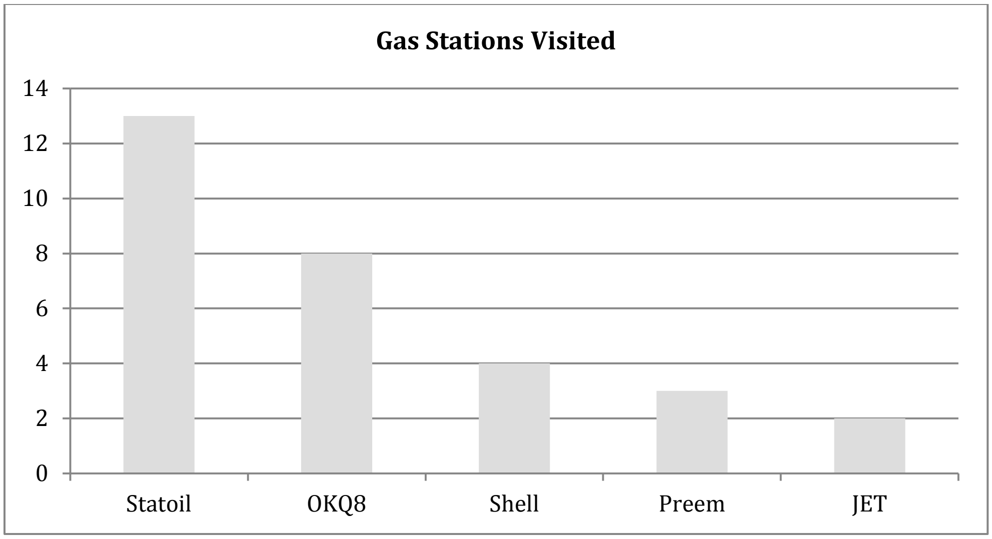

Figure 7. Distribution of gas stations visited

To randomize visits in terms of time of the day, area etc. we made a schedule over a two week period for each of the two interview rounds, March 1 – March 12 and April 9 – April 23. We interviewed drivers both before and after the switch, to investigate to which extent the drivers understand the parity change and are consistent in their choices.

4.2.2 Survey Execution

We conducted interviews in the morning (typically 7.00-10.00), during lunch time (typically 12.00-14.00) in the early afternoon (typically 14.00-17.00) and in the late afternoon (typically 17.00-20.00). During our interviews we were careful to not interview motorists when fuel choice could have been driven by queues to pumps.

We only approached drivers once they had made their decision at the pump and started fuelling, in order to avoid biasing their choice. First, we retrieved their fuel choice and quantity fuelled. Second, we asked them to explain their choice. The cases during the winter where drivers say that ethanol decreases engine performance or damages the engine would be distorting our data, as this means that the fuels are not interchangeable. We will therefore exclude these observations from the data set.

To investigate the drivers' stated preference, we combined the revealed preference information with data on stated preference: we asked the driver what her choice would have been had prices been different. Further, we inquired about their reason for the fuel choice under this hypothetical condition. More specifically, we asked what fuel the driver had chosen had the price of the chosen fuel been higher (above the parity relationship) and price of the other fuel held constant. To understand the relationship between the energy content of gasoline and E75/E85, which should be reflected in relative fuel prices, we have used a table of energy content from SPI's website, as described in the section on Parity Relations. This information was then summarized on a separate sheet of paper and price parities were calculated for gasoline and ethanol at each gas station upon arrival, to be used when setting and asking hypothetical fuel prices. If a consumer would state that her fuel choice was due to environmental concerns, we are able to assess the willingness to pay for green fuel. If a consumer would state that her fuel choice was due to price (or cash expense/km), her stated choice should be consistent with her revealed one; in particular, if the ratio p_{E75}/p_{G95} or p_{E85}/p_{G95} is kept unchanged, her choice should be the same or if her preferred fuel became cheaper, she should not optimize for the other one. Before moving on to the last section of the questionnaire, we asked the driver which fuel she finds most environmentally friendly, gasoline or ethanol, or if she viewed the two as equal in this matter.

Finally, we collected data on driver habits and characteristics. We started by asking for their weekly mileage, if in the previous two fuelling occasions they have also chosen the same fuel and gas station (plus motivation why) and how often the particular driver fuels the particular car. We also asked for their educational level and career choice, age, household size, home district and income bracket. Last, we retrieved their gender, number of passengers at the time of the interview, car brand, model and plate number.

4.3 Market-level Data

Aside from our conducted survey, we have also studied data obtained from SPI. On their website, SPI continuously updates statistics on average sales price (SEK/l) and volume (m^3) of gasoline and ethanol delivered to gas stations in Sweden. Gas companies we talked to before the switch in spring 2010 explained that each gas station refills its ethanol pumps at least once per week, which is why we make the assumption that *delivered* volumes of ethanol are close to actual volumes *sold*. We have downloaded data on ethanol volume delivered from January 2007 to July 2010. Further, we have used SPI's energy conversion table to find fuel parity relations, which can be found in Appendix 1.

5 Method

This section will briefly explain a standard probit regression model and discuss how to interpret the marginal effects and elasticities from such a regression. Thereafter, we will define our econometric models together with relevant assumptions made. Finally, we will describe how the revealed and stated demand curves for ethanol are constructed.

5.1 The Probit Regression Model

5.1.1 Model Definition and Interpretation

A probit regression model is used for regression when the dependent variable is in binary form. This means that the dependent variable is a 0/1 dichotomy where 1 represents a positive outcome (yes/success) and 0 a negative outcome (no/failure). The independent variable(s) can be either dichotomous like the dependent variable or take on any other values, continuous or discrete. Opting for a specific fuel is a binary choice, as is stating a specific reason for fuelling, which is why we believe that this method is suitable for our analysis. We have therefore chosen to apply the probit regression model on our data to analyze our two main questions; whether consumer preferences for fuel choice are price-driven, and which characteristics affect these preferences. We chose to perform probit regressions in the statistical software program STATA 9.2.

The probit function is the inverse cumulative distribution function (CDF) associated with the standard normal distribution. Y_i is the dependent variable which, as stated above, takes on only two values:

Y_i = 1

0

We want to model the probability of yes/success, i.e. the probability that the consumer makes a certain choice:

P_i = The probability that the i^{th} person makes a certain choice, $0 < P_i < 1$

P_i is affected by the independent variables which are denominated X_i. The probability of yes/success is expressed as a function of the control variables:

$$P_i = E(Y_i \mid X_i) = F(\beta_0 + \beta_i X_i) \qquad (1)$$

where

$$F(\beta_0 + \beta_i X_i) = \int_{-\infty}^{\beta_0 + \beta_i X_i} f(z)dz \qquad (2)$$

is the cumulative standard normal distribution function, and

$$f(z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}z^2} \quad (3)$$

is the probability density function of a standard normal distribution.

The outcome of a probit regression is more complicated to interpret than for a standard Ordinary Least Squares (OLS) regression. The main purpose of all regression analysis is to estimate the marginal effect of a regressor on the dependent variable, while controlling for the influence of other regressors. The interpretation of marginal effects or elasticities is how sensitive the dependent variable is to a one unit change in an independent variable. (Corneließen, 2005) In a standard linear regression, the beta-coefficients can be interpreted directly as marginal effects. This is however not the case for non-linear regression models such as the probit model. The probit regression does produce a parameter estimate that is analogous to the estimate of the beta-coefficient in a standard OLS regression, but it cannot be interpreted the same way. In a non-linear model, the marginal effects and elasticities are instead found by computing the derivative of the outcome probability with respect to the regressor. The derivative can be written as:

$$\frac{d\,P_i}{d\,X_i} = F(\beta_0 + \beta_i X_i)\beta_i \quad (4)$$

In other words, the effect of a one percent change in X_i on the probability that $Y_i = 1$ is found through deriving the main function with respect to X_i. (Gujarati, 2003) When the independent variable is also binary, for example an age variable where 1 = born in the 1940s and 0 = not born in the 1940s, the marginal elasticity of Y_i is the change in the predicted probability of $Y_i = 1$ when the dummy changes from 0 to 1, all else held constant. In the case of the age dummy, it is hence the change in probability of Y_i being 1 if the subject is a person born in the 1940s, compared to people of any other age. (Corneließen and Sonderhof, 2009)

5.1.2 Model Application and Assumptions

Hypothesis I, that fuel choice is driven only by fuel prices, is approached by i) looking at choice of the cheaper fuel, adjusting for differences in energy content ii) looking at fuel arbitrage (choosing the cheaper fuel *and* stating price as the main reason for fuel choice) and iii) estimating the price elasticity of demand for ethanol. Taking this to our survey sample we run three separate probit regressions of i) a cheaper fuel dummy ii) a fuel arbitrage dummy and iii) an ethanol choice dummy, as dependent variables on observed fuel prices and other independent variables. The dependent dummy variables are set to be 1 if respondents

i) chose the cheaper fuel ii) arbitraged across fuels and iii) chose to fuel ethanol, and consequently 0 in the opposite cases. The probit regression models we have applied are as follow:

$$\text{cheaperfuelD} = F(\beta_0 + \beta_i X_i) + u \quad (5)$$

$$\text{fuelArbD} = F(\beta_0 + \beta_i X_i) + u \quad (6)$$

$$\text{ethanolchoiceD} = F(\beta_0 + \beta_i X_i) + u \quad (7)$$

We have varied the ethanol choice regression slightly, first looking at relative prices (G_Epricediff), and secondly isolating the effects of respective fuel price by analyzing the absolute prices of ethanol and gasoline (Eprice, Gprice). The remaining independent variables are the same in all regressions, and include controls for education level, income, household size, age and more. Figure 8 below lists our independent variables in brief, while a more detailed list can be found in Appendix 3.

Variable Description
Interview round (dummy)
Number of adult members of household
Number of children in household
Education
Income bracket (dummy)
Profession category (dummy)
Year of birth, decade (dummy)
Home zip code (dummy)
Gender (dummy)
Having adult passengers in car at time of fuelling (dummy)
Having children (<18) in car at time of fuelling (dummy)
Car make (dummy)
Size of engine, kW
Privately owned vehicle (dummy)
Fuel consumption/10km, liters
Revealed fuel choice reason (dummy)
Number of last two fuelling occasions that were at the same station
Mileage per year, metric miles, that is paid for privately by interviewee
Seeing E75/E85 as more environmentally friendly (dummy)
The price relationship between gasoline price and ethanol price at day of interview
Gasoline (G95) price on interview day
E75/E85 price on interview day
Snow depth on day of survey
Temperature, avg. forecasted (5 days forward on day of survey)
Precipitation, avg. forecasted (5 days forward on day of survey)

Figure 8. Brief description of control variables in probit regressions

Our surveyed ethanol demand can be argued to serve as a proxy for the total sales volume of ethanol as it is a random sample of the FFV population. We have only conducted interviews in Stockholm, and made the assumption that attitudes are fairly similar across the country although Stockholm may act as a trend setter for smaller communities. Another assumption we have made is that information from SPI correctly identifies the energy content of our two fuels. This has been the basis for our calculations and dummies where we have identified the cheaper fuel.

Having obtained the stated main reason behind each motorist's choice, we also want to investigate the characteristics of different groups of interviewees. Do two people who give different stated reasons also demonstrate different individual characteristics, such as education or income? For this purpose, we apply probit regressions where we have modeled stated *reason* for fuel choice (Y_i) as a result of multiple characteristics (X_i). The model uses a dummy for the stated reason as the dependent variable, as seen below in Equation 8:

$$\text{ReasonD} = F(\beta_0 + \beta_i X_i) + \text{u} \tag{8}$$

These regressions use the independent variables (X_i) as listed in Figure 8, for which a more detailed list can be found in Appendix 3. After conducting the probit regressions presented above, we obtained marginal elasticities using STATA's marginal elasticities command *mfx, eyex*. All the regressions in this section have been performed using STATA's *cluster* command, clustering by three-digit zip code to adjust for any heteroskedasticity from regional trends. Variables which will eventually be dropped due to perfect correlation or collinearity, will for this reason not be included in the results tables in Appendix 4-10. We will however report estimates dropped due to perfect correlation in the extracted results tables in section 6 Results.

5.2 Demand Curves

We also aim at estimating demand curves for revealed and stated fuel choice in order to analyze how relative prices affect demand for fuels, in line with Hypothesis I. For each price level we compute the percentage of respondents choosing ethanol, and inversely also the percentage choosing gasoline. We call these revealed demand curves. In order to estimate price sensitivity, we also construct *stated* demand curves. These are constructed by computing the percentage of respondents choosing ethanol on each *hypothetical* price level asked. All demand curves are constructed excluding observations with less than five respondents since a percentage measure is less accurate with fewer respondents.

6 Results

In this section we report our results, which include descriptive statistics of the data set, correlation tests and demand curves. Further, we present significant or otherwise interesting results from our main regressions, corrected for those that do not hold up in our robustness checks. Full tables showing the outcome of all regressions, including robustness checks, can be found in Appendix 4-10.

6.1 Cost-minimization as Basis for Decision-making

In this section, we will display results on how important the fuel cost appears to be for our surveyed drivers in order to answer Hypothesis I: whether fuel prices are the only factor affecting fuel choice.

In interview round I, 48% of respondents' revealed preference was for ethanol, and correspondingly 52% chose to fuel gasoline as seen in Figure 9 below. In round II, these numbers were 64% and 36% respectively. This implies that there might be a group of flexible consumers which switch fuel depending on season, represented by c. 16% of the FFV drivers in our sample.

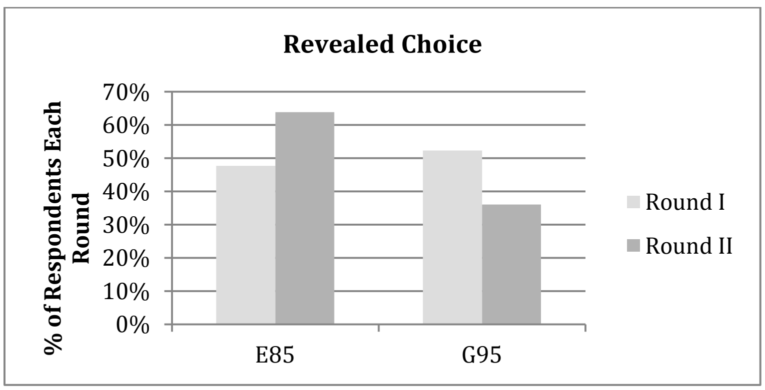

Figure 9. Consumer preferences for fuel choice, round I and round II

The main reasons drivers use to justify their fuel choice are Price, Environmental reasons (which in general favors ethanol), increased Autonomy (which favors gasoline as it is the more energy-efficient fuel and hence requires fewer fuelling stops), Habit, Alternates between the fuels and Other reasons. During the winter months, Engine quality/capacity optimization was also a common response.

If the fuel choice is motivated by price, consumers more closely conform to myopic economic agents – if they correctly choose the cheapest fuel, we call them *static* consumers. If fuel choice is motivated by environmental reasons, then consumers are said to be *altruistic* decision-makers, since they are incurring a cost in the name of current and future generations. Those consumers whose fuel choice is based on autonomy, implying that they assign a non-negligible cost to fuelling their car, are said to be *dynamic* consumers. Finally, it is also important to document consumer inertia, for which we have added the reason category *habit*.

In our sample of 219 interviews, 51 or 23% stated that the main reason for their fuel choice was price *and* correctly chose the cheaper fuel at the time of the interview. These can be referred to as fuel “arbitrageurs”. The distribution is slightly different across the two rounds with 27 arbitrageurs or 31% of the sample in the first round and 24 arbitrageurs or 18% of the sample in the second round. Additionally, 3 people in the first round and 17 in the second stated Price as main reason but did not identify the cheapest fuel. Adding these “failed” attempts at minimizing costs, the distribution of static decision-makers becomes more similar across the rounds; 35% (round I) versus 31% (round II). Below in Figure 10 we report the different reasons stated for respondents’ revealed fuel choice, split by interview round.

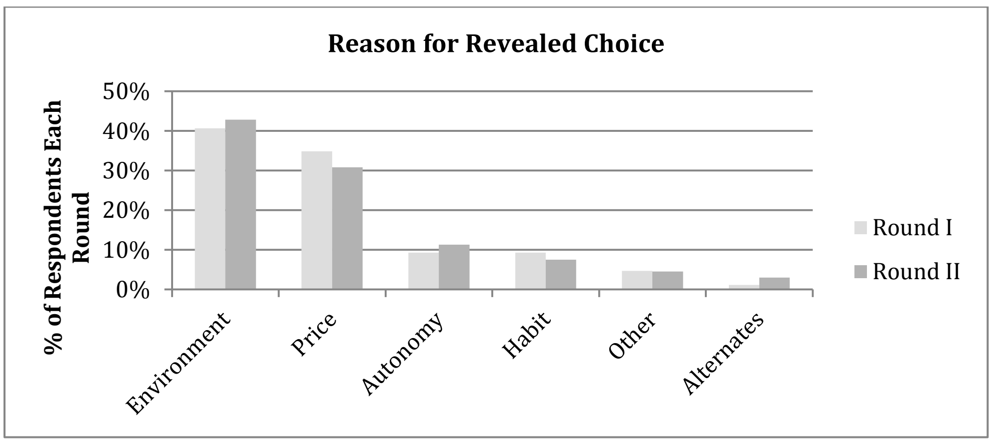

Figure 10. Reasons for revealed fuel choice, round I and round II

In Figure 11 below we report the results from two fuel choice regressions. The dependent variable in the left column is a dummy for whether or not the motorist arbitrages across fuels: she states that price is her main focus when choosing fuel *and* correctly chooses the cheaper fuel. The dependent variable in the right column is a dummy for whether or not the motorist chooses the cheaper fuel, regardless of stated reason.

Fuel Arbitrage Dummy			Cheaper Fuel Dummy		
Variable	*ey/ex and z-statistics*		*Variable*	*ey/ex and z-statistics*	
G_Epricediff	34.302		G_Epricediff	49.542	
	1.04			3.95	***
round1D	3.126		round1D	2.468	
	1.74	*		2.74	***
PriceD	-		PriceD	0.285	
	-			3.19	***
EnviD	-		EnviD	0.147	
	-			0.99	
AutoD	-		AutoD	-0.035	
	-			-1.21	
HabitD	-		HabitD	0.021	
	-			0.87	
educ	-0.940		educ	0.272	
	-1.03			0.69	
privmileage	0.338		privmileage	-0.153	
	1.06			-0.89	
income	0.175		income	0.272	
	0.23			-1.49	
fuelconsump	-2.055		fuelconsump	2.089	
	-0.96			2.34	**
hholdadults	-0.197		hholdadults	-0.904	
	-0.29			-1.91	*
fcasttemp	0.047		fcasttemp	0.022	
	0.53			0.45	
fcastprecip	0.104		fcastprecip	-0.263	
	0.37			-2.04	**
actualsnow	-1.331		actualsnow	-0.686	
	-0.82			-0.89	
passadultsD	-0.070		passadultsD	0.006	
	-1.01			0.20	
passchildrenD	-0.022		passchildrenD	-0.041	
	-0.49			-1.82	*
ethanolbetterD	-0.245		ethanolbetterD	0.009	
	-0.94			0.05	
ownershipPrivD	0.479		ownershipPrivD	0.214	
	2.20	**		1.97	**
Observations	190		Observations	196	
Pseudo R-squared	0.14		Pseudo R-squared	0.28	

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to collinearity display a dash (-) in the statistics column

Figure 11. Extract of results for fuel arbitrage and cheaper fuel regressions

Looking at the fuel arbitrage column on the left in Figure 11 above, it appears that the price relationship between gasoline and ethanol has no significant effect on whether the FFV driver is price-focused or not. Neither do income, education or the annual mileage driven. The only significant variables appear to be private ownership of the vehicle and the dummy for winter or summer round.

The results from the right column also show that the price relationship between gasoline and ethanol is positively correlated to choice of the cheaper fuel. It also shows that a person stating Price as main reason for fuel choice is more likely to choose the cheaper fuel, which is not very surprising. The same goes for a driver with a high-consuming engine, while private mileage has no effect. Having children present in the car while fuelling appears to decrease the likelihood of choosing the cheaper fuel. Forecasted precipitation also decreases the likelihood, possibly as snow may scare motorists away from ethanol even if it is cheaper.

In the first round the ethanol-based fuel contained 75% ethanol, and it was somewhat more expensive per energy unit than gasoline. The second round was conducted during the summer season, when the fuel composition was 85% ethanol and was sold at a discount to gasoline (adjusting for its lower energy content). In interview round I, the percentages of stated switchers in the E75 group and G95 group were 36% and 75% respectively. However, in interview round II when E85 was primarily the cheapest fuel, 47% in the E85 group stated that they would switch to G95 if the price difference between the two fuels decreased, whereas 67% in the G95 group would switch to E85 given an increase in price difference. This should be interpreted as that there is a group of consumers who are highly sensitive to the relative prices of the two fuels.

6.2 Fuel Demand and Price Elasticity

6.2.1 Fuel Prices and Market-level Demand

In order to continue examining Hypothesis I, we investigate the effect of ethanol and gasoline prices on the demand for ethanol in this section.

We do this by performing an analysis of market-level data on historical ethanol volume sales, obtained from SPI, and historical G95 and ethanol price data obtained from Statoil. First, we notice that there is a positive correlation of 46% between the price difference, $p_{G95}/p_{Ethanol}$, and ethanol volume sales during the period January 2007 to July 2010. This is shown in Figure 12 below.

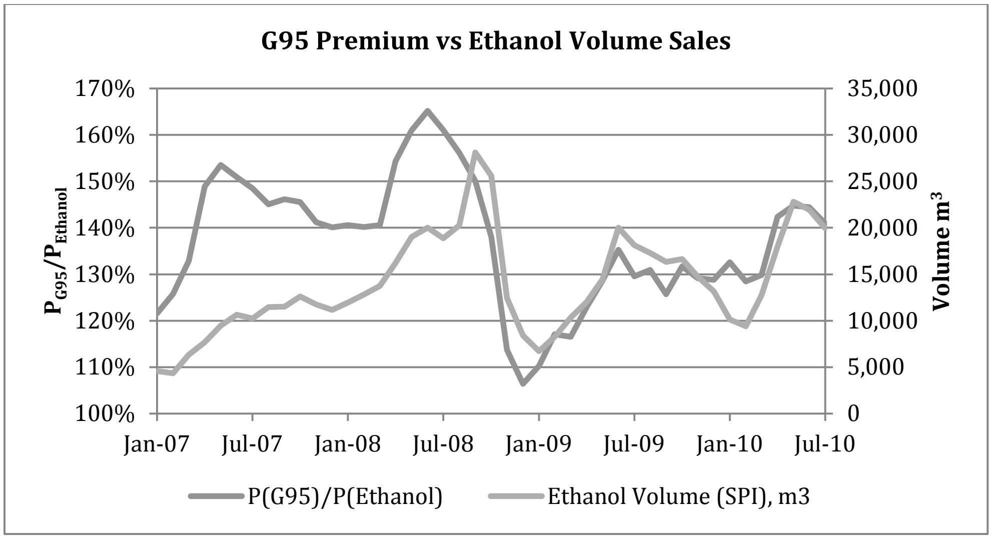

Figure 12. G95 price premium and ethanol sales. Source: Statoil III and SPI II

Next, we study ethanol volume sales and historical gasoline price only. The historical fluctuations of these two can be found in Figure 13 below. There is a substantially positive correlation of 73% between gasoline price and ethanol volume sales.

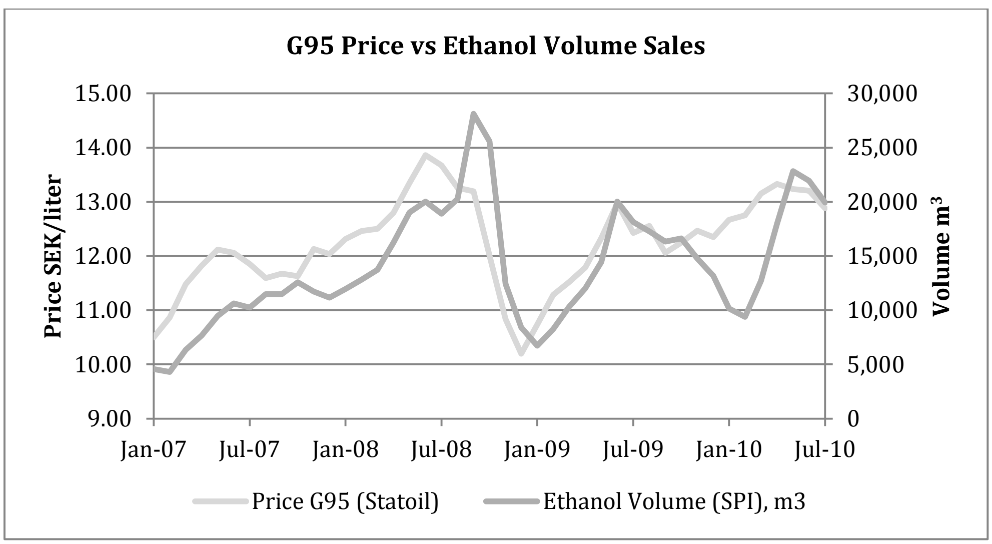

Figure 13. G95 price and ethanol sales. Source: Statoil III and SPI II

Finally, looking at the data in Figure 14, it appears that ethanol price has less influence on ethanol volume sales as the correlation between the two is close to zero, or 4%.

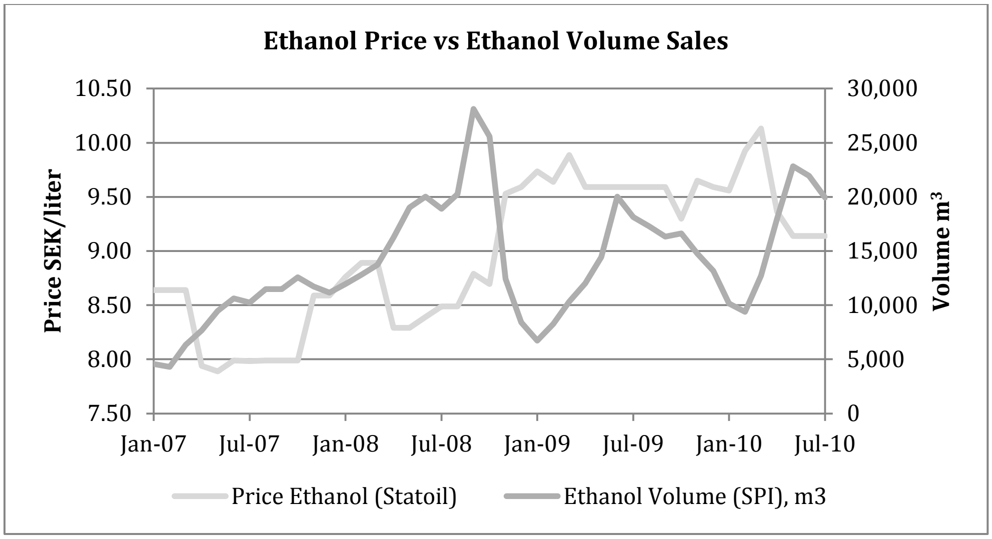

Figure 14. Ethanol price and ethanol sales. Source: Statoil III and SPI II

6.2.2 Fuel Prices and Surveyed Demand

After having analyzed market-level data on fuel prices and quantities sold, we apply a similar analysis on our survey data, to further investigate Hypothesis I.

First, we run a probit regression of an ethanol choice dummy (yes/no) on a number of control variables, including the price difference between gasoline and ethanol, expressed as $p_{G95}/p_{Ethanol}$. The outcome, displayed in Figure 15 below, indicates that the price parity (E_Gpricediff) appears not to have a significant effect. However, reason for choice being Environment, and the perception of ethanol as being the more environmentally friendly fuel, are significant on 1% and 5% levels. Also weather related regressors such as forecasted precipitation and actual snow depth seem to affect ethanol choice (5% and 1% significance levels). Next, we run the same regression but replace the price difference variable with one variable for the ethanol price and one for the gasoline price. Results from this regression on surveyed demand for ethanol show that the G95 price and the ethanol price are both significant on a 5% level, and that the effect from a one percent change in the gasoline price appears much larger than from the same change in the ethanol price.

Ethanol Choice Dummy					
		(+ Gprice + Eprice)[2]			(+ Gprice + Eprice)[2]
Variable	*ey/ex and z-statistics*	*ey/ex and z-statistics*	*Variable*	*ey/ex and z-statistics*	*ey/ex and z-statistics*
G_Epricediff	5.241	-	hholdchildren	-0.011	-0.003
	1.18	-		-0.38	-0.11
Gprice	-	34.751	fcasttemp	0.008	0.006
	-	2.48 **		0.63	0.52
Eprice	-	-17.276	fcastprecip	-0.131	-0.129
	-	-2.19 **		-2.10 **	-2.15 **
round1D	-1.188	-1.876	actualsnow	1.303	2.576
	-2.45 **	-3.46 ***		2.73 ***	3.72 ***
PriceD	0.016	0.015	genderD	0.008	0.016
	0.62	0.53		0.65	1.24
HabitD	-0.010	-0.012	passadultsD	-0.002	-0.007
	-1.24	-1.50		-0.13	-0.49
EnviD	0.305	0.314	passchildrenD	-0.008	-0.008
	3.43 ***	3.79 ***		-1.05	-0.91
educ	0.138	0.046	ownershipPrivD	-0.027	-0.003
	0.85	0.26		-0.63	-0.09
income	-0.008	-0.023	enginesize	-0.036	0.057
	-0.06	-0.16		-0.20	0.31
privmileage	-0.027	-0.044	ethanolbetterD	0.138	0.171
	-0.39	-0.58		1.99 **	2.58 ***
fuelconsump	0.007	0.204	last2here	0.010	0.024
	0.02	0.56		0.39	0.84
hholdadults	-0.115	-0.163	AutoD	*Pred. fail. perfectly*	*Pred. fail. perfectly*
	-0.73	-0.89			
Observations	182	182			
Pseudo R-squared	0.60	0.62			

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to collinearity display a dash (-) in the statistics column

[2] Excl. G_Epricediff

Figure 15. Extract of results for regressions of ethanol choice on relative (left) and absolute prices (right)

Next, we estimate *revealed* demand curves for E75, E85 and G95 using data from our interviews[3]. During round I G95 was the cheaper fuel as observed price relations were all below the breakeven parity of 34% – still, a number of motorists chose to fuel ethanol.

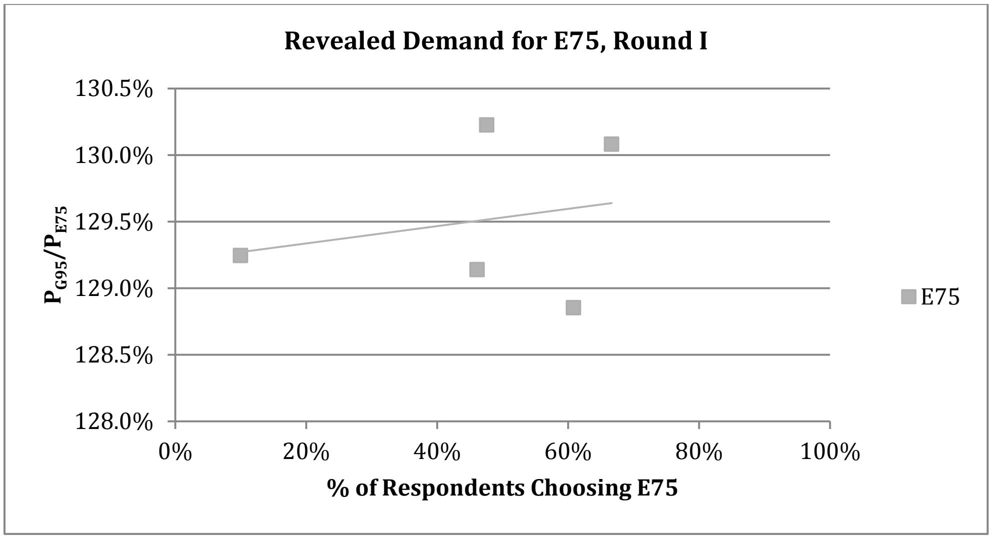

Figure 16. Revealed demand for E75, round I

During round II ethanol was generally the cheaper fuel, as observed parities were mainly above the breakeven level of 42%.

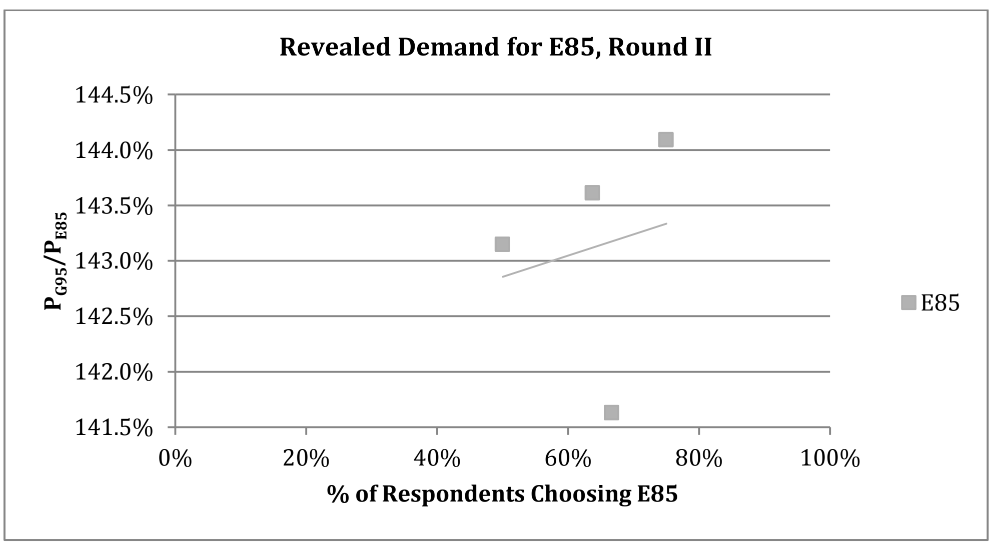

Figure 17. Revealed demand for E85, round II

[3] Corrected for parity levels with less than five interviews

Figure 16 and 17 show that ethanol becomes a more attractive fuel choice the larger the price difference is from the G95 price. Conversely, more drivers choose to fuel their cars with gasoline when the G95 price approaches the price of ethanol. These results from our data sample are in line with the findings from market-level data: a decrease in the price of ethanol relative to the price of gasoline leads to increased consumption of ethanol.

Furthermore, by analyzing our data on hypothetical price changes, we have constructed *stated* demand curves as seen below in Figure 18 and 19. The stated demand curves are similar to the revealed demand curves as they both show that as p_{G95}/p_{E75} and p_{G95}/p_{E85} increases, more but not all consumers will prefer to fuel ethanol.

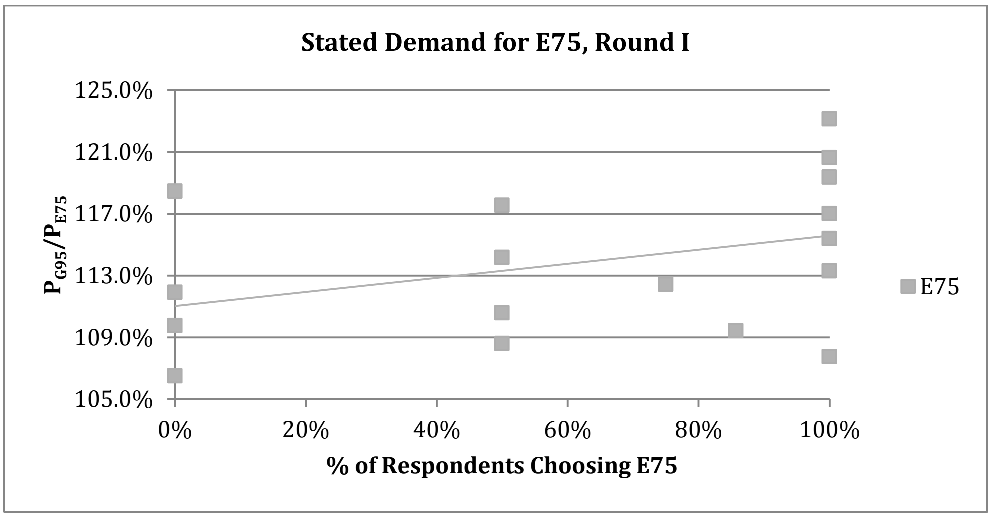

Figure 18. Stated demand for E75, round I

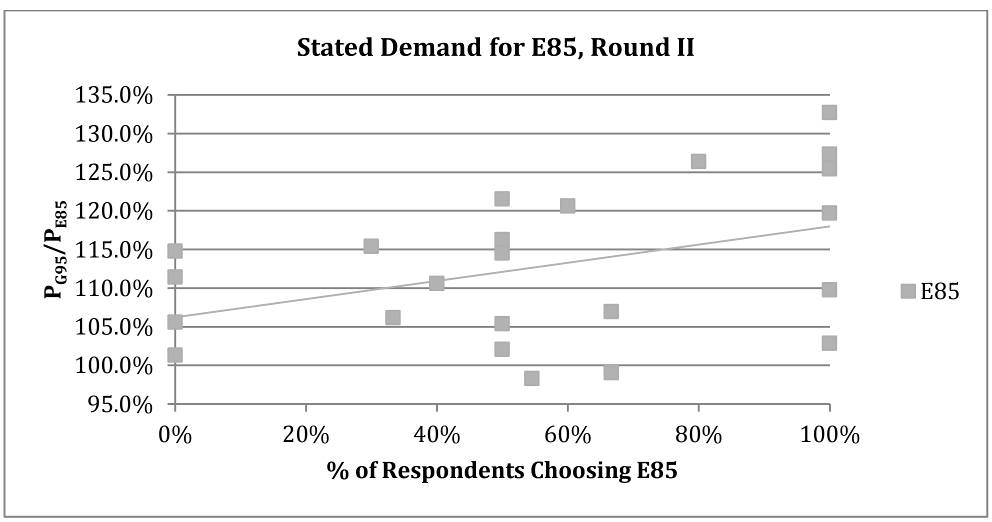

Figure 19. Stated demand for E85, round II

6.3 Pro-social and Pro-environmental Behavior

In order to answer our second hypothesis, determining if preferences for fuel are homogeneous regardless of individual characteristics, we want to investigate what characterizes different types of decision-makers. In this thesis, we have chosen to focus on the price-sensitive, also referred to as static, as well as the pro-environmental/pro-social, also referred to as altruistic decision-makers. We also look at those who say autonomy is the main reason for their fuel choice (belonging to the group of dynamic decision-makers), as well as those who state they choose fuel out of habit, in order to see what separates these from the static and altruistic groups above.

A probit regression with a dummy for reason Price as regressand indicates that private mileage and fuel consumption are significant regressors on 10% significance level, as is gender and adult passengers. Forecasted precipitation and being born in the 1940s are significant on 5% and 1% level, as seen in Figure 20 below.

Reason: Price Dummy					
Variable	*ey/ex and z-statistics*		*Variable*	*ey/ex and z-statistics*	
G_Epricediff	-22.441		hholdchildren	0.048	
	-0.81			0.32	
round1D	0.539		fcasttemp	-0.005	
	0.35			-0.06	
educ	-0.714		fcastprecip	0.505	
	-0.91			2.11	**
income	0.194		actualsnow	-1.191	
	0.33			-0.89	
privmileage	0.451		genderD	-0.154	
	1.79	*		-1.93	*
fuelconsump	-3.005		passadultsD	-0.119	
	-1.77	*		-1.90	*
born1930D	0.006		passchildrenD	0.019	
	0.29			0.55	
born1940D	-0.125		ownershipPrivD	0.061	
	-2.75	***		0.42	
born1950D	-0.184		enginesize	0.854	
	-1.27			0.91	
born1960D	-0.222		ethanolbetterD	-0.118	
	-1.48			-0.49	
born1970D	-0.115		last2here	0.027	
	-0.92			0.29	
hholdadults	0.813		born1990D	*Pred. fail. perfectly*	
	1.11				
Observations	190				
Pseudo R-squared	0.14				

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to collinearity display a dash (-) in the statistics column

Figure 20. Extract of results for regression on reason for fuel choice being Price

In a second regression, a dummy for reason Environment is set as the dependent variable. The results, displayed in Figure 21 below, show that a larger difference between the price of gasoline and the price of ethanol, i.e. relatively cheaper ethanol, increases the probability of our interviewees stating that they make their fuel choice based on environmental concern, on a 10% significance level. Being born in the 1940s also increases the likelihood of a motorist stating Environment as main reason. The probability also increases if the motorist is female, on a 95% confidence level. Having adult passengers in the car, seeing ethanol as more environmentally friendly and having visited the same gas station for the last two fuelling occasions are all positive and significant on a 1% level.

Reason: Environment Dummy

Variable	*ey/ex and z-statistics*		*Variable*	*ey/ex and z-statistics*	
G_Epricediff	30.454		hholdchildren	-0.037	
	1.73	*		-0.31	
round1D	1.205		fcasttemp	0.078	
	0.97			1.23	
educ	0.859		fcastprecip	0.125	
	1.17			0.60	
income	-0.241		actualsnow	0.441	
	-0.49			0.41	
privmileage	-0.189		genderD	0.107	
	-0.79			2.02	**
fuelconsump	0.550		passadultsD	0.107	
	0.34			2.58	***
born1940D	0.162		passchildrenD	0.009	
	1.85	*		0.35	
born1950D	0.228		ownershipPrivD	0.078	
	0.77			0.65	
born1960D	0.190		enginesize	-0.010	
	0.68			-0.01	
born1970D	0.233		ethanolbetterD	0.830	
	0.90			2.80	***
born1980D	0.020		last2here	0.220	
	0.23			3.40	***
hholdadults	-0.506		born1990D	Pred. fail.	
	-0.71			perfectly	
Observations	199				
Pseudo R-squared	0.27				

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to collinearity display a dash (-) in the statistics column

Figure 21. Extract of results for regression on reason for fuel choice being Environment

Next, we run a regression on Autonomy respondents and find that there is a negative correlation with education level, which is significant on 5%. Private mileage, forecasted temperature and forecasted precipitation are also negatively correlated and significant (10%, 5% and 10%). The car being privately owned and having made the last two fuelling stops at the same gas station are both significant on a 10% level and have negative coefficients.

Reason: Autonomy Dummy			
Variable	*ey/ex and z-statistics*	*Variable*	*ey/ex and z-statistics*
G_Epricediff	71.765	hholdchildren	-0.136
	0.92		-0.30
round1D	1.159	fcasttemp	-0.896
	0.19		-2.07 **
educ	-4.800	fcastprecip	-3.054
	-2.02 **		-1.91 *
income	-1.860	actualsnow	-2.992
	-0.80		-0.59
privmileage	-2.043	genderD	-0.326
	-1.73 *		-1.30
fuelconsump	5.963	passadultsD	-0.144
	1.19		-0.87
born1940D	-0.008	passchildrenD	-0.025
	-0.05		-0.35
born1950D	-0.384	ownershipPrivD	-0.833
	-0.67		-1.81 *
born1960D	0.839	enginesize	2.678
	1.27		0.77
born1970D	-0.569	ethanolbetterD	-0.394
	-1.17		-0.52
born1980D	-	last2here	-0.626
	-		-1.90 *
hholdadults	-4.188	born1930D	Pred. fail.
	-1.47		perfectly
		born1990D	Pred. succ.
Observations	143		perfectly
Pseudo R-squared	0.41		

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to collinearity display a dash (-) in the statistics column

Figure 22. Extract of results for regression on reason for fuel choice being Autonomy

The last characteristic regression is on consumers who choose fuel based on Habit. Private mileage and engine size are both significant on a 1% level, and display negative coefficients. Fuel consumption has a positive coefficient and is significant on a 5% level, while income is significant only at 10%. Seeing ethanol as the more environmentally friendly fuel is statistically significant (10%) and is negatively correlated with habit as stated reason for fuel choice.

Reason: Habit Dummy					
Variable	*ey/ex and z-statistics*		*Variable*	*ey/ex and z-statistics*	
G_Epricediff	-10.052		fcastprecip	-1.799	
	-0.11			-1.62	
round1D	-5.413		actualsnow	4.108	
	-0.80			0.70	
educ	3.755		genderD	0.156	
	1.13			0.54	
income	4.135		passadultsD	0.129	
	1.66	*		0.65	
privmileage	-2.359		ownershipPrivD	-0.817	
	-2.69	***		-1.20	
fuelconsump	16.692		enginesize	-16.319	
	2.39	**		-3.03	***
born1950D	-		ethanolbetterD	-1.807	
	-			-1.66	*
born1960D	-0.934		last2here	-0.445	
	-1.87	*		-1.49	
born1970D	-0.240		born1930D	Pred. fail.	
	-0.64			perfectly	
born1980D	0.128		born1940D	Pred. fail.	
	0.80			perfectly	
hholdadults	0.571		born1990D	Pred. fail.	
	0.16			perfectly	
hholdchildren	0.711		passchildrenD	Pred. fail.	
	0.96			perfectly	
fcasttemp	-0.022				
	-0.07				
Observations	121				
Pseudo R-squared	0.33				

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to collinearity display a dash (-) in the statistics column

Figure 23. Extract of results for regression on reason for fuel choice being Habit

7 Analysis

Results from the previous section will be further discussed below, and linked to the main theories of the paper; cost-minimization as basis for decision-making, incentives for pro-social and pro-environmental behavior and previous research on vehicles and fuel choice.

7.1 Cost-minimization as Basis for Decision-making

Our first hypothesis is that consumers only look at price when choosing fuel. As reported in section 6.1, 31% of our respondents in round I and 18% in round II state Price as their main decision factor *and* correctly identifies the cheaper fuel. It is possible that an even larger group in round II is actually price-focused, though not being honest about their motivation. Those choosing G95 during the winter because of price, presumably also stated that their choice was based on price. In the summer however, a part of those who chose E85 and claim to be focused on the environment, may instead actually be focused on price. This could be an explanation for the difference between rounds.

Hypothetically changing the price of the fuel chosen has a larger effect on the ethanol group versus the gasoline group in round II, and vice versa in round I. People whose revealed choice is ethanol are hence more inclined to switch fuel in round II than those who choose gasoline, according to their stated preferences. The pattern is the opposite round I, where those having chosen gasoline are more likely to switch. These findings further support the above theory about price-sensitive consumers choosing to fuel ethanol during the summer months. Regressing fuel arbitrage, a yes/no dummy for whether or not a person states that price is their main focus *and* correctly chooses the cheaper fuel, on control variables yields no significant answer to what induces this cost-minimizing behavior.

Conversely, our results also show that some motorists choose ethanol regardless of season or price. Hypothesis I is hence not valid for all motorists. The “cheaper fuel” regression, where the dependent variable is a dummy for choosing the cheaper fuel, shows that cheaper ethanol in relation to gasoline (higher G_Epricediff) makes it more likely that a random FFV motorist goes for the cheaper fuel. One conclusion that can be drawn from this is that some people are in fact altruistic decision-makers, with other-regarding preference. This will be further discussed in section 7.3.

Our survey indicates that a significant group of interviewees view fuel price as the most important factor for fuel choice. However, far from everyone state that Price is the main reason for their fuel choice, which indicates that many consumers are non-static decision-makers and is in contrary to Hypothesis I. This is further supported by the fact that the more expensive fuel has been chosen by respondents in both our interview rounds.

7.2 Fuel Demand and Price Elasticity

The connection between fuel prices and ethanol demand can indicate whether price is the main focus for FFV motorists, and help answer our first hypothesis. When studying the data we have obtained from SPI, there appears to be a positive correlation of 46% between the G95/ethanol price relationship and E75/E85 volume sales on the market-level. This implies that when gasoline becomes more expensive relative ethanol, or ethanol becomes cheaper relative gasoline, consumers will choose ethanol. When comparing ethanol volumes to the price of gasoline, there was an even greater correlation between the two, 73%. I.e. when the price of gasoline is high, FFV owners are keener on fuelling ethanol, and vice versa. Though these results are not adjusted for other possibly relevant variables, the correlation is so strong that it is reasonable to believe that there is a connection. This correlation is in line with the findings of Bromiley et al. (2008), who established that the price difference between ethanol and gasoline has a large effect on ethanol sales. Further, increasing gasoline prices raise ethanol sales according to the study. It was also found that declining ethanol prices increase the volume of ethanol sold, which we have not been able to assert by examining Swedish market-level data. The substantial effect of the gasoline price on ethanol sales would imply that consumers are highly price sensitive. When also taking into account the relatively low importance of the ethanol price, this may be interpreted as that ethanol is viewed chiefly as a substitute for gasoline.

We have also investigated what our survey data can show on this question. When regressing ethanol choice on a number of independent variables, including the relative price of ethanol to gasoline, we find no evidence of the impact of the price difference. However, we have also regressed ethanol choice on the absolute prices of ethanol and gasoline, in a different regression to avoid the multicollinearity between relative and absolute prices. These results show that both the ethanol price and the gasoline price are relevant for fuel choice, with 5% significance. However, the effect is much larger for G95 than for ethanol. A one percent *increase* in the price of gasoline seems to have a significantly stronger effect on the probability of choosing ethanol than a one percent *decrease* in the price of ethanol. We find these results very interesting as they are in line with our market-level analysis above, which also indicated that the gasoline price is a key driver of ethanol sales.

Some people are willing to pay more for ethanol than what is reasonable from a pure cost-minimizing perspective, which is conflicting with our first hypothesis of price being all that influences fuel choice. Demand curves based on revealed and stated fuel choice highlight this fact. We also discovered through our interviews that many motorists feel that there is a limit to the premium they are willing to pay for ethanol. We kept our hypothetical prices within the interval of 50% over/under the actual ethanol price in order to gain more knowledge about the boundaries of this limit. Though our sample size may limit the depth of our analysis, our findings are roughly in line with the findings of Anderson (2010) on the price elasticity of ethanol. Anderson (2010) concluded that preferences for ethanol differ between individuals, some discount it 25% below gasoline while others do not discount it at all but compare the two only on actual price, and that other factors than price affect these preferences. However, the revealed and stated demand curves both show that as p_{G95}/p_{E75} and p_{G95}/p_{E85} increases, more consumers will prefer to fuel ethanol. This relationship confirms that consumers are static to some extent, even though not everyone is perfectly static in their fuel decision-making.

Looking at our survey data, many consumers appear to be static decision-makers as the prices of ethanol and gasoline have a powerful effect on ethanol sales. However, even more powerful is the correlation with the gasoline price alone. This would imply that price-focused consumers see ethanol mainly as a substitute to gasoline when the latter becomes too expensive. This indicates that Hypothesis I should be rejected, as the price of both fuels should be equally important for fuel choice if price was all that mattered. Further motivation for the rejection of Hypothesis I is that many motorists are willing to pay a certain premium for ethanol.

7.3 Pro-social and Pro-environmental Behavior

Our findings support that consumers are to some extent static, as they do incorporate prices into their fuelling decision. However if we continue examining the ethanol choice regressions in 6.2.2, we see that there is another relevant factor: altruism. Some people appear more altruistic than others, which is contrary to our second hypothesis that there is no effect of any variations in individual characteristics. In addition to the weather variables, which are connected to possible engine problems from ethanol, there are two other independent variables for which we get a significant value. These are the dummy for giving Environment as reason for fuelling and the dummy for viewing ethanol as better for the environment than gasoline. People who appear to be altruistic thus choose ethanol to a higher extent. This has two potential implications: either people who fuel ethanol want to broadcast an image of altruism to increase social esteem (Lepper et al., 1973), or they are actually concerned about the environment. In either case, the conclusion is that there are individuals who assign value to choosing ethanol for its environmental benefits. Those in our sample who stated that the environment was the main reason for their choice, and chose ethanol when it was more expensive, displayed clear pro-social behavior, i.e. engaged in an activity that primarily benefits others while being costly to themselves. This is in line with literature on the subject, where Leiser and Azar (2008) among others have found that focus has shifted from assumptions of complete rationality and cost-minimizing behavior to a view that also incorporates psychological theory. Jensen et al. (2007) found that humans are not rational maximizers in an ultimatum game as also fairness and other-regarding preferences mattered. It seems that multiple factors, including other-regarding preferences such as environmental concerns, are considered by a large share of FFV drivers.

The ecological advantage of ethanol contra gasoline is a factor affecting fuel choice for our surveyed drivers. There are individuals choosing ethanol for its environmental benefits, even if this choice incurs a financial loss.

It is interesting to analyze whether the source of this altruistic behavior can be defined as attempted by Bénabou and Tirole (2006). The two authors attempted to explain pro-social behavior by intrinsic motivation (assigning value to performing a pro-social task), extrinsic motivation (outside factors/rewards) and reputational motivation (assigning value to others knowing that you perform a pro-social task). They found that extrinsic incentives may crowd out the reputational factor, since they create uncertainty about the motivation behind the good deed. When applying their theory on our results, we find that there are certain discrepancies. Intrinsic motivation clearly plays a role since people choose ethanol even during the winter when it is commonly known that it is more expensive. The subsidized ethanol price (the only extrinsic reward in this case) seems to have little effect on choice since there is no proven correlation between ethanol prices and ethanol quantities sold on the market-level. This would be supportive of Bénabou and Tirole (2006), had it not been for the fact that the gasoline price has a substantial effect on ethanol volumes also on the market-level. If a reward such as a more favorable ethanol price crowds out the value for those who choose ethanol for reputational reasons, then this reputational value should be crowded out also when it is the gasoline that becomes more expensive, as this creates the same doubt about the true reason for choosing ethanol. A favorable price appears therefore not to be significantly crowding out the reputational value of choosing ethanol. It is however not even certain that this reputational value exists. We do find significant evidence for the fact that a person is more likely to state Environment as fuel choice reason with adult passengers in the car: having adult passengers affects the stated *reason for choosing ethanol*. On the contrary, the variable for adult passengers did not impact the *actual fuel chosen.* Similarly, a person is less likely to state Price as reason when there are adult passengers present. Reputational concern in this case seems to be a “side effect” of the pro-social action, it does not affect the action itself, but the consumer may still try to exploit its image value. In support of Bénabou and Tirole (2006), one could argue that the reputational effect comes from owning an FFV and not from the fuel choice itself.

It can hence not be shown that the reputational effect of choosing ethanol is crowded out by the subsidy on ethanol.

To continue to examine Hypothesis II, we want to determine what affects the different types of decision-makers that we have identified. When studying previous research on topics related to ours, we find that several researchers have looked at economic behavior through a psychological framework. This may give a better understanding of economic decision-making by taking into account the effect of individual characteristics such as awareness, education and personal values. We commence by looking further into the marginal elasticities obtained from our probit regression for reason Price, to see the factors affecting the probability of someone stating price as main reason for their fuel choice. We see that an increase in private miles driven per year increases the probability of a person stating price as their main reason. This is quite straightforward: the stakes are higher for people driving more. They buy more fuel and thus focus more on the cost of the fuel. This would imply that these consumers are rational as they care more about fuel price, the more fuel they purchase. This would support the findings of Slonim and Roth (1998) and Cameron (1999), who found that larger stakes were positively correlated with increasingly "rational" economic behavior. On the other hand, when looking at the variable for how much fuel a car consumes per driven mile, we see that an increase in fuel consumption actually decreases the probability of caring about price. This appears contradictory at first, as higher consumption also would mean higher stakes. Consumption per mile can however be chosen when buying the car. One possible explanation is that price-concerned people may from the beginning purchase a car that consumes less, meaning that a car consuming little fuel correlates with the owner being price sensitivity as above. Also forecasted precipitation seems to increase probability of reason Price. This may be related to winter/summer effects when the ethanol composition changes and the cheaper fuel changes from gasoline to ethanol.

Output from the regression for reason Environment show stronger results for the effect of person characteristics on the motivation for decision-making. Individuals with a positive view on ethanol choose the fuel to a higher extent than those that do not see the environmental benefits, as do women compared to men. Another strong result we get is that individuals born in the 1940s are more inclined to state that their main reason for fuelling is the environment, which may be due to generational trends. As shown above, being born in the 1940s was negatively correlated to stating Price as a reason. This means that there may be generational attitude affecting fuel choice. A result that is more difficult to interpret is that respondents whose last two visits were at this particular gas station increase the likelihood of reporting Environment as reason. A possible explanation for this is that since not all stations offer ethanol, it is necessary to stick to one that does if one wants to be sure to find the desired fuel. It would then be the results of an external factor (fuel availability) and not an individual characteristic (preferring routines over variation).

Regressions on Autonomy as main reason also show the impact of individual characteristics. There is a strong negative relationship between education and likelihood of caring chiefly about autonomy. I.e. the higher the education level, the less likely that the person cares about not having to stop too often for fuel. We also find a negative relationship between respondents whose last two visits were at this particular gas station and the probability of reporting Autonomy as reason. These individuals are less likely to fuel at the same gas station twice in a row, presumably because they want to be able to stop whenever they like and not at a given station. Other non-characteristic variables also seem to matter, one of them being private ownership of the car. Those who do not own their car are more likely to care about autonomy. This could be explained by company car owners driving much more/longer distances and thus valuing autonomy (gasoline) higher. This is not reflected in private mileage but in their company mileage, which should have a positive impact if we had included it in the regression. An increase in private miles driven per year significantly decreases the probability of a person stating Autonomy as their main reason – which may seem contradictory. There could be several explanations: driving more could make each stop less bothersome even though the total number of stops increases – after a while the driver just does not care whether she needs to stop 200 or 250 times. Or, those who drive much *and* care about autonomy may care so much that they do not choose an FFV from the beginning. A third alternative could be that people who drive much are more concerned about price and hence fall into the price group. Two weather-related variables, forecasted temperature and forecasted precipitation both have a negative impact on reason Autonomy.

The outcome from the regression of Habit as stated reason is in line with our findings on the Price reason regarding the importance of the size of the stake. The Habit regression indicates that an increase in private miles driven significantly decreases the probability of a person stating Habit as their main reason. It is likely that those who drive fewer miles and fuel more seldom care less about other factors such as price because their stakes are relatively small. This group of drivers may perceive the cost of keeping informed of which fuel is better and/or cheaper as too high, and simply choose the same fuel as last time. Correspondingly, there is a positive correlation between income level and probability of choosing fuel out of habit. Since higher income decreases the impact of a high fuel price, meaning that the higher the income the lower the stake, this result also supports the theory that a higher stake increases the likelihood of paying attention to fuel prices. Another strong result we observe is that individuals with a large engine size are much less likely to choose fuel out of habit – which further supports the reasoning above as larger engines in general consume more fuel. There is however a strong positive relationship between fuel consumption and habit – which is somewhat puzzling. The same discussion as on the Price dummy can be applied, highlighting the difference between miles driven (chosen by the driver herself) and fuel consumption (an inherent characteristic of the car) as a possible explanation for these contradictory results. People having more fuel consuming cars may not even be aware of this. Finally, drivers who do not view ethanol as a better fuel for the environment than gasoline are more likely to make their fuel decision based on Habit.

Hypothesis II should be rejected as larger stakes appear to affect the motivation behind decision-making, as do individual characteristics such as income, education and age. The relevant characteristics affecting whether FFV drivers make their decision based on Price, Environment, Autonomy or Habit differ significantly.

7.4 Troubleshooting

The following section contains information on robustness controls of our main results, as well as possible limitations and suggested improvements of our study.

7.4.1 Robustness

There are a few issues that have emerged during our research period and that may affect the robustness of our results. A crucial step has been identifying and selecting the relevant independent variables. Though we believe to have created a solid model, we have run alternative regressions in order to test the robustness of our conclusions. We have specifically considered the independent variables that may be correlated with each other, and excluded one or more of them to see if this affects the regression outcome. The results can be found in Appendix 4-10 and show that our main findings are not affected by varying the independent variables included. The omitted variable bias can never be avoided as we have not created a model that explains reality to 100 percent. Our face-to-face interviews have nevertheless given us a unique opportunity to observe and discuss with FFV drivers, and we have attempted to use these insights when creating the model.

Our winter round was planned for and conducted in early March, the latest possible part of the winter season, in order to minimize the effect of the cold weather. However, the temperature during these weeks was much lower than what is normal for the period, as much as 5 degrees below 30-year average (SMHI). Certain auto producers and vendors inform current and potential vehicle owners that the car does not function on ethanol-based fuel at temperatures below -15°C. Others say that the winter blend E75, which has a higher percentage of gasoline, is counteracting this problem, and that FFVs are thus fully functional regardless of outside temperature. Some interviewees stated that they chose gasoline for the sake of the engine. This information together with the unusually cold temperatures have both been taken care of in our robustness checks. We have controlled for weather by including weather-related variables in the probit regressions, and observations with stated reason being engine-related have been excluded from our data sample. If the observations excluded differ from the average observation, there may be noise in our data due to this discrepancy. This potential noise is likely to have been avoided with better weather conditions.

Important to note on the hypothetical price changes is also that people did not seem to have considered a scenario where gasoline and/or ethanol prices would change massively. When we applied prices 20-25% above current prices in the hypothetical prices case, it was noticeable that interviewees did not see this as reasonable. The study should hence be seen more as showing changes caused by normal price fluctuations and not as a model for estimating reactions to major output shocks. We chose not to inquire about higher price levels for the same reason; the above price span was where we would obtain more definite answers, and therefore the most meaningful data from an analytical perspective.

Another issue is our sample size. As we ourselves conducted the interviews, we could only invest a total of one month/200 hours in doing so. This, combined with the fact that Sweden still has a small share of FFVs, resulted in a small sample size (total 200+ interviews). Naturally, the time/quantity tradeoff may have implications for data robustness. We believe that a larger sample size would have given more significant results and hence improved the quality of our thesis. A study similar to ours has been performed in Brazil by Salvo and Huse (2010). Their results are likely to be more reliable as the sample size and thus the statistical accuracy is much higher.

7.4.2 Possible Limitations and Improvements

One possible limitation of our study is the size of the stake, i.e. the yearly gain of choosing the cheaper fuel. Prices have rarely been more than 1 SEK away from the breakeven, assuming energy consumption levels from SPI. This means that a person driving 2,000 metric miles/year, in a car consuming 1 liter gasoline per mile, saves a maximum of 2,000 SEK annually if keeping informed about prices. Seeing that the median income category in our sample is 400,000-600,000 SEK per year, this translates to 0.40% of an average interviewee's disposable income – not a significantly large portion. As discussed, research has shown that the effects of large stakes are significant while smaller stakes have no/less effect. Our own research also indicates that stakes do matter. If the fuel cost is overall considered to be a minor cost, our results may not be as significant as they had been for larger stakes.

We have used the information on energy content provided by SPI when calculating the breakeven parity between gasoline and ethanol-based fuel. However, different auto makers provide different information on fuel consumption (see Figure 3), and the numbers vary much between different producers. Moreover, in a test performed by the magazine Auto Motor & Sport in 2007, Volvo V70F and Saab 9.5 Biopower were reported to consume 59% and 51% more ethanol than gasoline. These values would have yielded different results on how many it is that choose the cheapest fuel, and, more importantly, this variation of information makes it difficult for us to know how informed consumers actually are – they have all received different information.

During our interviews we have also used the situation to inquire about general opinions on fuel choice, and listened to the issues the interviewees themselves considered important in the matter. One opinion that numerous interviewees voluntarily shared was that the government was not subsidizing ethanol enough. They felt it should be sold at an even lower price, because of its environmental benefits, and that it was the government's responsibility to bring about further price decreases. While some still chose ethanol as a fuel, many stated that they chose gasoline on purpose – as a protest to the "high" ethanol prices. Previous research, as discussed in this paper, has shown that other regarding preferences and the aversion to unfair outcomes play a central part in the human social setting. Here, it appears that it also affects human decision-making. Feeling that an "unfair" percentage of the cost of ethanol is placed on the individual while the state is not paying as much as it should, seems to motivate some people to avoid the cost-efficient and/or socially beneficial fuel due to the perceived injustice. Accounting for this opinion in our questionnaire, as a reason for fuelling or as a separate question, would have increased the accuracy of our regressions as it clearly is a relevant variable.

We asked the driver how much they have fuelled, and how much they would have fuelled had the prices been different. This turned out to be unnecessary as basically all respondents kept their amount constant. When the tank is empty, it needs to be filled up. A more valuable question would have been to ask how much less they would drive (yearly), had these new prices sustained. This as many respondents said that different price levels would make them adjust their total mileage, but they would still need to fill up the tank today.

Finally, it needs to be noted that purchasing a flexible-fuel vehicle is in itself an active choice, so our sample is naturally skewed towards the environmentally friendly/pro-social. Investigating a sample only including those who have been assigned a company car that is an FFV, but who pay for their own fuel, would give much cleaner results. Getting assigned a company car can be assumed to be a random act, and we would hence obtain a random sample of the Swedish/Stockholm population. The scarcity of these people as a percent of all car owners makes this a difficult group to study without spending a very large amount of time, but the results from such a study would be very interesting.

8 Conclusion

The purpose of this thesis has been to investigate whether consumer preferences for fuel choice are driven only by the objective of minimizing costs, Hypothesis I, as well as to investigate the characteristics affecting these preferences, Hypothesis II. The answer to the first question is ambiguous. Market-level data shows that the correlation between relative fuel prices and ethanol sales is evident, 46%, but still not perfectly correlated, which implies that not all FFV drivers arbitrage across fuels. Analysis of our surveyed fuel choice, where we have used a number of control variables, shows that only 31% of respondents in round I and 18% in round II stated that the main reason for their fuel choice is Price, *and* correctly chose the cheaper fuel at the time of the interview. These findings are in line with previous research, notably Anderson's study on the price elasticity of ethanol, and confirm that consumer preferences for fuel choice are not entirely focused on price. Both our analyses and the market-level data indicate that consumers are more sensitive to changes in the gasoline price, while variation of the ethanol price can only be proven to have a significant effect in our survey data. This would imply that many consumers mainly consider ethanol to be a substitute to gasoline when the latter becomes too expensive. When asked to motivate their fuel choice, only 35% of respondents in round I and 31% in round II report Price as main reason. This group clearly has minimizing fuel expenditure as their main priority. Other interviewees mentioned different reasons for their fuel choice, comprising Environment, Autonomy, Habit, Alternates between fuels, as well as more rare motives. Answers indicating environmental focus or preferences of autonomy imply that these interviewees view ethanol and gasoline as imperfect substitutes. Hypothesis I can therefore be rejected as fuel choice is not only price-driven. However, price is clearly a significant factor. Ethanol demand appears to be somewhat elastic even for the environmentally concerned, and the price elasticity of ethanol needs to be further examined.

As a second line of questioning, we wanted to investigate the characteristics affecting these preferences for fuel choice. We can conclude that Hypothesis II should be rejected, as characteristics for individuals who choose fuel based on the reasons Price, Environment, Autonomy and Habit differ significantly. Larger stakes appeared to affect motivation in several cases, which is in line with Slonim and Roth (1998) and Cameron (1999). The perceived environmental advantage of ethanol over gasoline is a factor affecting fuel choice, and a significant portion of consumers are willing to pay a premium for ethanol. The implication is that the pro-environmental households, represented by over 40% of our sample, do not require large subsidies to purchase ethanol. On the other hand, the price-focused and autonomy-preferring often need heavy subsidies in order to choose ethanol, the former due to lacking knowledge on the price relationship between the fuels and the latter due to a pro-gasoline bias. The current tax rebate, resulting in gasoline and ethanol being sold at approximately the same price as gasoline after adjusting for energy content, may therefore not result in enough of a change within either group to motivate the cost – further research on consumer attitudes and behavior is needed in order to identify the optimal level of subsidies.

8.1 Suggestions for Further Research

The conclusions from this paper can be used to improve decision-making on policies that regulate fuel choice and promote ethanol and other biofuels. They may also be used as a basis for research as well as decision-making in other issues regarding subsidies and environmental incentives.

Our results show that certain households purchase ethanol even when it is the more expensive fuel. Even though many of these do have an upper limit for when they switch to gasoline, this limit is often far above the breakeven price. These households may very well be willing to pay the same premium for other environment-friendly goods, such as locally grown foods, green electricity or clothes/merchandise produced in a carbon-conscious way. Further research would show just how much value is attributed to socially and environmentally beneficial goods.

This paper also touches on the subject of awareness. We ask for the main reason for respondents' fuel choice and observe the actual choice at the pump, yet some people focused on price end up choosing the more expensive fuel. A further look into the subjects' awareness of the fuel consumption of their car would enable a better understanding of this discrepancy. It would be very interesting to investigate how informed consumers are, and which cost they attribute to keeping updated on fuel consumption and prices. It is also likely that it is not possible to set a fixed limit since cars differ in relative consumption. More data on each type of engine, both from manufacturers and users, would enable a more accurate and thorough study on the topic.

Another theme that would be worthwhile investigating is the difference between those driving private and those driving company cars. Private FFV drivers have purposefully chosen a green car, and are likely to be far more pro-environmental than an average citizen. Observing company car drivers on the other hand, would give a heterogeneous sample of people who have not actively chosen this kind of car. The behavior of these "random" FFV owners would be a much closer proxy for the attitudes of the average citizen, and would therefore be greatly valuable for policy makers and scientists alike.

References

Print Sources

Anderson, S.T. (2010). ”The Demand for Ethanol as a Gasoline Substitute.” National Bureau of Economic Research (NBER) Working Paper No. 16371. Issued in September 2010.

Andreoni, J. (1990). “Impure altruism and donations to public goods: a theory of warm-glow giving.” *The Economic Journal*, 100: 464–477.

Archibald, R., and Gillingham, R. (1980). “An analysis of the short-run consumer demand for gasoline using household survey data.” *Review of Economics and Statistics*, 62(4): 622-628.

Archibald, R., and Gillingham, R. (1981). “A decomposition of the price and income elasticities of the consumer demand for gasoline.” *Southern Economic Journal*, 47(4): 1021-1031.

Bénabou, R., and Tirole, J. (2006). “Incentives and Prosocial Behavior.” *The American Economic Review*, 96(5): 1652–1678.

Brekke, K.A., Kverndokk, S., and Nyborg, K. (2003a). ”An Economic Model of Moral Motivation.” *Journal of Public Economics*, 87(9/10), 1967–1983.

Brekke, K.A., and Rege, M. (2003b). In: Advertising as Manipulation of Social Learning paper presented at the 2003 (VI) Meeting of the Society for the Advancement of Economic Theory, Rodos, Greece.

Bromiley, P., Gerlach, T., Marczak, K., Taylor, M., and Dobrovolny, L. (2008). “Statistical Analysis of the Factors Influencing Consumer Use of E85.” U.S. Department of Energy, National Renewable Energy Laboratory (NREL).

Bruvoll, A., Halvorsen, B., Nyborg, K. (2002). ”Households’ recycling efforts, resources.” *Conservation and Recycling*, 36(4): 337–354.

Cameron, L.A. (1999). “Raising the stakes in the ultimatum game: experimental evidence from Indonesia.” *Economic Inquiry*, 37: 47-59.

Clark, C.F., Kotchen, M.J., and Moore, M.R. (2003). “Internal and external influences on pro-environmental behavior: Participation in a green electricity program.” *Journal of Environmental Psychology*, 23: 237–246.

Cornelißen, T. (2005). “Standard errors of marginal effects in the heteroskedastic probit model.” Discussion Paper No. 320, Institute of Quantitative Economic Research, University of Hannover, Germany. Issued in August 2005.

Cornelißen, T., and Sonderhof, K. (2009). “Partial effects in probit and logit models with a triple dummy variable interaction term” Discussion Paper No. 386, Institute of Labor Economics, University of Hannover, Germany. Issued in June 2009.

Dahl, C., and Sterner, T. (1991). “Analyzing Gasoline Demand Elasticities” *Energy Economics*, 13(3): 203-210.

Frey, B.S. (1997). “Not Just for the Money. An Economic Theory of Personal Motivation.” *Edward Elgar, Cheltenham, UK.*

Frey, B.S., and Jegen, R. (2001). “Motivation Crowding Theory.” *Journal of Economic Surveys*, 15(5): 589–611.

Gneezy, U., and Rustichini, A. (2000). “Pay Enough or Don’t Pay at All.” *Quarterly Journal of Economics*, 115(3): 791–810.

Gujarati, D.N. (2003). Basic Econometrics, 4th edition. Boston: McGraw-Hill.

Gutierrez Karp, D. (1996). “Values and Their Effect on Pro-Environmental Behavior.” *Environment and Behavior*, 28(1): 111-133.

Jensen, K., Call, J., and Tomasello, M. (2007). “Chimpanzees Are Rational Maximizers in an Ultimatum Game.” *Science*, 318: 107-109.

Kollmuss, A., and Agyeman, J. (2002). “Mind the Gap: why do people act environmentally and what are the barriers to pro-environmental behavior?” *Environmental Education Research,* 8(3): 239-260.

Leiser, D., and Azar, O.H. (2008). “Behavioral Economics and Decision Making: Applying Insights from Psychology to Understand How People Make Economic Decisions," *Journal of Economic Psychology*, 29(5): 613-618.

Lepper, M., Greene, D., and Nisbett, R. (1973). “Undermining Children’s Interest with Extrinsic Rewards: A Test of the ’Overjustification Hypothesis’.” *Journal of Personality and Social Psychology*, 28(1): 129 –37.

Naturvårdsverket (Swedish Environmental Protection Agency) (2009). Index över nya bilars klimatpåverkan 2008. Rapport 5946. Stockholm.

Nyborg, K., Howarth, R.B., and Brekke K.A. (2006). “Green consumers and public policy: On socially contingent moral motivation” *Resource and Energy Economics*, 28: 351–366.

Salvo, A., and Huse, C. (2010). “Consumer Choice Between Gasoline and Sugarcane Ethanol” Northwestern University (KSM) and Stockholm School of Economics. Working Paper. Issued in December 2010.

Slonim, R., and Roth, A.E. (1998). “Learning in high stakes ultimatum games: an experiment in the Slovak republic.” *Econometrica*, 66: 569-596.

Titmuss, R. (1970). “The Gift Relationship: From Human Blood to Social Policy.” London: Allen and Unwin.

Turaga, R.M.R., Howarth, R.B., and Borsuk, M.E. (2010). “Pro-environmental behavior – Rational choice meets moral motivation.” *Annals of the New York Academy of Sciences,* 1185: 211–224.

Electronic Sources

Auto Motor & Sport (2007). http://www.automotorsport.se/nyhetsmall.asp?version=65585 [Accessed February 20, 2010]

Dagens Industri (2010). ”Krönika: Att skrota etanolen riskerar bli mycket dyrt misstag” http://di.se/Default.aspx?sr=6&tr=272601&rlt=0&pid=207575__ArticlePageProvider [Accessed May 30, 2010]

European Commission (2010). http://ec.europa.eu/energy/renewables/biofuels/biofuels_en.htm [Accessed January 25, 2010]

Government of Sweden (2007). "Kan bättre miljö och ökad handel gå hand i hand?" http://www.regeringen.se/sb/d/8652/a/79835 [Accessed January 25, 2010]

OKQ8 (2007). http://www.okq8.se/data/internal/data/10/69/1167834368846/Etanol%20E85.pdf [Accessed February 1, 2010]

SEKAB (Svensk Etanolkemi AB). http://www.sekab.com/default.asp?id=1901&refid=1982&l3=1974#13 [Accessed January 30, 2010]

Shell. http://www.shell.com/home/content/se-sv/priser/fragor_svar/bensin_diesel_villaoljepris.html#4 [Accessed February 1, 2010]

SMHI (Swedish Meteorological and Hydrological Institute) (2010). Weather data ordered from SMHI.

SPI (Swedish Petroleum Institute) I. http://spi.se/faktadatabas/artiklar/berakningsmodeller [Accessed February 1, 2010]

SPI (Swedish Petroleum Institute) II. http://spi.se/statistik/volymer [Accessed February 1, 2010]

Statoil I. http://www.statoil.se/FrontServlet?s=sdh&state=faq&faqid=13 [Accessed February 15, 2010]

Statoil II. http://www.statoil.se/FrontServlet?ds=Statoil&state=Statoil_dynamic&viewid=1999861 [Accessed February 15, 2010]

Statoil III. http://www.statoil.se/FrontServlet?ds=Statoil&state=Statoil_dynamic&viewid=2115642 [Accessed February 15, 2010]

Trafikanalys (Transport Analysis). http://www.trafa.se/Statistik/Vagtrafik/Fordon/Manadsstatistik1/ [Accessed December 10, 2010]

Interviews

Interviews with Volvo, Peugeot, Ford, Citroën, Saab, VW, Skoda and Renault customer service units

Appendix

Appendix 1 Parity Calculations

Parity relations have been calculated using information on energy content for different fuel types found on the website of the SPI, reconstructed below:

Fuel	**Energy Content kWh/m**^{3}
Gasoline w/o ethanol G98	9,100
Gasoline w ethanol G96	9,004
Gasoline w ethanol G95	8,940
Ethanol	5,900
Ethanol E85, summer, c. 85% ethanol, 15% gasoline	6,300
Ethanol E75, winter, c. 75% ethanol, 25% gasoline	6,650

SPI provided no information on G96 energy content. However, Preem states that G96 is a mix of G95 (gas + 5% pure ethanol) and G98 (all gas, no ethanol), and that G96 contains 3% ethanol after being mixed. We have assumed that the energy content of G96 equals 97% of the energy content of G98 and 3% of the energy content of pure ethanol, meaning that the energy content of G96 is 9,004 kWh/m^3.

Parity Relations
$p_{G98} = p_{E75}/(6{,}650/9{,}100) = \frac{p_{E75}}{0.7308} = p_{E85}/(6{,}300/9{,}100) = \frac{p_{E85}}{0.6923}$
$p_{G96} = p_{E75}/(6{,}650/9{,}004) = \frac{p_{E75}}{0.7386} = p_{E85}/(6{,}300/9{,}004) = \frac{p_{E85}}{0.6997}$
$p_{G95} = p_{E75}/(6{,}650/8{,}940) = \frac{p_{E75}}{0.7438} = p_{E85}/(6{,}300/8{,}940) = \frac{p_{E85}}{0.7047}$
$p_{E85} = p_{G95}*(6{,}300/8{,}940) = p_{G95}*0.7047 = p_{G96}*(6{,}300/9{,}004) = p_{G96}*0.6997 = p_{G98}*(6{,}300/9{,}100) = p_{G98}*0.6923$
$p_{E75} = p_{G95}*(6{,}650/8{,}940) = p_{G95}*0.7438 = p_{G96}*(6{,}650/9{,}004) = p_{G96}*0.7386 = p_{G98}*(6{,}650/9{,}100) = p_{G98}*0.7308$

Appendix 2 Survey Questionnaire, Round I and II

Basic Details
Interviewer:
Gas station name:
Address:
Area/Zip code:
Contact person:

- Confirm that the car in question is a flexi-fuel car
- Confirm that the car is _________ privately owned _________company car

Questions:
01. Car brand, model and engine size: ____

02. What was your fuel choice?
1. Ethanol 85
2. Gasoline 95
3. Gasoline 96
4. Gasoline 98
5. Both Ethanol 85 and Gasoline ___ (write if 95/96/98)

03. How much have you fuelled? ___ SEK or ___ liters ___ FT

04. What is the main reason for your fuel choice?
1. Better price
2. Better for the environment
3. More autonomy
4. Habit
5. I alternate between fuels
6. Engine gets more power/works better
7. Other (describe): ______________________________

05. How often are you the one fuelling the car?
1. Always
2. Most of the time
3. Sometimes
4. Practically never

06. The last 2 times you fuelled your car, your choice was:
1. Twice Ethanol 85
2. Twice Gasoline ___ (write if 95/96/98)
3. Once each ___ (write if 95/96/98)
4. Other (describe): ______________________________

07. In the last 2 times you fuelled your car, how many were in this gas station?
1. Twice
2. Once
3. None

08. Why have you chosen this gas station?
1. Close to home
2. Close to work
3. Good brand
4. No reason in particular, was just passing by
5. Price
6. Other (describe): ______________________________

09. On average, what is your mileage? ___ km/miles per ___ day/week/month/year

10. Assume Ethanol 85 price was _______ SEK/l and Gasoline price _______ SEK/l ___ (write if 95/96/98)

11. What fuel type would you have chosen?
1. Ethanol 85
2. Gasoline 95
3. Gasoline 96
4. Gasoline 98
5. Both Ethanol 85 and Gasoline ___ (write if 95/96/98)

12. How much would you have fuelled? ___ SEK or ___ liters ___ FT

13. How sure are you about this?
1. Definitely sure
2. Probably sure

14. Could you please comment on the reason for this choice?
1. Better price
2. Better for the environment
3. More autonomy
4. Habit
5. I alternate between fuels
6. Engine gets more power/works better
7. Other (describe): ______________________________

15. Which fuel do you consider to be better for the environment?
1. Ethanol 85
2. Gasoline
3. Ethanol 85 and Gasoline are equally good for the environment

16. For this car, are you aware of the relationship between fuel consumption of Ethanol 85 and Gasoline ___ (write if 95/96/98)? ___ Yes or ___ No

17. If **yes**, what is the relationship between fuel consumption of Ethanol 85 and Gasoline ___ (write if 95/96/98)? ___ % Ethanol 85 and ___ % Gasoline ___ (write if 95/96/98)
Gasoline ___ (write if 95/96/98) minimum _____ SEK/l more expensive than Ethanol 85 in order for me to choose Ethanol 85

Statistics
18. Could you please tell us your household size, including yourself? ___ adults ___ children

19. What is your last completed education?
1. Elementary school
2. Gymnasium
3. University Degree

20. Profession: ______________________________

21. Which year were you born? ______

22. Could you please give us your 5 digit zip code? ________

23. Could you please provide your income bracket, SEK/month?
1. 0-15.000
2. 15-25.000
3. 25-35.000
4. 35-50.000
5. Over 50.000

24. Gender:
1. Male
2. Female

25. No. of passengers in the car: ____

26. Plate number: ______________________

27. Date and time of interview: ___/___/ 2010 ___ h : ___ min.

Appendix 3 Variables Included in Probit Regressions

Main Variables			
Variable Name	**Variable Description**	**Coding**	**Variable Values**
round1D	Interview round (dummy)	0, 1	1=Winter (March) 0=Summer (April)
hholdadults	Number of adult members of household	0 - ∞	-
hholdchildren	Number of children in household	0 - ∞	-
educ	Education	1, 2, 3	1=Elementary School 2=Secondary Education/ "High School" 3=University
income	Estmated average of each of the surveyed income brackets (dummy)	10,000, 20,000, 30,000, 42,500, 55,000	10,000=(0-15,000) 20,000=(15-25,000) 30,000=(25-35,000) 42,500=(35-50,000) 55,000=(50,000+)
occup*D	Profession category (dummy)	0, 1	occup1D=Business/Administration occup2D=Technology/IT occup3D=Medical occup4D=Creative occup5D=Construction/Transport occup6D=Services occup7D=Operational occup8D=Unemployed/Retired occup9D=Sales/Marketing
born*D	Year of birth, decade (dummy)	0, 1	born1950D=Born in the 1950s, etc.
zipc*D	Home zip code, by area (dummy)	0, 1	zc112D=Zip code begins with 112, etc.
genderD	Gender (dummy)	0, 1	1=Female 0=Male
passadultsD	Having adult passengers in car at time of fuelling (dummy)	0, 1	-
passchildrenD	Having children (<18) in car at time of fuelling (dummy)	0, 1	-
car_*D	Car make (dummy)	0, 1	car_fordD=Car is a Ford, etc.
enginesize	Size of engine, kW	0 - ∞	-
ownershipPrivD	Privately owned vehicle (dummy)	0,1	-
fuelconsump	Fuel consumption/10km, liters	0 - ∞	Fuel consumption for the specific engine type, if driving on gasoline
ethanolchoiceD	Revealed fuel choice (dummy)	0, 1	1=E75/E85 0=G95
PriceD, EnviD AutoD, HabitD	Revealed fuel choice reason (dummy)	0, 1	PriceD=Price main reason for fuel choice EnviD=Environment –"– AutoD=Autonomy –"– HabitD=Habit –"–
last2here	Number of last two fuelling occasions that were at the same station	0, 1, 2	-

privmileage	Mileage per year, metric miles, that is paid for privately by interviewee	0 - ∞	-
ethanolbetterD	Seeing E75/E85 as more environmentally friendly (dummy)	0, 1	1=E75/E85 is better for the environment 0=E75/E85 is worse or E75/E85 is equal to gasoline
G_Epricediff	The price relationship between gasoline price and ethanol price at day of interview	0 - ∞	G_Epricediff=Gprice/Eprice
Gprice	Gasoline (G95) price on interview day	0 - ∞	-
Eprice	E75/E85 price on interview day	0 - ∞	-
actualsnow	Snow depth on day of survey	-∞ - ∞	-
fcasttemp, fcastprecip	Weather, avg. forecasted (5 days forward on day of survey)	-∞ - ∞	Fcasttemp=Temperature Fcastprecip=Precipitation
cheaperfuelD	Having chosen the cheaper fuel, adjusting for differences in energy content (dummy)	0, 1	-
fuelArbD	Having chosen the cheaper fuel, adjusting for differences in energy content, *and* stated reason is price (dummy)	0, 1	-
Robustness Variables			
Variable Name	**Variable Description**	**Coding**	**Variable Values**
stake	Fuel consumed/year (gasoline only), liters	0 - ∞	stake=privmileage*fuelconsump

Appendix 4 Full Result Table: Cheaper Fuel Dummy

	Cheaper Fuel Dummy									
	All		**All - round1D**		**All + stake**		**All - enginesize**		**All - fcasttemp, actualsnow**	
Variable	*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*	
G_Epricediff	49.542		29.952		49.126		49.766		52.404	
	3.95	***	2.60	***	3.91	***	3.90	***	4.25	***
round1D	2.468		-		2.496		2.503		1.796	
	2.74	***	-		2.80	***	2.77	***	3.55	***
PriceD	0.285		0.306		0.291		0.287		0.289	
	3.19	***	4.08	***	3.17	***	3.20	***	3.27	***
HabitD	0.021		0.022		0.024		0.021		0.022	
	0.87		0.99		0.94		0.85		0.91	
AutoD	-0.035		-0.021		-0.032		-0.035		-0.030	
	-1.21		-0.76		-1.10		-1.18		-1.10	
EnviD	0.147		0.191		0.152		0.148		0.157	
	0.99		1.45		1.01		0.99		1.09	
educ	0.272		0.271		0.296		0.271		0.274	
	0.69		0.79		0.75		0.69		0.73	
income	-0.507		-0.565		-0.523		-0.494		-0.541	
	-1.49		-1.84	*	-1.54		-1.54		-1.66	*
privmileage	-0.153		-0.186		-0.820		-0.149		-0.163	
	-0.89		-1.14		-0.92		-0.86		-0.97	
fuelconsump	2.089		2.015		1.363		2.208		2.109	
	2.34	**	2.26	**	1.37		2.81	***	2.35	**
born1940D	0.039		0.036		0.043		0.040		0.045	
	0.91		0.78		0.97		0.91		1.04	
born1950D	-0.063		-0.052		-0.057		-0.063		-0.040	
	-0.51		-0.40		-0.45		-0.50		-0.32	
born1960D	0.146		0.159		0.152		0.145		0.167	
	1.18		1.21		1.21		1.20		1.36	

born1970D	0.020		0.022		0.030		0.020		0.038	
	0.18		0.18		0.26		0.18		0.33	
born1980D	0.035		0.025		0.037		0.035		0.037	
	1.24		0.83		1.28		1.24		1.30	
hholdadults	-0.904		-0.964		-0.908		-0.895		-0.909	
	-1.91	*	-2.00	**	-1.93	*	-1.90	*	-1.88	*
hholdchildren	-0.112		-0.119		-0.112		-0.110		-0.113	
	-1.28		-1.32		-1.28		-1.26		-1.29	
fcasttemp	0.022		-0.004		0.025		0.021		-	
	0.45		-0.10		0.50		0.44		-	
fcastprecip	-0.263		-0.294		-0.247		-0.258		-0.303	
	-2.04	**	-2.32	**	-1.93	*	-2.02	**	-2.49	**
actualsnow	-0.686		0.912		-0.709		-0.716		-	
	-0.89		1.88	*	-0.92		-0.95		-	
genderD	-0.023		-0.019		-0.024		-0.023		-0.022	
	-0.55		-0.47		-0.58		-0.56		-0.54	
passadultsD	0.006		0.003		0.008		0.007		0.004	
	0.20		0.10		0.24		0.23		0.14	
passchildrenD	-0.041		-0.051		-0.040		-0.041		-0.044	
	-1.82	*	-2.52	**	-1.80	*	-1.79	*	-2.03	**
ownershipPrivD	0.214		0.211		0.212		0.211		0.212	
	1.97	**	1.99	**	1.97	**	1.99	**	1.94	*
occup1D	-1.519		-1.538		-1.473		-1.512		-1.497	
	-0.21		-0.28		-0.21		-0.21		-0.21	
occup2D	-0.476		-0.470		-0.462		-0.476		-0.466	
	-0.22		-0.28		-0.21		-0.21		-0.21	
occup3D	-0.092		-0.099		-0.089		-0.092		-0.092	
	-0.17		-0.24		-0.17		-0.17		-0.17	
occup4D	-0.222		-0.227		-0.216		-0.222		-0.220	
	-0.23		-0.30		-0.22		-0.23		-0.22	
occup5D	-0.139		-0.138		-0.134		-0.139		-0.137	
	-0.17		-0.22		-0.17		-0.17		-0.17	

occup6D	-0.137	-0.142	-0.131	-0.136	-0.135
	-0.19	-0.26	-0.19	-0.19	-0.19
occup7D	-0.282	-0.292	-0.276	-0.281	-0.282
	-0.23	-0.31	-0.22	-0.22	-0.23
occup8D	-0.308	-0.317	-0.302	-0.306	-0.305
	-0.25	-0.33	-0.24	-0.25	-0.24
occup9D	-0.536	-0.547	-0.518	-0.535	-0.532
	-0.22	-0.29	-0.21	-0.21	-0.21
car_fordD	0.040	0.046	0.044	0.000	0.042
	0.48	0.56	0.52	0.00	0.51
car_volvoD	-0.115	-0.118	-0.114	-0.169	-0.121
	-1.47	-1.51	-1.46	-0.65	-1.55
car_saabD	-	-	-	-0.050	0.003
	-	-	-	-0.21	0.26
car_renaultD	0.003	0.002	0.003	-	-
	0.23	0.24	0.32	-	-
enginesize	0.132	0.380	0.176	-	0.192
	0.23	0.64	0.30	-	0.34
ethanolbetterD	0.009	0.043	0.001	0.009	0.029
	0.05	0.24	0.00	0.05	0.16
last2here	0.026	-0.002	0.027	0.025	0.020
	0.42	-0.04	0.44	0.42	0.36
stake	-	-	0.663	-	-
	-	-	0.78	-	-
Observations	196	196	196	196	196
Pseudo R-squared	0.28	0.26	0.28	0.28	0.28

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to perf. corr. or collinearity display a dash (-) in the statistics column

Appendix 5 Full Result Table: Fuel Arbitrage Dummy

	Fuel Arbitrage Dummy									
	All[1]		**All[1] - round1D**		**All[1] + stake**		**All[1] - enginesize**		**All[1] - fcasttemp, actualsnow**	
Variable	*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*	
G_Epricediff	34.302		1.536		38.436		35.749		40.046	
	1.04		0.05		1.15		1.08		1.30	
round1D	3.126		-		3.028		3.318		1.784	
	1.74	*	-		1.65	*	1.83	*	1.49	
PriceD	-		-		-		-		-	
	-		-		-		-		-	
HabitD	-		-		-		-		-	
	-		-		-		-		-	
AutoD	-		-		-		-		-	
	-		-		-		-		-	
EnviD	-		-		-		-		-	
	-		-		-		-		-	
educ	-0.940		-0.932		-0.966		-0.964		-0.910	
	-1.03		-1.04		-1.05		-1.06		-1.04	
income	0.175		0.092		0.169		0.239		0.097	
	0.23		0.12		0.22		0.33		0.13	
privmileage	0.338		0.282		3.108		0.358		0.304	
	1.06		0.93		1.70	*	1.14		0.97	
fuelconsump	-2.055		-2.176		0.901		-1.288		-1.990	
	-0.96		-1.03		0.31		-0.79		-0.94	
born1930D	0.006		0.011		0.009		0.006		0.005	
	0.26		0.48		0.37		0.27		0.22	
born1940D	-0.104		-0.093		-0.105		-0.103		-0.098	
	-2.08	**	-1.84	*	-2.08	**	-2.05	**	-1.90	*
born1950D	-0.383		-0.329		-0.378		-0.378		-0.361	
	-2.30	**	-1.95	*	-2.27	**	-2.30	**	-2.09	**

born1960D	-0.304		-0.243		-0.289		-0.314		-0.284	
	-1.67	*	-1.36		-1.60		-1.76	*	-1.57	
born1970D	-0.257		-0.221		-0.266		-0.252		-0.245	
	-1.62		-1.40		-1.66	*	-1.60		-1.51	
hholdadults	-0.197		-0.229		-0.249		-0.127		-0.231	
	-0.29		-0.33		-0.37		-0.18		-0.33	
hholdchildren	0.202		0.189		0.205		0.209		0.193	
	0.98		0.90		0.99		1.02		0.93	
fcasttemp	0.047		0.006		0.032		0.043		-	
	0.53		0.07		0.37		0.49		-	
fcastprecip	0.104		0.046		-0.014		0.133		0.015	
	0.37		0.16		-0.05		0.51		0.05	
actualsnow	-1.331		0.301		-1.186		-1.489		-	
	-0.82		0.27		-0.73		-0.94		-	
genderD	-0.121		-0.128		-0.115		-0.117		-0.124	
	-1.61		-1.76	*	-1.56		-1.53		-1.65	*
passadultsD	-0.070		-0.076		-0.079		-0.068		-0.072	
	-1.01		-1.12		-1.14		-0.97		-1.02	
passchildrenD	-0.022		-0.032		-0.026		-0.022		-0.030	
	-0.49		-0.73		-0.60		-0.49		-0.69	
ownershipPrivD	0.479		0.480		0.501		0.454		0.479	
	2.20	**	2.22	**	2.26	**	2.10	**	2.23	**
occup1D	2.622		2.571		2.412		2.660		2.652	
	0.16		0.19		0.14		0.16		0.17	
occup2D	0.805		0.802		0.751		0.811		0.820	
	0.16		0.19		0.14		0.16		0.17	
occup3D	0.208		0.200		0.196		0.208		0.207	
	0.17		0.20		0.16		0.17		0.18	
occup4D	0.368		0.360		0.345		0.371		0.373	
	0.17		0.19		0.15		0.17		0.18	
occup5D	0.320		0.319		0.293		0.323		0.325	
	0.16		0.19		0.14		0.16		0.17	

occup7D	0.453	0.434	0.418	0.463	0.449
	0.16	0.18	0.14	0.16	0.17
occup8D	0.462	0.437	0.432	0.472	0.465
	0.16	0.18	0.15	0.17	0.17
occup9D	1.033	1.016	0.953	1.039	1.038
	0.18	0.21	0.16	0.18	0.19
car_fordD	-0.356	-0.351	-0.386	-0.347	-0.314
	-0.93	-0.97	-1.05	-0.90	-0.83
car_volvoD	-0.474	-0.461	-0.492	-0.457	-0.425
	-0.98	-1.02	-1.05	-0.93	-0.89
car_saabD	-0.362	-0.356	-0.358	-0.347	-0.307
	-0.72	-0.74	-0.73	-0.68	-0.62
car_vwD	-0.014	-0.010	-0.012	-0.017	-0.011
	-0.50	-0.36	-0.44	-0.61	-0.37
enginesize	0.875	1.162	0.893	-	0.990
	0.74	0.96	0.75	-	0.85
ethanolbetterD	-0.245	-0.133	-0.232	-0.234	-0.183
	-0.94	-0.53	-0.89	-0.90	-0.73
last2here	0.110	0.061	0.112	0.115	0.091
	0.93	0.56	0.93	0.97	0.80
stake	-	-	-2.779	-	-
	-	-	-1.6	-	-
Observations	190	190	190	190	190
Pseudo R-squared	0.14	0.13	0.14	0.13	0.13

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to perf. corr. or collinearity display a dash (-) in the statistics column

[1] Excl. PriceD, EnviD, AutoD and HabitD

Appendix 6a Full Result Table: Ethanol Choice Dummy (G_Epricediff)

	Ethanol Choice Dummy									
	All		All - round1D		All + stake		All - enginesize		All - fcasttemp, actualsnow	
Variable	*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*	
G_Epricediff	5.241		17.944		6.211		5.300		0.685	
	1.18		2.78	***	1.35		1.16		0.11	
round1D	-1.188		-		-1.180		-1.199		-0.142	
	-2.45	**	-		-2.39	**	-2.52	**	-0.51	
PriceD	0.016		0.002		0.011		0.016		0.011	
	0.62		0.04		0.42		0.62		0.25	
HabitD	-0.010		-0.015		-0.012		-0.010		-0.014	
	-1.24		-1.08		-1.35		-1.23		-0.93	
EnviD	0.305		0.347		0.297		0.306		0.376	
	3.43	***	4.37	***	3.31	***	3.47	***	4.18	***
educ	0.138		0.207		0.159		0.142		0.234	
	0.85		0.91		0.95		0.84		1.12	
income	-0.008		-0.037		-0.010		-0.011		-0.023	
	-0.06		-0.22		-0.08		-0.08		-0.13	
privmileage	-0.027		-0.010		0.262		-0.028		0.008	
	-0.39		-0.10		0.84		-0.43		0.09	
fuelconsump	0.007		0.107		0.237		-0.028		0.162	
	0.02		0.23		0.58		-0.10		0.33	
born1930D	0.000		-0.001		0.000		-		0.001	
	0.06		-0.19		0.01		-		0.26	
born1940D	-0.009		-0.008		-0.010		-0.010		-0.014	
	-0.66		-0.46		-0.78		-0.58		-0.76	
born1950D	-0.006		-0.001		-0.009		-0.009		-0.004	
	-0.15		-0.02		-0.25		-0.16		-0.08	
born1960D	-0.006		-0.003		-0.009		-0.008		-0.006	
	-0.16		-0.07		-0.25		-0.17		-0.13	

born1970D	-0.001		0.008		-0.006		-0.004		-0.001	
	-0.04		0.20		-0.21		-0.09		-0.02	
born1980D	-		-		-		-0.001		-	
	-		-		-		-0.05		-	
hholdadults	-0.115		-0.135		-0.099		-0.115		-0.167	
	-0.73		-0.57		-0.64		-0.73		-0.67	
hholdchildren	-0.011		-0.029		-0.013		-0.011		-0.020	
	-0.38		-0.71		-0.45		-0.39		-0.48	
fcasttemp	0.008		0.020		0.006		0.008		-	
	0.63		1.22		0.53		0.65		-	
fcastprecip	-0.131		-0.177		-0.148		-0.134		-0.167	
	-2.10	**	-2.43	**	-2.06	**	-2.15	**	-2.55	**
actualsnow	1.303		0.653		1.317		1.317		-	
	2.73	***	2.42	**	2.72	***	2.77	***	-	
genderD	0.008		0.000		0.008		0.007		0.005	
	0.65		0.02		0.70		0.61		0.26	
passadultsD	-0.002		-0.008		-0.002		-0.002		-0.012	
	-0.13		-0.43		-0.17		-0.15		-0.67	
passchildrenD	-0.008		-0.003		-0.009		-0.008		0.001	
	-1.05		-0.31		-1.11		-1.04		0.11	
ownershipPrivD	-0.027		-0.016		-0.030		-0.026		-0.022	
	-0.63		-0.27		-0.69		-0.63		-0.40	
occup1D	-0.017		-0.031		-0.018		-0.018		-0.039	
	-0.74		-0.91		-0.78		-0.84		-1.05	
occup2D	0.001		-0.014		0.001		0.001		-0.016	
	0.09		-0.88		0.11		0.09		-1.08	
occup3D	0.002		0.006		0.002		0.002		0.004	
	0.47		0.87		0.49		0.47		0.47	
occup5D	-0.001		-0.002		0.001		-0.001		-0.004	
	-0.16		-0.33		0.15		-0.14		-0.72	
occup7D	0.001		0.003		0.001		0.000		0.001	
	0.06		0.22		0.07		0.03		0.06	

occup8D	-0.009		-0.013		-0.008		-0.010		-0.015	
	-0.78		-0.80		-0.64		-0.82		-1.05	
car_fordD	0.000		0.014		-0.007		-0.003		0.043	
	0.01		0.21		-0.14		-0.08		0.69	
car_volvoD	-0.024		-0.003		-0.027		-0.029		0.052	
	-0.49		-0.04		-0.59		-0.71		0.72	
car_saabD	-0.009		0.014		-0.009		-0.013		0.056	
	-0.23		0.23		-0.24		-0.35		1.01	
car_citroenD	0.000		0.000		0.000		0.000		0.002	
	-0.08		-0.10		-0.12		-0.15		0.59	
car_renaultD	-0.001		0.000		-0.002		-0.001		0.000	
	-0.54		-0.11		-0.77		-0.59		0.02	
car_vwD	-		-		-		-		-	
	-		-		-		-		-	
enginesize	-0.036		-0.156		0.000		-		-0.240	
	-0.20		-0.61		0.00		-		-0.85	
ethanolbetterD	0.138		0.180		0.139		0.139		0.140	
	1.99	**	1.76	*	2.04	**	1.99	**	1.47	
last2here	0.010		0.034		0.008		0.010		0.039	
	0.39		1.01		0.34		0.40		1.13	
stake	-		-		-0.282		-		-	
	-		-		-0.98		-		-	
Observations	182		182		182		182		182	
Pseudo R-squared	0.60		0.57		0.61		0.60		0.55	

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to perf. corr. or collinearity display a dash (-) in the statistics column

Appendix 6b Full Result Table: Ethanol Choice Dummy (Gprice, Eprice)

Ethanol Choice Dummy										
	All[3]		All - round1D		All + stake		All - enginesize		All - fcasttemp, actualsnow	
Variable	*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*	
Gprice	34.751		25.852		36.332		33.907		-10.399	
	2.48	**	2.06	**	2.67	***	2.29	**	-1.04	
Eprice	-17.276		-21.281		-18.664		-16.883		3.545	
	-2.19	**	-2.73	***	-2.41	**	-2.05	**	0.53	
round1D	-1.876		-		-1.863		-1.842		-0.359	
	-3.46	***	-		-3.28	***	-3.33	***	-1.14	
PriceD	0.015		0.000		0.009		0.015		0.017	
	0.53		0.00		0.32		0.53		0.41	
HabitD	-0.012		-0.015		-0.014		-0.012		-0.014	
	-1.50		-1.11		-1.60		-1.50		-0.98	
EnviD	0.314		0.347		0.307		0.313		0.376	
	3.79	***	4.27	***	3.69	***	3.69	***	4.24	***
educ	0.046		0.188		0.073		0.043		0.264	
	0.26		0.83		0.39		0.24		1.29	
income	-0.023		-0.050		-0.024		-0.019		-0.018	
	-0.16		-0.29		-0.16		-0.13		-0.11	
privmileage	-0.044		-0.014		0.251		-0.042		0.001	
	-0.58		-0.14		0.81		-0.57		0.01	
fuelconsump	0.204		0.153		0.420		0.258		0.053	
	0.56		0.31		0.91		0.87		0.12	
born1930D	-		-		-		-		0.000	
	-		-		-		-		0.00	
born1940D	-0.017		-0.004		-0.017		-0.017		-0.015	
	-0.96		-0.16		-0.98		-0.95		-0.86	
born1950D	-0.052		0.013		-0.054		-0.050		-0.003	
	-0.86		0.14		-0.87		-0.82		-0.06	

born1960D	-0.042		0.009		-0.044		-0.042		-0.005	
	-0.84		0.12		-0.86		-0.84		-0.11	
born1970D	-0.034		0.021		-0.038		-0.033		-0.002	
	-0.77		0.29		-0.85		-0.75		-0.05	
born1980D	-0.009		0.003		-0.008		-0.009		-	
	-0.76		0.14		-0.72		-0.76		-	
hholdadults	-0.163		-0.148		-0.147		-0.162		-0.167	
	-0.89		-0.60		-0.81		-0.89		-0.72	
hholdchildren	-0.003		-0.027		-0.004		-0.003		-0.024	
	-0.11		-0.66		-0.13		-0.11		-0.59	
fcasttemp	0.006		0.024		0.006		0.006		-	
	0.52		1.44		0.46		0.50		-	
fcastprecip	-0.129		-0.166		-0.148		-0.126		-0.176	
	-2.15	**	-2.28	**	-2.16	**	-2.11	**	-2.51	**
actualsnow	2.576		0.854		2.607		2.524		-	
	3.72	***	2.38	**	3.71	***	3.47	***	-	
genderD	0.016		0.002		0.016		0.016		0.003	
	1.24		0.09		1.25		1.27		0.21	
passadultsD	-0.007		-0.010		-0.007		-0.006		-0.006	
	-0.49		-0.54		-0.53		-0.46		-0.35	
passchildrenD	-0.008		-0.002		-0.008		-0.008		-0.003	
	-0.91		-0.20		-0.97		-0.92		-0.23	
ownershipPrivD	-0.003		-0.011		-0.006		-0.004		-0.033	
	-0.09		-0.19		-0.15		-0.11		-0.63	
occup1D	-0.007		-0.028		-0.009		-0.005		-0.041	
	-0.25		-0.79		-0.33		-0.20		-1.13	
occup2D	0.001		-0.015		0.001		0.001		-0.011	
	0.06		-1.01		0.07		0.06		-0.79	
occup3D	0.003		0.007		0.003		0.003		0.002	
	0.62		0.95		0.67		0.62		0.35	
occup5D	-0.002		-0.002		0.001		-0.002		-0.004	
	-0.30		-0.28		0.11		-0.35		-0.67	

occup7D	-0.001		0.003		-0.001		0.000		0.000	
	-0.11		0.21		-0.10		-0.06		0.02	
occup8D	-0.011		-0.013		-0.009		-0.011		-0.015	
	-0.94		-0.84		-0.79		-0.94		-1.02	
car_fordD	-0.013		0.022		-0.016		-0.013		0.039	
	-0.30		0.37		-0.36		-0.29		0.63	
car_volvoD	-0.064		0.003		-0.061		-0.063		0.050	
	-1.07		0.04		-0.99		-1.03		0.73	
car_saabD	-0.043		0.021		-0.036		-0.043		0.055	
	-0.73		0.28		-0.60		-0.73		1.03	
car_citroenD	-		-		-		-		0.002	
	-		-		-		-		0.44	
car_renaultD	-0.002		0.000		-0.002		-0.002		0.000	
	-0.57		0.01		-0.60		-0.65		0.08	
car_vwD	0.001		0.000		0.001		0.000		-	
	0.20		0.10		0.30		0.13		-	
enginesize	0.057		-0.141		0.103		-		-0.215	
	0.31		-0.55		0.56		-		-0.83	
ethanolbetterD	0.171		0.180		0.173		0.171		0.139	
	2.58	***	1.80	*	2.63	***	2.57	***	1.53	
last2here	0.024		0.040		0.022		0.023		0.026	
	0.84		1.13		0.80		0.83		0.77	
stake	-		-		-0.291		-		-	
	-		-		-0.98		-		-	
Observations	182		182		182		182		182	
Pseudo R-squared	0.62		0.57		0.63		0.62		0.56	

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to perf. corr. or collinearity display a dash (-) in the statistics column

[3] Excl. G_Epricediff, incl. Gprice, Eprice

Appendix 7 Full Result Table: Reason: Price Dummy

	Reason: Price Dummy									
	All		**All - round1D**		**All + stake**		**All - enginesize**		**All - fcasttemp, actualsnow**	
Variable	*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*	
G_Epricediff	-22.441		-27.467		-21.169		-21.168		-16.437	
	-0.81		-1.06		-0.75		-0.77		-0.64	
round1D	0.539		-		0.501		0.735		-0.403	
	0.35		-		0.32		0.48		-0.41	
educ	-0.714		-0.715		-0.709		-0.747		-0.703	
	-0.91		-0.90		-0.90		-0.95		-0.91	
income	0.194		0.186		0.200		0.257		0.146	
	0.33		0.31		0.34		0.44		0.25	
privmileage	0.451		0.442		1.355		0.468		0.428	
	1.79	*	1.77	*	0.98		1.86	*	1.72	*
fuelconsump	-3.005		-3.031		-2.029		-2.242		-2.997	
	-1.77	*	-1.80	*	-0.90		-1.84	*	-1.76	*
born1930D	0.006		0.006		0.006		0.006		0.004	
	0.29		0.33		0.32		0.30		0.21	
born1940D	-0.125		-0.123		-0.125		-0.124		-0.118	
	-2.75	***	-2.69	***	-2.75	***	-2.73	***	-2.50	**
born1950D	-0.184		-0.177		-0.180		-0.183		-0.172	
	-1.27		-1.20		-1.24		-1.28		-1.16	
born1960D	-0.222		-0.213		-0.218		-0.233		-0.209	
	-1.48		-1.42		-1.45		-1.56		-1.38	
born1970D	-0.115		-0.111		-0.119		-0.113		-0.105	
	-0.92		-0.87		-0.94		-0.91		-0.81	
hholdadults	0.813		0.801		0.804		0.874		0.756	
	1.11		1.09		1.09		1.19		1.02	
hholdchildren	0.048		0.048		0.044		0.060		0.050	
	0.32		0.31		0.29		0.40		0.32	

fcasttemp	-0.005		-0.011		-0.010		-0.009		-	
	-0.06		-0.14		-0.12		-0.11		-	
fcastprecip	0.505		0.495		0.469		0.529		0.480	
	2.11	**	2.06	**	1.99	**	2.20	**	2.03	**
actualsnow	-1.191		-0.880		-1.142		-1.359		-	
	-0.89		-0.95		-0.86		-1.02		-	
genderD	-0.154		-0.154		-0.150		-0.152		-0.153	
	-1.93	*	-1.95	*	-1.88	*	-1.92	*	-1.95	*
passadultsD	-0.119		-0.120		-0.122		-0.116		-0.119	
	-1.90	*	-1.97	**	-1.94	*	-1.85	*	-1.94	*
passchildrenD	0.019		0.016		0.018		0.019		0.013	
	0.55		0.50		0.51		0.56		0.41	
ownershipPrivD	0.061		0.063		0.061		0.041		0.060	
	0.42		0.43		0.41		0.28		0.40	
occup1D	2.690		2.680		2.630		2.719		2.705	
	0.23		0.25		0.22		0.23		0.24	
occup2D	0.870		0.870		0.854		0.872		0.879	
	0.24		0.26		0.23		0.24		0.25	
occup3D	0.199		0.198		0.196		0.199		0.200	
	0.22		0.24		0.22		0.23		0.24	
occup4D	0.342		0.341		0.336		0.343		0.345	
	0.21		0.23		0.20		0.21		0.23	
occup5D	0.301		0.301		0.293		0.303		0.307	
	0.21		0.22		0.20		0.21		0.22	
occup7D	0.457		0.454		0.448		0.467		0.455	
	0.22		0.24		0.21		0.23		0.24	
occup8D	0.505		0.501		0.498		0.513		0.508	
	0.25		0.27		0.24		0.25		0.26	
occup9D	1.021		1.018		0.998		1.024		1.021	
	0.25		0.27		0.24		0.25		0.26	
car_fordD	0.019		-0.498		-0.510		-0.491		-0.472	
	0.07		-1.56		-1.60		-1.51		-1.51	

car_volvoD	0.046	-0.662	-0.671	-0.647	-0.639
	0.13	-1.59	-1.62	-1.51	-1.58
car_saabD	0.121	-0.526	-0.528	-0.516	-0.499
	0.39	-1.26	-1.27	-1.21	-1.23
car_citroenD	0.020	-	-	-	-
	1.31	-	-	-	-
car_vwD	-	-0.030	-0.030	-0.033	-0.027
	-	-1.26	-1.29	-1.42	-1.14
enginesize	0.854	0.905	0.837	-	0.994
	0.91	0.99	0.89	-	1.06
ethanolbetterD	-0.118	-0.102	-0.112	-0.108	-0.094
	-0.49	-0.44	-0.47	-0.45	-0.40
last2here	0.027	0.019	0.028	0.031	0.013
	0.29	0.22	0.30	0.34	0.14
stake	-	-	-0.904	-	-
	-	-	-0.70	-	-
Observations	190	190	190	190	190
Pseudo R-squared	0.14	0.14	0.14	0.14	0.14

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to perf. corr. or collinearity display a dash (-) in the statistics column

Appendix 8 Full Result Table: Reason: Environment Dummy

	Reason: Environment Dummy									
	All		**All - round1D**		**All + stake**		**All - enginesize**		**All - fcasttemp, actualsnow**	
Variable	*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*	
G_Epricediff	30.454		21.430		30.192		30.433		30.869	
	1.73	*	1.31		1.71	*	1.73	*	1.77	*
round1D	1.205		-		1.212		1.201		1.281	
	0.97		-		0.97		0.98		1.98	**
educ	0.859		0.910		0.858		0.859		0.917	
	1.17		1.29		1.17		1.19		1.26	
income	-0.241		-0.277		-0.245		-0.242		-0.255	
	-0.49		-0.57		-0.50		-0.50		-0.51	
privmileage	-0.189		-0.205		-0.541		-0.190		-0.202	
	-0.79		-0.86		-0.50		-0.80		-0.84	
fuelconsump	0.550		0.498		0.175		0.540		0.661	
	0.34		0.30		0.10		0.45		0.41	
born1940D	0.162		0.160		0.164		0.162		0.156	
	1.85	*	1.87	*	1.91	*	1.85	*	1.72	*
born1950D	0.228		0.230		0.235		0.228		0.224	
	0.77		0.78		0.81		0.77		0.74	
born1960D	0.190		0.193		0.197		0.190		0.186	
	0.68		0.70		0.71		0.68		0.65	
born1970D	0.233		0.228		0.240		0.233		0.222	
	0.90		0.90		0.95		0.90		0.83	
born1980D	0.020		0.016		0.020		0.020		0.017	
	0.23		0.19		0.24		0.23		0.20	
hholdadults	-0.506		-0.575		-0.492		-0.507		-0.442	
	-0.71		-0.81		-0.69		-0.72		-0.64	
hholdchildren	-0.037		-0.039		-0.039		-0.037		-0.035	
	-0.31		-0.33		-0.33		-0.31		-0.30	

fcasttemp	0.078		0.064		0.079		0.079		-	
	1.23		1.01		1.25		1.25		-	
fcastprecip	0.125		0.112		0.134		0.125		0.042	
	0.60		0.53		0.64		0.60		0.23	
actualsnow	0.441		1.221		0.431		0.444		-	
	0.41		2.21	**	0.39		0.42		-	
genderD	0.107		0.105		0.106		0.107		0.107	
	2.02	**	2.00	**	1.99	**	2.02	**	2.09	**
passadultsD	0.107		0.108		0.108		0.107		0.105	
	2.58	***	2.58	***	2.59	***	2.53	**	2.57	***
passchildrenD	0.009		0.004		0.009		0.009		0.006	
	0.35		0.15		0.36		0.35		0.26	
ownershipPrivD	0.078		0.080		0.078		0.078		0.091	
	0.65		0.69		0.65		0.65		0.74	
occup1D	-2.463		-2.466		-2.437		-2.464		-2.475	
	-0.28		-0.32		-0.28		-0.28		-0.28	
occup2D	-0.762		-0.756		-0.754		-0.762		-0.763	
	-0.29		-0.32		-0.28		-0.29		-0.29	
occup3D	-0.197		-0.199		-0.196		-0.197		-0.199	
	-0.31		-0.35		-0.31		-0.31		-0.31	
occup4D	-0.305		-0.305		-0.301		-0.305		-0.306	
	-0.26		-0.30		-0.26		-0.26		-0.26	
occup5D	-0.276		-0.275		-0.274		-0.276		-0.281	
	-0.29		-0.33		-0.29		-0.29		-0.30	
occup6D	-0.192		-0.192		-0.189		-0.192		-0.194	
	-0.22		-0.25		-0.22		-0.23		-0.23	
occup7D	-0.426		-0.430		-0.423		-0.426		-0.428	
	-0.29		-0.33		-0.28		-0.29		-0.29	
occup8D	-0.468		-0.472		-0.464		-0.468		-0.472	
	-0.32		-0.36		-0.31		-0.32		-0.32	
occup9D	-0.927		-0.926		-0.917		-0.927		-0.929	
	-0.31		-0.35		-0.31		-0.31		-0.31	

car_fordD	-0.117		-0.095		-0.119		-0.117		-0.107	
	-0.60		-0.50		-0.61		-0.62		-0.50	
car_volvoD	-0.389		-0.363		-0.394		-0.390		-0.368	
	-1.50		-1.44		-1.54		-1.57		-1.28	
car_saabD	-0.378		-0.352		-0.384		-0.378		-0.358	
	-1.57		-1.50		-1.62		-1.62		-1.35	
car_vwD	-0.024		-0.023		-0.023		-0.024		-0.023	
	-1.74	*	-1.71	*	-1.72	*	-1.74	*	-1.67	*
enginesize	-0.010		0.123		0.011		-		-0.132	
	-0.01		0.13		0.01		-		-0.14	
ethanolbetterD	0.830		0.847		0.823		0.830		0.860	
	2.80	***	2.89	***	2.80	***	2.81	***	2.95	***
last2here	0.220		0.205		0.220		0.220		0.231	
	3.40	***	3.29	***	3.38	***	3.31	***	3.62	***
stake	-		-		0.345		-		-	
	-		-		0.35		-		-	
Observations	199		199		199		199		199	
Pseudo R-squared	0.27		0.27		0.27		0.27		0.26	

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to perf. corr. or collinearity display a dash (-) in the statistics column

Appendix 9 Full Result Table: Reason: Autonomy Dummy

Reason: Autonomy Dummy										
	All		**All - round1D**		**All + stake**		**All - enginesize**		**All - fcasttemp, actualsnow**	
Variable	*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*	
G_Epricediff	71.765		59.221		102.238		80.862		17.509	
	0.92		0.89		1.30		0.98		0.23	
round1D	1.159		-		1.733		2.416		-0.418	
	0.19		-		0.28		0.39		-0.15	
educ	-4.800		-4.921		-4.679		-4.526		-4.294	
	-2.02	**	-2.10	**	-1.96	**	-1.90	*	-1.97	**
income	-1.860		-1.918		-2.511		-1.481		-2.641	
	-0.80		-0.85		-0.93		-0.71		-1.20	
privmileage	-2.043		-2.099		6.933		-1.942		-2.035	
	-1.73	*	-1.91	*	0.93		-1.72	*	-1.68	*
fuelconsump	5.963		6.038		14.413		8.165		5.631	
	1.19		1.25		1.35		1.48		1.38	
born1940D	-0.008		-0.003		-		0.001		-	
	-0.05		-0.02		-		0.01		-	
born1950D	-0.384		-0.353		-0.307		-0.395		-0.238	
	-0.67		-0.65		-0.64		-0.69		-0.50	
born1960D	0.839		0.891		0.907		0.722		0.918	
	1.27		1.42		1.70	*	1.14		1.79	*
born1970D	-0.569		-0.551		-0.611		-0.569		-0.440	
	-1.17		-1.13		-1.51		-1.15		-1.46	
born1980D	-		-		0.009		-		0.010	
	-		-		0.08		-		0.10	
hholdadults	-4.188		-4.246		-4.285		-3.889		-4.438	
	-1.47		-1.45		-1.44		-1.44		-1.56	
hholdchildren	-0.136		-0.162		-0.089		-0.039		-0.146	
	-0.30		-0.35		-0.20		-0.08		-0.35	

fcasttemp	-0.896		-0.892		-0.910		-0.901		-
	-2.07	**	-2.22	**	-2.30	**	-2.04	**	-
fcastprecip	-3.054		-3.070		-3.441		-2.898		-1.890
	-1.91	*	-2.07	**	-1.75	*	-1.98	**	-1.58
actualsnow	-2.992		-2.266		-2.782		-3.891		-
	-0.59		-1.02		-0.54		-0.77		-
genderD	-0.326		-0.336		-0.299		-0.273		-0.297
	-1.30		-1.22		-1.18		-1.27		-1.22
passadultsD	-0.144		-0.153		-0.144		-0.093		-0.138
	-0.87		-0.87		-0.87		-0.60		-0.83
passchildrenD	-0.025		-0.027		-0.022		-0.013		-0.025
	-0.35		-0.38		-0.30		-0.21		-0.36
ownershipPrivD	-0.833		-0.832		-1.080		-0.867		-0.701
	-1.81	*	-1.78	*	-2.05	**	-1.99	**	-1.62
occup1D	5.154		5.139		5.106		5.204		4.831
	4.31	***	0.13		0.11		4.50	***	0.11
occup5D	0.878		0.883		0.847		0.874		0.827
	4.22	***	0.19		0.15		4.43	***	0.16
occup7D	0.870		0.863		0.852		0.906		0.809
	3.39	***	0.12		0.10		3.46	***	0.10
occup8D	0.895		0.893		0.922		0.907		0.822
	10.30	***	0.16		0.14		11.12	***	0.13
occup9D	1.893		1.883		1.837		1.880		1.691
	3.56	***	0.13		0.11		3.79	***	0.11
car_fordD	-		-		-1.490		-		-1.130
	-		-		-1.71	*	-		-1.56
car_volvoD	0.733		0.747		-1.966		0.700		-1.541
	1.42		1.37		-1.31		1.42		-1.25
car_saabD	0.879		0.905		-1.723		0.786		-1.473
	1.50		1.39		-1.15		1.33		-1.13
car_vwD	0.136		0.140		-		0.117		-
	1.56		1.61		-		1.47		-

enginesize	2.678		2.838		2.183		-		3.109	
	0.77		0.81		0.62		-		0.97	
ethanolbetterD	-0.394		-0.381		-0.449		-0.470		-0.541	
	-0.52		-0.52		-0.58		-0.61		-0.72	
last2here	-0.626		-0.646		-0.798		-0.627		-0.649	
	-1.90	*	-1.86	*	-1.68	*	-1.86	*	-1.80	*
stake	-		-		-8.157		-		-	
	-		-		-1.13		-		-	
Observations	143		143		143		143		143	
Pseudo R-squared	0.41		0.41		0.43		0.41		0.38	

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to perf. corr. or collinearity display a dash (-) in the statistics column

Appendix 10 Full Result Table: Reason: Habit Dummy

Reason: Habit Dummy										
	All		**All - round1D**		**All + stake**		**All - enginesize**		**All - fcasttemp, actualsnow**	
Variable	*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*		*ey/ex and z-statistics*	
G_Epricediff	-10.052		31.222		-7.783		-51.378		-35.844	
	-0.11		0.36		-0.08		-0.74		-0.37	
round1D	-5.413		-		-4.866		-6.484		-2.163	
	-0.80		-		-0.67		-1.13		-0.58	
educ	3.755		4.011		4.187		2.085		4.123	
	1.13		1.15		1.13		1.07		1.07	
income	4.135		4.659		5.612		1.054		4.421	
	1.66	*	1.73	*	2.15	**	0.63		1.47	
privmileage	-2.359		-2.384		8.987		-1.759		-2.253	
	-2.69	***	-2.54	**	1.14		-2.63	***	-2.45	**
fuelconsump	16.692		17.305		29.033		0.220		15.804	
	2.39	**	2.33	**	2.35	**	0.06		2.29	**
born1950D	-		-		-		-0.273		-	
	-		-		-		-0.54		-	
born1960D	-0.934		-0.936		-1.082		-0.606		-0.919	
	-1.87	*	-1.88	*	-1.93	*	-1.24		-1.63	
born1970D	-0.240		-0.264		-0.334		-0.337		-0.293	
	-0.64		-0.71		-0.78		-0.73		-0.72	
born1980D	0.128		0.153		0.120		-		0.126	
	0.80		0.95		0.71		-		0.78	
hholdadults	0.571		0.792		1.270		0.159		0.771	
	0.16		0.23		0.37		0.07		0.22	
hholdchildren	0.711		0.597		0.658		0.301		0.678	
	0.96		0.84		0.89		0.65		0.88	
fcasttemp	-0.022		-0.016		-0.059		0.061		-	
	-0.07		-0.05		-0.19		0.23		-	

fcastprecip	-1.799		-2.080		-1.834		-1.257		-1.802	
	-1.62		-1.65	*	-1.57		-1.58		-1.71	*
actualsnow	4.108		0.209		3.535		4.330		-	
	0.70		0.07		0.58		0.89		-	
genderD	0.156		0.139		0.168		0.119		0.115	
	0.54		0.47		0.54		0.55		0.38	
passadultsD	0.129		0.114		0.092		0.064		0.137	
	0.65		0.56		0.44		0.42		0.62	
ownershipPrivD	-0.817		-0.899		-0.864		-0.395		-0.934	
	-1.20		-1.26		-1.12		-0.71		-1.27	
occup1D	5.310		5.517		4.136		4.326		5.317	
	5.27	***	0.10		0.07		5.23	***	0.10	
occup3D	0.448		0.473		0.353		0.410		0.458	
	11.69	***	0.12		0.09		12.52	***	0.12	
occup7D	1.114		1.194		0.984		0.813		1.157	
	5.60	***	0.12		0.09		5.24	***	0.11	
occup8D	0.509		0.549		0.493		0.347		0.526	
	4.18	***	0.15		0.12		4.06	***	0.13	
occup9D	1.781		1.866		1.240		1.570		1.822	
	3.61	***	0.10		0.06		4.10	***	0.09	
car_fordD	-0.952		-1.012		-0.843		-1.054		-0.983	
	-1.50		-1.51		-1.41		-2.16	**	-1.43	
car_volvoD	-0.875		-1.026		-0.711		-0.997		-0.853	
	-0.92		-1.09		-0.72		-1.33		-0.93	
car_saabD	-1.489		-1.540		-1.338		-1.299		-1.406	
	-1.42		-1.50		-1.21		-1.84	*	-1.39	
enginesize	-16.319		-17.443		-18.424		-		-16.597	
	-3.03	***	-2.88	***	-3.25	***	-		-2.67	***
ethanolbetterD	-1.807		-2.022		-1.951		-1.463		-2.045	
	-1.66	*	-1.80	*	-1.58		-1.78	*	-2.19	**
last2here	-0.445		-0.425		-0.591		-0.315		-0.437	
	-1.49		-1.48		-1.62		-1.27		-1.39	

stake	-	-	-12.029	-	-
	-	-	-1.44	-	-
Observations	121	121	121	121	121
Pseudo R-squared	0.33	0.33	0.35	0.26	0.33

*** Significant at 10% ** Significant at 5% *** Significant at 1%**

Variables not included in regression or dropped due to perf. corr. or collinearity display a dash (-) in the statistics column