Biogas cars in Sweden
An emerging market

The case of Sweden

Author: Gabriela Alina Vanciau 780217-3620
        Nino Miresashvili  900304-3206
Supervisor: Lars Pettersson
Deputy Supervisor: Therese Norman
Jönköping: May 2012
Abstract

The energy sector is a vital part of country’s economy. Continuous increase in energy consumption, the limited resources in the sector, price volatility and the necessity of environment protection determined people to look for alternative sources of energy. An important fraction of the energy is consumed in the transport sector, thus it is not surprising that important investments and researches have been focused on finding substitute fuels in order to diminish the dependency of fossil fuels and reduce the quantity of CO₂. The aim of this thesis is to analyze how the consumer behavior regarding the biogas cars per capita, being determined by income per capita, the share of educated population, the existence of plant production at local level, the density of gas stations and the population, differs across Sweden’s municipalities.

As the biogas sector is in the beginning of its stage of development, there are no previous studies analyzing this sector using a specific regression model. Earlier research papers are based on surveys mostly looking into environmental studies of transport sector. Owing to this fact, we made a model that presents the actual situation for all Swedish municipalities. We did this by constructing the model with the variables that have a relatively significant impact on consumer behavior regarding bio vehicles. Our regression model defines the number of biogas cars per 10000 inhabitants as a function determined by the medium income, the share of educated population, the existence of plant production at local level the density of gas stations and the number of population. All variables mentioned above were analyzed at municipal level, in order to detect the factors standing behind the market development of biogas cars and finding out which of the factors tend to have a greater impact on consumer behavior.

In order to analyze the consumer behavior in the biogas car market, we used cross-sectional data for the year of 2010. The time series data collected for the period 2009-2012 is also analyzed. It is important to point out that the data was not available before the year of 2009. This can explain relatively limited number of observations used in the regression model for years 2009-2012. The time period which we focused on in our research, coincides with the beginning of the biogas car product life cycle, showing that demand for biogas cars is strongly determined by all the variables included in the model.
The result of our study showed that the number of biogas cars per capita is differently influenced by all the factors in our model. The biggest effect in the determination of the number of biogas cars per capita is represented by the factors like income and the number of population, while the variable local production, the density of gas stations and the share of educated population has an insignificant effect.
Table of Contents
1. INTRODUCTION .................................................................................................................. 6
2. BACKGROUND ....................................................................................................................... 8
3 THEORETICAL FRAMEWORK ............................................................................................... 12
   3.1 Consumer behavior .......................................................................................................... 12
4 EMPIRICAL ANALYSIS AND DESCRIPTIVE STATISTICS ................................................. 16
   4.1 Cross –sectional Data ...................................................................................................... 16
   4.2 Time series data .............................................................................................................. 19
   4.3 Descriptive Statistics ...................................................................................................... 20
   4.4 Analysis ........................................................................................................................... 21
5 CONCLUSION ......................................................................................................................... 25
   Further Research .................................................................................................................. 25
   Recommendations ............................................................................................................... 26
References ................................................................................................................................... 27
Appendix .................................................................................................................................... 35

List of Tables
Table 1- descriptive statistics for cross-sectional data 2010 ...................................................... 21
Table 2- The output of the regression model for cross-sectional data 2010 ............................ 22

List of Tables in appendix
Table 1 A - VIF for Table 2 the output of the regression model for cross-sectional data 2010 .................................................................................................................. 39
Table 2 A - White´s test for Table 2 the output of the regression model for cross-sectional data 2010 .................................................................................................................. 39

List of Graphs in Appendix
Graph 1– Usage of Biogas ........................................................................................................... 35
Graph 2– Plotting the residual ................................................................................................... 36
Graph 3- Plotting the residual .................................................................................................... 36
Graph 4- Number of biogas cars for period 2009-2011 ......................................................... 37
Graph 5- Prices for biogas for period 2009-2011 .................................................................... 37
Graph 6 - Number of gas stations for period 2009 -2011 .................................................... 38
Graph 7 – Number of Biogas cars per capita ......................................................................... 38
Acknowledgment

We started this thesis in order to attain a bachelor thesis degree being very excited about the subject of study. We want to thank our supervisors Lars Pettersson and Therese Norman for their academic support concerning the comprehension of the research questions of the thesis. We are grateful to have been given the opportunity to work with you. Special tanks go to Michelle Ekman from Energigas Sverige for supplying important statistical data. Without this contribution the goal of our study would have been impossible to accomplish. Thank you for your time and effort spent on providing us with the statistical data that was not available from public sources!

Gabriela Vanciu
Nino Miresashvili
Jönköping University, May/ 2012
1. INTRODUCTION

The purpose of this thesis is to find out how the factors characterizing the supply and demand sides of the biogas market in Sweden influence the consumer behavior and hence the quantity demanded of biogas vehicles across municipalities. We are also interested in analyzing how the number of biogas cars varies across Sweden’s municipalities and what causes the differences. Analyzing the demand side we will investigate the impact of consumer preferences on the market of the biogas cars. The research considers following questions:

How has the market for biogas cars developed in Sweden, during the period of 2009- 2011? Where has the market for biogas cars developed mostly in Sweden? Why does the demand for these types of cars vary across different regions in Sweden? How important is the supply side of biogas (which is represented by the number of gas stations and local production) for the development of biogas car market?

In order to perform the study, we conduct a cross sectional analysis for the year 2010 for all Swedish municipalities. We also analyze the data from time period 2009- 2011 in order to observe the existing tendencies for biogas vehicles. There are no previous studies using cross sectional or time series data, as the market for biogas cars is a relatively new concept and the records are not obtainable before the year 2009. Due to the limited number of observations, we decided to put less emphasis on the time series data. The empirical model is constructed by us, considering the theory of consumer behavior towards bio cars and taking its important determinants into account. The demand as well as the supply side of the biogas car market is described further in the paper. The number of biogas cars per 10000 inhabitants is determined by income per capita, the share of educated population, the existence of plant production at local level the density of gas stations and the number of population.

We chose this study based on a reason, that energy sector is one of the most important and fastest growing segments in every country’s economy, making almost all other sectors dependent on it. As the number of world population continues to rise, so does the number of cars on the road. Escalating number of vehicles increases the dependency on oil imports, generating the problems associated with the security supply (consumers are not able to obtain the desired quantity of fuel when they need it, at transparent prices) and amplifying the urban pollution (E.G.Lindfeldt, 2010). The Information Centre for and about the Global Auto Industry, Ward, reported a historical increase in number of registered cars at the global level, from 980 million in 2009 to 1.015 million in 2010 (Sousanis, 2011) leading to further exponential rise in the quantity demanded for fuels. The developed industrial society is heavily dependent on fossil fuels that supply us with more than 90% of energy. With the recent development of countries, like Brazil, India and China, the demand for energy has risen even more rapidly. This in turn has increased the quantity of CO₂ emissions, negatively affecting the environment by pollution and generation of the greenhouse effect. Sweden makes no exception from this trend if we think that its population rose in the last years and so did the number of cars. Simultaneously the total consumption of fuels enlarged, while its price almost doubled.
The limited resources of oil and its price volatility (price variation from the average value over a measured time period) makes people come to the conclusion that the oil and natural gas resources will come to an end in near future.

A solution to our problem regarding the pollution generated by cars can be the production of environmentally friendly vehicle that drives on biogas fuel and at the same time does not contribute to enhanced greenhouse effect (Erfors, 2010). The production of biogas is a relatively new technology that allows people to solve the following problems: to assure the energy essential for driving cars and to solve the dilemma of pollution by diminishing quantity of CO₂ emissions.
2. BACKGROUND

Political leaders and car owners are concerned about the continuous rise in diesel and gasoline prices as the political instability from Middle East threatens the steadiness of an already fragile global economy. This is one of the reasons of determination for looking for alternative sources of energy (P. Paliwa, 2012). Another reason for this determination is caused by pollution factor that harms not only the environment but people’s health as well (European Environmental Agency, 2011). One of the answers to these problems is substituting the harmful fuels with biogas, a renewable fuel that can be produced from diverse organic raw materials like cereals, rape seed corn and sugar cane, oil palms, organic residues from agriculture, etc. (P. Börjesson, 2008) Some institutions claim that the biogas production is not sustainable, as its production increases the demand for agricultural products that led to further increases in food prices generating the World food crisis, (Fan, 2008). On the other hand, biogas use is designed to determine major improvements regarding resource efficiency, sustainability and environmental issues (M. Lantza, 2007) securing the long time-supply (J. Held, 2008). Therefore the production of biogas necessitates a complex system where different factors such as municipalities, energy companies, farmers etc. are concerned about influencing the system (M. Lantza, 2007). Meeting the future challenges, the political and decisional institutions decided to create small production plants that, in long run, can establish a substantial biogas system able to develop friendly environment and sustainable society (M. Hammar, 2007).

An EU directive recommends that 5.75% of total oil consumption in Sweden, and 20% of bio fuels in transport sector, must be reached by 2020. In order to achieve the goals governments worldwide started to encourage the investment in the development of sustainable energy and technology. The European Commission decided to stimulate the demand for bio fuels considering that it brings environmental benefits by reducing emissions of greenhouse gases in a sustainable manner, assuring the energetic security, increasing number of employment and the competitiveness of the European industry (European Commission, 2006).

Since 1960 bacteria was used in Sweden to transform waste into biogas. This helped to diminish the quantity of trash, but the production of biogas did not exist at that time. When the oil crisis hit the world’s economy in 1970 and 1990, scientists started to develop new technologies in order to become independent of oil imports (Molina, 2011). In 1980 the production of biogas from food waste was started. Nowadays biogas is used not only for heat and electricity but also as a car fuel (Molina, 2011).

Biogas can be used in different ways. The biggest percentage of biogas production 43, 9% is used as car fuel, being the fastest growing sector. It is followed by its use as heat 43, 7, while the other uses are insignificant. (See Graph 1 in the appendix 1 pg. 35) (Biogasportalen, 2011). A vivid advantage of biogas consumption is the independence of economy from oil market fluctuations, (K. McCormick, 2006) and the reduction of CO₂ emissions, as biogas cars emit almost 80% less CO₂ than the gasoline cars (Hugosson, 2010). Sweden is one of the leading countries that desire to become independent of fossil fuels until the end of 2030. In 1990 the transport sector was 100% dependent on fossil fuels, being responsible for one third of the total CO₂ emission. Nowadays, the development of hybrid, electric and bio fuel cars reduced the CO₂ emission by more than 9% determining a low national emission per capita, while the GDP has risen with 48% between 1990- 2007. Taxes on energy and emissions are
helpful tools contributing to fuel selection helping to achieve targets within the climate and energy area that can influence the behavior of both households and enterprises (Ministry of Enterprise, Energy and Communications, 2009).

Measured in cubic meters (Nm³) and generating almost 20% more energy than other fuels, (Energigas Sverige, 2012) biogas is a cheaper alternative of fuels (Fordongas, 2012). Other advantages that drive people from the use of a biogas cars are as follows: the local authorities reduce taxes, subsidize building of biogas stations with almost 1/3, reduce taxes on company cars or introduce dispensation for parking fees for environmentally friendly vehicles in order to encourage their use (Energigas Sverige – Swedish Gas Association, 2011). Furthermore, when using a biogas car “the risk of fire or explosion is less than for other fuels” and the noise is substantially diminished. Moreover the maintenance price for natural gas vehicles (NGV) is the same or even lower than traditional gasoline vehicles (Torresani, 2010).

In spite of all the positive points, there are some problems associated with driving biogas cars. A controversial debate takes place due to some evidences that increasing food prices are associated with a rise in biogas production, as manufacturing of biogas increases the demand for agricultural products used in production process and reduces the accessibility of food supply. Some authors argue that the production of biogas from different types of cereals, especially maize and sugar cane leads to an increase in the demand for those agricultural products and changes the specificity of land area from food production towards bio fuels production. As a consequence, the raise in the prices of maize and sugar cane stimulate the supply side by determining peasants produce more cereals in order to increase the profitability. Meanwhile the consumers shift their demand to other grains which affect the prices as well (Rosegrant, 2008). Sweden also followed the international trend and the increase in biogas production lead to a boost in food prices. For example the price of corn has risen in Sweden from 144, 4 per 100 kg in 2008 till 177, 7 per 100 kg in February 2011, which results in total increase of almost 23% (Jordsbruksverket, 2012). Other authors state that the increase in food prices is mostly determined by the increase in fuel prices, financial speculation and recent strong economic growth of China, India and other developed countries that raised the demand for food (Ajanovic, 2011). Another negative aspects derived from using green vehicles is associated with tax reduction strategy that affects the budget negatively (Stenkjaer, 2008). Biogas cars can be inconvenient because of their constant need to be refilled whereas the biogas stations are pretty scarce. Other risks can be enumerated as: risk for poisoning due to non-purified trace elements, risks appeared due to high pressure etc. (Petersson A. , 2011).

Sweden has a natural advantage in exploiting the renewable energy sources, especially bio fuels, because of its abundant forest resources. One of the most important factors is the political willingness to reduce the dependence on fossil fuels. (Traufetter, 2006). The present percent of bio fuels used in Swedish transport sector amounts in 5, 2%, meaning that the opportunities of attainment the compulsory objective of 10% by 2020 are possible (T. Rydberg, 2010). Sweden’s final goal is to become “fossil fuel independent” of road vehicles. In order to achieve the goal, it is necessary to increase the demand for bio fuels and other renewable vehicles, so that the quantity supplied of biogas can also be enlarged (T. Rydberg, 2010). The use of biogas vehicles depends on many factors such as: the competition for biogas use and its relative price (in transport, heat, and electricity use), the level of financial assistance that lowers the market price of biogas determining the consumers demand on it, the
price of biogas cars that is higher compared to other vehicles, the limited number of biogas filling stations, the lack of information of potential buyers etc. (T. Rydberg, 2010). The Government of Sweden has defined more than 16 general goals in order to improve the environment and to decrease the dependence of fossil oil (J. Held, 2008). The intention of the Swedish government is to reduce the CO\textsubscript{2} emissions with more than 40% by 2020 reaching 0% by 2050. Governments intend to attain 50% of Sweden’s energy from renewable energy sources until 2020, and 10% of this share must come from transport sector. This is how the aim of the Swedish government looks like. In 2030 Sweden wants to have a 100% independency of fossil fuels in transport sector (Ministry of Enterprise, Energy and Communications, 2009).

In order to achieve this target the government developed instruments like energy and carbon taxes that put a price on emissions, obliging the polluters to pay, which makes driving a high emission car more costly. The level of taxation for cars will be different depending on how much carbon the car produces. Starting from July 1 2009 the green cars are free from taxes for five years while the classification of “green cars” will be tightened step by step. The government will also stimulate the development of alternative technologies. Investment in environmental technology, production of renewable fuels and improvement of knowledge about green vehicles are priorities for researchers and Sweden’s government (Ministry of Enterprise, Energy and Communications, 2009). Sweden’s active policy makers, encourage usage of renewable vehicles by tax reduction trying to reduce pollution and the greenhouse effect. A positive effect derived from this measure is the reduction of oil import dependency, creating incentives to produce bio fuels at the local level and increase the number of employment in the sector (Stenkjaer, 2008).

2.1 Previous research

As environmentally friendly cars is a relatively new subject there are only few studies about the consumer behavior towards biogas vehicles. Nevertheless some studies about green cars were conducted in a few regions of the world and in the North of Sweden. The previous studies are mostly based on surveys, because the scarcity of statistical data. The novelty of our research is caused by the fact that we succeeded to collect all the necessary data and construct our investigation on it.

Nitin Joshi, D. P. Mishra (2011) in their paperwork about Environment Friendly Car: A study of Consumer Awareness with special reference to Maharashtra State conducted a study about the consumer behavior. The aim of the study was to determine people’s awareness of environmentally friendly cars by splitting costumers in various age groups (less than 35 years and more than 35 years) and geographical areas (metro or a non-metro in Maharashtra). In order to collect the necessary data from Maharashtra—one of the most developed regions of India, the sample survey technique was used for the study. The outcome showed that there is insignificant difference in people’s awareness of environmentally friendly cars with reference to the two age groups. However there is a great difference in people’s awareness level in metros and non-metros regions, in the sense of costumers living in cities being more aware of the importance of using environmental friendly cars (N. Joshi, 2011).

An interesting research was conducted by Hanna Wang-Helmreicha and Stefan Lochnerb concerning the quantification of the CO\textsubscript{2} reduction potential in case of natural gas cars introduction on Germany’s road transportation on the large scale. They identified the main barriers for introduction of the green cars associated with filling station infrastructure,
vehicles qualities and capital and operating costs. They made an analysis based on different scenario of the emission reduction potential and the abatement cost, demonstrating that the abatement potential in Germany is higher in medium and long run only if the supply of gas is sufficient and its price is considerably lower than gasoline and diesel prices. They also concluded that the capital cost for construction of natural gas infrastructure is too high and its realization can be reached only in case of the low prices of gas (S. Lochner, 2011).

Mahzabin Chowdhury and Khan Rifat Salam studied in 2011 the attributes that determine the consumer behavior for green cars, their buying decision and the effect of consumer's awareness about environmental concern on this decision. The study was conducted in Sweden in the Umeå Kommun. They used monotone regression model, pre-screening survey and interviews in automobile industry in order to assess the importance of these attributes. Their findings show that price, brand and engine power are relevant factors for consumer decision making process when buying environmentally friendly vehicles (M. Chowdhury, 2011).

M. R. Byrne and M. J. Polonsky from University of Newcastle in Australia studied the “Real and perceived impedimenta to consumer purchasing: alternative fuels vehicles” They studied a series of factors like: regulatory barriers, resources, and infrastructure and vehicles characteristics that can influence the consumer’s attitude towards alternative fuels vehicles. They consider that these factors have also impact on different categories of stakeholders: Government, suppliers, producers, competitions and Activist Groups. In their opinion the Government has an important contribution to the development of the alternative fuel vehicles (AFV) by its legislation requirement legislation regarding the CO₂ emission. Also with the help of tools like subsidies and tax reduction the Government can increase the potential production of AFV. The stockholders represent the producer of AFV that try to meet the government requirement as well the buyers need and satisfaction. However the producers of AFV are dependent on the availability of the alternative fuels and by their partnership with fuels suppliers, market distributors and infrastructure providers. Activist Groups have an important impact on public opinion leading to an easier acceptance of AFV. Finally the consumers that are the most important target of producers represent that reason of AFV development. As impediment for AFV production Byrne and Polonsky enumerate the regulatory barriers like environment regulations, the relative lack of information accessibility about safety as there already exist concurrent regulations regarding the safety of traditional cars, the lack of demand, the purchasing price, and the insufficient development of infrastructure. The conclusion states that the consumer decision to buy AFV has rather economical roots than ideological which means that initial reason for buying AFV is the increasing price of oil, not the reduction of the pollution (M.R. Polonsky, 2001).
3 THEORETICAL FRAMEWORK

3.1 Consumer behavior

Erasmus (2001) defines the consumer behavior as a process in which a person is implicated in obtaining, consuming and disposing a product or a service, including the judgment process that precedes and follows his decision (A. Erasmus, 2001). “Consumer behavior is much more than buying things, it also embraces study about how having (or not having) things affects our lives, and how our possessions influence the way we feel about ourselves and about each other – our state of being” (Solomon, 1992). In our case consumer behavior refers to the factors standing behind the buying decision of a biogas car.

Consumer behavior is influenced by many factors, one of the most significant being the utility gained by purchasing a product. The utility term refers to the amount of satisfaction that a person receives from consuming a good or a service and is based on “individual’s preferences- indifference relation” that can be interpreted as choice of alternatives that determine the demand for one good (Fishburn, 1968).

An important factor that can have an effect on consumer behavior is the life cycle of the product. Consumers should have an ability of making a tradeoff between purchasing price of the product and the future operating cost (Deutsch, 2007). Therefore the product life cycle has been a recurring concept in consumer behavior analysis. Product life cycle models are based upon the idea of declining demand due to market dissemination, introduction of more advanced goods and technologies, or the changes in taste of consumers (Bollen, 1999). The process is characterized by the expanding regime in the beginning, accompanied by the demand growth, eventually switching to the decadence cycle, when the demand declines over time (Bollen, 1999).

As stated before consumer behavior is a practice when a person incorporates the judgment process on the subject of buying decision. The decision is equally affected by the demand and the supply sides of the market. The demand for biogas cars can be defined by several factors such as income, consumer preferences, number of buyers, price of related goods, and future expectations of price. The supply on the other side is analyzed by the cost of the product, technology advances, number of sellers on the market and future expectation of prices. Economic theory proves that the demand for one product increases when its price decreases, while the vice versa is true for the supply. In case of introduction of new technologies, like biogas cars or biogas fuels, their selling price is soaring because of the high level of required investment for research and production costs. In this case the demand for these products can be low not only due to prices but also because of the existence of various substitutes. Because of the existence of environmental and economic advantages coming up with this type of consumption, the government intervened with tools like tax reduction and subsidies, which alter consumer’s behavior by increasing their demand for biogas cars as well as biogas fuels (Cohen&Winn, Market imperfections, opportunity and sustainable entrepreneurship, 2007). This market imperfection stimulates not only the demand part of the market but its supply side too.

In reality the consumer behavior towards biogas vehicles is affected by a series of factors like: gender, age, occupation, income, level of education etc. and has an important effect on the
definition of the product market as “usage decisions can vary widely from person to person and from culture to culture” (D. Hoyer, 2008). Level of education plays an important role in consumer behavior regarding biogas cars. For example: the higher the level of education is, the bigger is people’s environmental awareness, meaning that they are more conscious about human actions on the environment (Asli K., 2012). Its leading role in determining people’s awareness can change their attitude regarding the use of green vehicles. If they know what are the environmental advantages of driving these types of cars they are more willing to change their behavior. Regarding the consumer behavior towards the use of green fuel or technology, positive attitude can be observed due to benefits generated for environment as well as status or altruism (V. Griskevicius, 2010). The most important reason that stays behind the consumers behavior is the awareness that the environment must be protected and the green products must be developed, even if they are more expensive or the quality criteria is not the best (Paliwal, Consumer behaviour towards alternative energy product, 2012). Other important findings for consumer’s researches regarding biogas cars are personality, cognitive dissonance, perceived risk, life style, fashion, attitudes and intention, interpersonal influences, relationship between supplier and buyer, family decision, information acquisition etc. (J. R. Bettman, 1978).

**Demand side**

The most important factors influencing the demand side of the consumer behavior regarding biogas cars are: consumer utility, income, price of the product, the level of education, fuel economy, CO₂ emissions optimal advertising etc.

*Consumer utility* - The human desires are unlimited while the resources are scarce, so the consumer cannot satisfy all wishes and therefore one must choose between different models of cars in order to obtain the maximum satisfaction. The consumer chooses between different types of vehicles because of the satisfaction or utility gained from the product (Perloff, 2008). The utility gain in this case is defined as the power of a car to give satisfaction to purchaser derived from consuming the good (Pressman, 1999). The consumer will try to maximize its utility to the budget constraint that is determined by derivative of the demand function (Slutsky, sulla Teoria del Bilancio del Consummatore, 1915) and (Antonelli, 1886) or by the algebraic condition of the demand function implying the maximizing behavior named revealed preference theory (Samuelson, A Note on the Pure theory of Consumer's Bahaviour, 1938).

*Income* - The budget constraint represents the bundle of cars that can be bought if the entire budget is spent on cars at a given price while its slope measures the rate at which the buyer will trade off one type of car for another and their relative prices. Furthermore, the indifference curve represents a set of different combinations of cars between the customers, giving buyers the same satisfaction or utility by consuming them. It represents the willingness to trade one model of car for another. The rate of exchange between different types of cars is called the marginal rate of substitution (MRS) (Perloff, 2008). The demand function for cars implies the revealed preferences demonstrating that the buyer will choose the best bundle that one can afford while the indifference curve is convex to origin, leaving the consumer with only one bundle on his budget constraint (P. Samuelson, 1947). The theory demonstrates how the consumers substitute one type of car with another when its price rises and how the entire
demand function for vehicles shifts upward when the income rises, or shifts downward when the income falls (Perloff, 2008). The slope of the demand curve is affected by the change in the prices of bio cars. The utility is maximized at the point where the budget constraint meets the indifference curve. The elasticity of a product is quite important due to the fact that it reveals the willingness of buyers to change one product with another then when its price is changing. Falling prices rotate the budget constraint upwards, making the elasticity of the slope rise, as the consumers can buy more, whereas increasing prices rotate the budget constraint inwards, resulting in rather inelastic slope.

**Fuel Economy** - one of the most important factors determining the choice of the cars due to the increase in the oil prices (Vasilash, 2010). For example in Poland the increasing popularity of using alternative fuels and consumers behavior is not determined by their orientation towards ecological vehicles in the first place, but rather by the continuous increasing price of oil and the association that is made between gas price and the economic benefits (Urbanska, 2011).

**Price of the product** - The consumer behavior regarding biogas cars is strongly related with product’s price elasticity and elasticity of substitution. Price elasticity of demand is defined as the change in quantity demanded that derives from changes in prices, while all the other factors are held constant (S. Hoch, 1995). The elasticity determines the responsiveness of the demand on a biogas car to change in their prices. As the demand on a bio vehicles depend on various factors, there are different kinds of elasticity (J. Munksgaard, 2001). The elasticity of substitution can be described as a special case in which the consumer’s demand for biogas cars increases or decreases as an effect of rising or falling in prices of normal cars (Slutsky, sulla Teoria del Bilancio del Consummatore, 1915). In case of existence of many substitutes or complementary for biogas cars, its cross-price elasticity would be rather big numerically than if there were only few substitutes. The neoclassical model approach of consumer behavior assumes that a consumer’s selection behavior can be illustrated by obtaining from utility maximization subject to a budget constraint (Varian, 1983). Prices influence the consumer behavior in the same degree as the fuel economy. Lane (2007) argues that the price of vehicle influences the attitude-behavior difference regarding consumers’ buying habits of biogas cars (Lane, 2007).

**Engine Power** - Although not being the most influential factor in consumer decision making, it has a significant effect on making the final choice (B. Caulfield, 2010)

**CO₂ emission** - the quantity of the CO₂ emission specifies the degree of pollution produced by a car and determines its level of taxation. Amount of the taxes are considered to be one of the most significant factors in consumer decision making. (J. Hill, 2009).

**Brand** - It plays a substantial role in purchasing process, explained by buyer’s previous experience and utility of brand identity. It can also be related to social status (Bloemer&Lemmink, 1992).

**Car Size** - The size of car is stated to be among top three factors for the car buyers, revealing the consumer’s needs for space (J. Hill, 2009).

**Optimal advertising** - (Näslund, Consumer behaviour and optimal advertising, 1979) is a way of informing people about new products like biogas technologies. This factor has the
advantage of increasing customer’s awareness regarding economic and ecological benefits derived from biogas car use.

**Supply Side**

Analyzing the supply side of the market the following factors can be considered to have a significant effect on consumer behavior:

*Infrastructure* - Another major factor that influences the consumer behavior is represented by the number of filling stations for biogas cars that must be comfortable for customers. As the use of biogas cars is at the beginning of its life cycle, an already well-established infrastructure does not exist in this field. Furthermore, oil stations are not usually compatible with biogas stations and their number must be nearly the same as ordinary oil stations. This fact is considered to be a barrier for the increase in number of biogas cars (Schwoon, 2006).

The location of gas stations – is strongly correlated with infrastructure as the easy accessibility to gas stations is a necessity when buying a biogas car. The existence of at least two gas stations located in the same town give confidence to consumers that the investment in biogas is a long-term project (M Hammar, 2007). The greatest distance between biogas stations must be 40 km in order to determinate the consumer to adopt biogas cars (Wang-Helmereich, 2011).

*Local production* - can also be an important factor influencing the consumer behavior, if we inform the customers about where and in what conditions products are produced, what kind of environmental and social impacts are associated with production. Moreover, the customer can also influence the production. By the act of raising demand for ecological products people influence company’s behavior, encouraging their thinking about long-term and global implications, so the firms become more determined to produce environmentally friendly products. The basic assumptions of the neoclassical economics are: people are rational individuals with rational preferences, they maximize their utility and companies maximize their profits, and lastly, people act independently on the basis of full and relevant information. Being a rational individual with rational preferences the costumer will purchase the product that brings the maximum utility for him as well as for the society (Pertsova, 2007).
4 EMPIRICAL ANALYSIS AND DESCRIPTIVE STATISTICS

The purpose of our study is to find out how the market for biogas cars has developed in Sweden and why its demand is not homogenous between country’s regions. In order to get to this point we use cross sectional data for years 2010 and time series data for period 2009-2012 from different sources. The data for number of the biogas cars and total number of cars in traffic was collected from Trafik Analysis (Trafik Analys, 2012), population (SBC, 2011), educated population by municipalities (SCB, 2011), income (SCB, 2011) and land areas (SCB, 2011) comes from Sweden Statistics, the statistic for prices of gasoline were collected from Svenska Petroleum & Biodrivsmedel Instuitut (SPBI, 2012) and the information about the numbers of biogas stations and the prices for biogas were obtained by direct correspondence with Energigas Sverige (Ekman, 2012). The dummy variables are also used in our cross sectional analysis and they take the value of 1 if the biogas is produced at the local level and 0 otherwise. The data regarding the places where the biogas production takes place was collected from Biogasportalen (Biogasportalen, 2011).

4.1 Cross-sectional Data

Using the cross-sectional data representing the statistics of the year 2010, we created maps, representing the distribution of biogas cars per capita, the density of biogas stations and the location of biogas production in the Swedish Municipalities in order to have a better representation of our data.

Map 1- Distribution of Bio-cars per 10000 inhabitants in Sweden

The map above is representing the number of biogas cars per 10000 inhabitants. The highest density is found in Stockholm Region, with a medium value equal to 27, 29. The municipality
with the highest compactness is Solna municipality with a number of 177, 27 biogas cars per 10000 inhabitants, followed by Nacka municipality with a density equal to 101, 65. The lowest value in the Stockholm region is found in Nynäshamn with a density of 6,53. Halland region is ranked second with values between 9,82 and 36,33 that correspond to Hylte and Halmstad municipalities. Västra Gotaland, Skåne and Östergötland stand for a medium value of 22,35; 20,97; 19,75 respectively corresponding to biogas cars per 10000 inhabitants. In Västra Gotaland the highest density is found in Lilla Edet with a value of 70,75. In Göteborg the number of biogas cars per 10000 inhabitants is equal to 55,37. Skåne region is represented in the top with Malmo municipality, having a density of biogas cars per 10000 inhabitants equal to 57, 59 while Östergötland, Linkoping reaches the value of 54,84.

Map 2- Distribution of Gas stations in Sweden

Observing the map above we can detect that the biggest amount of biogas stations is found in Västra Gotaland with the total number of 49 gas stations, followed by Skåne region with the total amount of 23 gas stations and Stockholm region with 20 gas stations. The majority of the gas stations are situated in the Southern part of Sweden, while in the Northern part of the country scarcity is observed in the amount of filling stations. As for the density of the gas stations, the biggest amount of concentration is observed in Stockholm region. Although the ranking of the regions from largest to smallest and the descending number of cars are not
perfectly proportional, we can conclude that the number of bio vehicles and the amount of the
gas stations are strongly correlated. The high number of biogas stations in Västra Gotaland
can be explained by the size of the region, which is by far the largest among the three areas.
The same trend is detected in case of other two regions, meaning that the number of biogas
stations diminishes with the decreasing size of a particular region. On the other hand, the large
number of the biogas vehicles in Stockholm region can be correlated with the number of
population, reaching 2 091 473, almost double compared to the second ranked region- Västra
Gotaland with the total amount of 1 590 604 inhabitants (SCB, 2012). In the north part of
Sweden we can see that we have a significant number of biogas cars, while the number of gas
stations is relatively low. This can be explained by the fact that many municipalities own non-
public gas stations for the purpose of refilling and sustaining the public traffic.

Map 3 - Production of biogas in Sweden

From map number 3 we can observe that the majority of plant production of biogas in Sweden
is distributed on the southern part of the country, having the biggest concentration in the same
regions where the number of biogas cars is the largest, although the northern part of Sweden,
for example Kiruna, can be regarded as an exception due to the presence of the production
plants. The existence of a high number of biogas cars in Västerbotten region can be explained
by the fact that there is a considerable number of non-public gas stations in Sweden, that are
used for supplying the public local traffic with gas and by the fact that the majority of
production is used for heat.
The map number 4 represents the percentage of educated population in Swedish municipalities. The highest percent of educated population is found in Järfälla, with more than 24%, followed by Kiruna with 20%. In all the other municipalities the percentage of educated population varies between a maximum of 19% and a minimum of 12 %. The minimum percent of educated population is found in Tomelilla and Danderyd. The highest percentage of educated population in Municipality of Järfälla can be explained by its proximity to Stockholm (being considered a Stockholm’s suburb); also its intense economic activity contributed to this concentration. For Kiruna the high number of educated people can be clarified by the fact that the iron extraction is a key industry and corporations established there require highly educated personal. Another important factor that determines the high concentration of educated population in this region is the Swedish Government’s decision to relocate the Swedish Space Corporation, and the Environment and Space Research Institute in the Kiruna region in order to reduce the regions dependency on mining. These institutions also required to have highly educated personal.

4.2 Time series data

The time series data collected from Energy Gas Sweden for the period 2009-2010 representing the number of gas stations, the prices and the number of biogas cars was used only in order to capture a general image about the evolution of the market over the last three years. As the number of observations is limited to 39 and the existence of the increasing trend
does not allow us to run a regression without taking the first difference, which in turn destroys our data, we will only describe them.

Observing the data (See Graphs 4-6, pg. 37-38 in Appendix) we can say that there is an increasing trend in all our chosen variables and there is a correlation between the numbers of gas stations, prices and the number of cars. We can also confirm that there is an almost constant increase over the time in the number of the biogas cars as well in the number of the biogas stations.

4.3 Descriptive Statistics

Considering our variables, the regression model looks like:

\[
\log (\text{Biocarscrecap} \times 10000) = \beta_0 + \beta_1 \log (\text{Educorp}) + \beta_2 \text{Densegasstations} + \beta_3 \log (\text{Income}) + \beta_4 \text{Dummy} + \beta_5 \log (\text{population}) + \varepsilon
\]

In order to analyze the circumstances in different regions of Sweden we use the method of least squares considering the number of biogas cars per 10000 inhabitants as the dependent variable and the level of medium income per capita, the percentage of educated population, the density of gas stations, the existence of the biogas plants as independent variables and the total population. The Log model is used. The Log model is used because the variables are skewed (their graphical representation indicates that the tail on the right side is longer than the left side and the mass of the values is found to the left of the mean). Another reason can be that the implementation and acceptance of technology takes considerable amount of time. The log model also gives the possibility to calculate the elasticity using the slope coefficient \( \beta \).

The study is conducted for the year 2010. All the variables are on a municipal level.

The dependent variable, biogas cars per 10000 inhabitants was calculated by dividing the number of biogas cars by the number of population and multiplying this with 10000 inhabitants.

The level of medium income per capita is defined as the sum of money received by an individual during a fixed period of time from the salary, business income, the pension and sickness benefits. The variable was chosen due to the fact that it represents the purchaser availability to buy or not to buy a product. A rise in income level is expected to have a positive impact on the demand of biogas cars. The variable of the percentage of educated population was included in our model as the theory proves that a higher level of education increases the level of understanding and the awareness of people regarding the environmental issues, in this case the necessity of driving environmentally friendly cars. A higher number of educated people is expected to determine an increase in the number of biogas cars. The variable was calculated by dividing the number of educated population by the number of total population. The educated individual is regarded as a person who has completed at least 3 years of the university studies. The density of gas stations variable is included in the model because the existence of infrastructure is a mandatory requirement, without which filling up a car with biogas would be impossible. It is expected, that a greater density of gas stations will generate an increasing trend in the number of biogas cars. The variable was calculated by dividing the number of gas stations by the total land area of municipalities. The existence of
plant production of biogas considered as a dummy variable takes the value of 1 if the biogas is produced at the local level and 0 otherwise. It is included in our model because while producing biogas at the local level, the community obtains energetic independence by having access to a renewable source of energy avoiding the high price fluctuations that characterize the oil market. Finally the total population variable was included in the regression due to the fact that the number of population would help us to predict the potential expansion of the market for the biogas cars.

In the table 1 below, we can observe the outcomes of the descriptive statistics explaining the nature of the statistics used in the regression model. For each variable, the mean, range, minimum, maximum and standard deviation values are described.

Table 1- Descriptive statistics for cross-sectional data 2010

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nr. Obs.</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>St.Dev.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biocarspercap*10000</td>
<td>290</td>
<td>0.435</td>
<td>177.271</td>
<td>86.22</td>
<td>17.28</td>
<td>176.835</td>
</tr>
<tr>
<td>Mediumincome</td>
<td>290</td>
<td>179696</td>
<td>311356</td>
<td>223696,310</td>
<td>21648,078</td>
<td>131660</td>
</tr>
<tr>
<td>%educpop</td>
<td>290</td>
<td>0,012</td>
<td>0,240</td>
<td>0,169</td>
<td>0,153</td>
<td>0,228</td>
</tr>
<tr>
<td>Population</td>
<td>290</td>
<td>2460</td>
<td>847073</td>
<td>32467,48</td>
<td>64912,849</td>
<td>844613</td>
</tr>
<tr>
<td>Dummy</td>
<td>290</td>
<td>0</td>
<td>1</td>
<td>0,46</td>
<td>0,499</td>
<td>1</td>
</tr>
<tr>
<td>Densegasstations</td>
<td>290</td>
<td>0</td>
<td>0,850</td>
<td>0,002</td>
<td>0,007</td>
<td>0,085</td>
</tr>
</tbody>
</table>

The number of observations for all variables is 290, with values for the dependent variable that reached minimum at 0.435 and maximum at the value of 177.271. The variable population has the highest standard deviation value (64912,849) representing the spread of observations of the mean, while the lowest value is 0,007 for the variable density of gas stations.

4.4 Analysis

In our analysis we run a cross sectional regression in order to find out how the dependent variable biogas cars per 10000 inhabitants is determined by the variables income, population, the share of educated population, density of gas stations and the existence of the plant production at the local level.
The table 2 below shows the outcome from our cross-sectional regression model. Interpreting the data obtained in the regression above we test the significance of our variables at the 5% significance level. The following hypotheses are stated:

H0: β coefficients for percentage of educated population, density of gas stations, income per capita, and dummy for plant production and population are significant at the 5% significance level;

H1: β coefficients are not significant at 5% significance level.

The regression shows that the variables income per capita, density of gas stations, and population are significant for the regression model because their p values are lower than 0.05 significance level, while the variables percentage of educated population, and dummy for

<table>
<thead>
<tr>
<th>Dependent:</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biocarspercap*10000</td>
<td>-45.05224</td>
<td>8.874720</td>
<td>-5.076469</td>
<td>0.0000</td>
</tr>
<tr>
<td>Log(Mediumincome)</td>
<td>3.395490</td>
<td>0.742515</td>
<td>0.224792</td>
<td>0.0000</td>
</tr>
<tr>
<td>Log(%educpop)</td>
<td>-0.433756</td>
<td>0.355859</td>
<td>-1.218897</td>
<td>0.2239</td>
</tr>
<tr>
<td>Log(population)</td>
<td>1.493888</td>
<td>0.083164</td>
<td>4.572956</td>
<td>0.0000</td>
</tr>
<tr>
<td>Dummy</td>
<td>0.032137</td>
<td>0.142962</td>
<td>-0.187154</td>
<td>0.8517</td>
</tr>
<tr>
<td>Densegasstations</td>
<td>22.63432</td>
<td>10.12253</td>
<td>2.236033</td>
<td>0.0261</td>
</tr>
</tbody>
</table>

R-squared 0.310060
Adjusted R-squared 0.297913
F-statistic 25.52598
Prob(F-statistic) 0.000000
plant production are not significant for our model because their p values are higher than 0.05 significance level.

In order to check for the normality of the residuals, we saved the residual as a new variable and plotted the data to see if the Heteroscedasticity existed (See Table 2A in appendix pg. 39-40). The figure shows no existence of heteroscedasticity. In order to be more precise we run White´s Heteroscedasticity Test.

Testing for Heretoscedasticity we state the following Hypothesis:

H₀: There is Heteroscedasticity

H₁: No Heteroscedasticity

Testing at 5% significance level, the chi-square observed value at 19 degrees of freedom is equal to 23.01106, which is less than the critical value equal to 31.0000 meaning that we should reject H₀. We can conclude that there is no heteroscedasticity in the residuals.

Multicollinearity can be a problem if the correlation between the independent variables exist as it increases β coefficients standard errors. Multicollinearity can be detected by checking the VIF value. Value close to 1 indicates that there is no multicollinearity, while value around or greater than 5 specifies that the collinearity related to that variable occurs. In our case, multicollinearity does not exist as the values of VIF for all the variables are in between 1 and 2 (See table number 1 A in the appendix, pg. 39).

The model shows that there is no problem regarding heteroscedasticity or multicollinearity so the β coefficients can be interpreted considered the log model.

Analyzing the results from the regression model, we can observe that the changes in independent variables included in the model explain 31% of the change in the dependent variable. The β coefficient shows the slope elasticity of the dependent variable meaning that 1% increase in the independent variable determines the change equal to β coefficient’s value in the dependent variable. Considering the consumer behavior theory we can confirm that the income is one of the most important factors that determining the upward movement of the demand curve. Describing the output more specifically, 1% changes in income causes an increase equal 3.95490%. The variable educated population was included in our regression model because earlier studies proved that this factor can raise the awareness of people regarding the environmental benefits of driving biogas vehicles. In our case the output of the regression could not prove the theory because the factor is insignificant, having a p-value of 0.2239 that is greater than our 0.05 significance value. Moreover, the β coefficient shows a negative value, indicating that if we increase the number of population by 1 percent the number of biogas cars would be influenced negatively with – 0.43756%. The variable size of the population confirmed previous study conducted by Nitin Joshi and D. P. Mishra regarding people’s awareness level about environmentally friendly cars in metros and non-metros regions, in the sense that the level of awareness is higher in regions where the number of population is greater. The variable total number of population used in our regression model shows that 1% increase in the number of population would cause a change in the demanded number of biogas cars equal to 1.493888%.
Analyzing the supply side factors that influencing the consumer behavior, the variables density of gas stations included in the regression model have significant effect at 5% significance level because its p-value 0.0261 is lower than 0.05. Moreover, 1% increase in the independent variable density of gas stations determine an increase in the number of biogas cars per 10000 inhabitants equal with 22.63432. The dummy variable representing the presence of local production of biogas is not significant for our regression model because its p-value is higher than 0.05 significance level.

In conclusion, the model shows that except for the level of educated population variable all the other factors have an influence in determining the dependent variable. The variable income has one of the biggest impacts in defining the number of biogas cars. Surprisingly the variable educated population affects the dependent variable negatively.

Regarding the supply side factors that influence the consumer behavior, we can conclude that, the number of gas stations has a significant influence in determining the number of biogas cars per 10000 inhabitants, while the dummy, representing the local production plants, is not important at 0.05 significance level.

As the R-square value is low, equal to 0.310060, the independent variables cannot sufficiently explain the changes in the dependent variable. There must be other factors that influence the consumer behavior regarding the biogas cars. Factors like local prices, substitute prices (in this case oil prices), technical performances of biogas cars, car’s prices, brand, Engine Power, car size, reduction in local taxes and other facilities etc. can explain more accurately why the number of biogas cars increase.
5 CONCLUSION

Investigating the situation from 2010 regarding the demand and supply of gas vehicles with the help of cross section data we found out that their spreading on Sweden’s territory depends on factors like income per capita, the share of educated population, the existence of plant production at local level the density of gas stations and the number of population only in small proportion.

The data shows that the biggest concentration of gas vehicles is associated with Sweden’s largest cities (Stockholm, Goteborg and Malmo) and their surroundings regions (Solna-, Nacka, Lilla Edet) depending on the population size and the density of gas stations. Our regression model confirms some of our predictions, regarding the positive correlation between the number of biogas cars and the variables income, the density of gas stations and the number of population. These predictions take into account the consumer behavior theory as well as the previously made studies, regarding the buyer’s awareness of environmental issues. The predictions about the influence of the education level and the biogas production on the local level, are not sustained in practice, thus they have negative influence on the number of biogas cars. The other variables used in the regression model do not turn out to have a significant effect on the change in number of biogas cars.

The aim of this thesis was to analyze the Sweden’s actual situation regarding the consumer’s behavior towards biogas cars and to identify few important factors that stand behind their attitude for green cars market. As stated above the variables included in our regression model could not sufficiently explain the changes in the number of biogas cars. There are many other factors (like: local prices, prices of substitutes, tax reduction and other advantages that derived from driving an environmental friendly car, etc.) that influence the consumer behavior for biogas vehicles. Those factors could not be included in our regression model due to the lack of data.

Further Research

It is recommended to study the evolution of the biogas car market for longer time period using time series data, including such variables as income, the level of taxes, gender, age etc. Furthermore, it would be interesting to find out how the elimination of taxes for the green vehicles affects the budget of the country. Another research could be made about the impact of using the agricultural products in the biogas production on food prices. It would be
challenging to find out how much of the percentage increase in the prices of food is determined by the use of the agricultural products in the biogas production.

**Recommendations**

In order to increase the number of biogas cars a good strategy could be to inform the customers better regarding the benefits derived from owning this type of vehicles. The infrastructure represented by the number of gas stations is an important factor that influences the demand for biogas cars as well the price of biogas. Many drivers do not know the advantages of the economy fuels; in fact biogas prices are cheaper compared to gasoline prices. Moreover, the location of gas stations is not so visible, for instance the majority of gas stations are located in cities but not on the highways where the traffic movement is intense. If a driver has to travel for long distance, searching for the biogas filling station can be inconvenient as it might cause the loss of time. Owing to those facts better advertising of biogas cars is necessary. The construction of few gas stations showing the comparison of biogas and gasoline prices in close proximity to highways can be an efficient way to inform the consumers.
References

(s.f.).


Energigas Sverige. (1 de march de 2012). *Vad betyder jämför pris per 1 liter bensin?*. Recuperado el 28 de Marsh de 2012, de Gasbilen.se: http://www.gasbilen.se/Att-tanka-dingasbil/FAQFordongas/FAQJamforpris


Fordongas. (1 de 03 de 2012). Recuperado el 28 de Marsh de 2012, de Fordongas: http://www.fordonsgas.se/Svenska/Kundsupport


SCB. (2011). Land and water area in square kilometre by region, type of area and period. Stockholm: SCB.


Sousanis, J. (15 de August de 2011). *World Vehicle Population Tops 1 Billion Units*. Recuperado el 05 de marzo de 2012, de Wards Auto- webbplats:
http://wardsauto.com/ar/world_vehicle_population_110815/

SPBI. (15 de May de 2011). *Priser & skatter*. Recuperado el 16 de May de 2011, de Statistik:
http://spbi.se/statistik/priser?gb0=year&df0=2000-01-01&dt0=2012-12-31&ts0=0


SPBI. (15 de April de 2012). *Statistik bensin priser*. Recuperado el 24 de April de 2012, de Priser & skatter: http://spbi.se/statistik/priser/bensin?gb0=month&df0=2009-01-01&dt0=2012-12-31&ts0=0

SPBI. (15 de May de 2011). *Volymer Statistik*. Recuperado el 16 de May de 2011, de Statistik:
http://spbi.se/statistik/volymer?gb0=year&df0=2000-01-01&dt0=2011-12-31&ts0=0


Trafetter, G. (22 de 03 de 2006). *Oil Independece- Sweden Plans Wood-fueled Future*. Recuperado el 21 de 03 de 2012, de Spiegel Online International:
http://www.spiegel.de/international/spiegel/0,1518,406937,00.html


Appendix

Graph 1– Usage of Biogas

Source: Biogasportalen.se
Graph 2– Plotting the residual

![Graph 2](image)

Graph 3- Plotting the residual

![Graph 3](image)
Graph 4 - Number of biogas cars for period 2009-2011

Graph 5 - Prices for biogas for period 2009-2011
Graph 6 - Number of gas stations for period 2009 - 2011

Graph 7 – Number of Biogas cars per capita
Table 1A – VIF for Table 2
The output of the regression model for cross-sectional data 2010

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncentered VIF</th>
<th>Centered VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>21867.53</td>
<td>NA</td>
</tr>
<tr>
<td>LOG(MEDIUMINCOME)</td>
<td>23111.29</td>
<td>1.30158</td>
</tr>
<tr>
<td>LOG(EDUCPOP)</td>
<td>112.0054</td>
<td>1.021556</td>
</tr>
<tr>
<td>LOG(POPULATION)</td>
<td>190.5469</td>
<td>1.738888</td>
</tr>
<tr>
<td>DUMMY</td>
<td>2.551458</td>
<td>1.377257</td>
</tr>
<tr>
<td>DENSEGASSTATIONS</td>
<td>1.085533</td>
<td>1.039757</td>
</tr>
</tbody>
</table>

Table 2A – White’s test for Table 2
The output of the regression model for cross-sectional data 2010

Heteroskedasticity Test: White

<p>| Test Equation: | Coefficient Std. Error t-Statistic Prob. |
|----------------|----------------------------------------|----------------------------------------|
| Dependent Variable: RESID^2 |                                         |                                         |
| Method: Least Squares |                                         |                                         |
| Date: 06/16/12  Time: 12:31 |                                         |                                         |
| Sample: 1 289 |                                         |                                         |
| Included observations: 289 |                                         |                                         |
| Collinear test regressors dropped from specification |                                         |                                         |
| C               | -2852.680 1181.251 -2.414966 0.0164 |                                         |
| LOG(MEDIUMINCOME) | 476.8591 193.9938 2.458115 0.0146 |                                         |
| (LOG(MEDIUMINCOME))^2 | -20.06614 8.085338 -2.481794 0.0137 |                                         |
| (LOG(MEDIUMINCOME))<em>(LOG(_EDUCPOP)) | -5.751795 13.21782 -0.435154 0.6638 |                                         |
| (LOG(MEDIUMINCOME))</em>(LOG(POPULATION)) | 0.805463 1.390120 0.579420 0.5628 |                                         |
| (LOG(MEDIUMINCOME))*DUMMY | -2.242847 2.587228 -0.866892 0.3868 |                                         |
| (LOG(MEDIUMINCOME))<em>DENSEGASSTATIONS | 21.45196 217.4730 0.098642 0.9215 |                                         |
| LOG(EDUCPOP)                  | 68.44147 154.1021 0.444131 0.6573 |                                         |
| (LOG(EDUCPOP))^2               | -0.399027 1.039469 -0.383876 0.7014 |                                         |
| (LOG(EDUCPOP))</em>(LOG(POPULATION)) | 0.197531 1.695888 0.116477 0.9074 |                                         |
| (LOG(EDUCPOP))*DUMMY            | -2.166798 3.327738 -0.651132 0.5155 |                                         |
| (LOG(EDUCPOP))*DENSEGASSTATIONS | -797.3422 667.8646 -1.193868 0.2336 |                                         |</p>
<table>
<thead>
<tr>
<th></th>
<th>Coefficient 1</th>
<th>Coefficient 2</th>
<th>Coefficient 3</th>
<th>Coefficient 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOG(POPULATION)</td>
<td>-5.193714</td>
<td>17.32581</td>
<td>-0.299767</td>
<td>0.7646</td>
</tr>
<tr>
<td>(LOG(POPULATION))^2</td>
<td>-0.220459</td>
<td>0.116008</td>
<td>-1.900383</td>
<td>0.0585</td>
</tr>
<tr>
<td>(LOG(POPULATION))^2*dummy</td>
<td>0.486993</td>
<td>0.367922</td>
<td>1.323632</td>
<td>0.1867</td>
</tr>
<tr>
<td>(LOG(POPULATION))^2*densgasstations</td>
<td>-5.410997</td>
<td>12.69454</td>
<td>-0.426246</td>
<td>0.6703</td>
</tr>
<tr>
<td>dummy</td>
<td>18.95670</td>
<td>31.32709</td>
<td>0.605122</td>
<td>0.5456</td>
</tr>
<tr>
<td>dummy*densgasstations</td>
<td>-97.67873</td>
<td>69.67607</td>
<td>-1.401898</td>
<td>0.1621</td>
</tr>
<tr>
<td>densgasstations</td>
<td>-1620.166</td>
<td>2742.684</td>
<td>-0.590723</td>
<td>0.5552</td>
</tr>
<tr>
<td>densgasstations^2</td>
<td>792.4016</td>
<td>1126.643</td>
<td>0.703330</td>
<td>0.4825</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared</td>
<td>0.079623</td>
<td>Mean dependent var</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.014615</td>
<td>S.D. dependent var</td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>1.414612</td>
<td>Akaike info criterion</td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>538.3028</td>
<td>Schwarz criterion</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-499.9515</td>
<td>Hannan-Quinn criter.</td>
</tr>
<tr>
<td>F-statistic</td>
<td>1.224818</td>
<td>Durbin-Watson stat</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.236665</td>
<td></td>
</tr>
</tbody>
</table>