Gasoline pricing systems and the attractiveness of high-ethanol blends: The cases of Brazil and Sweden

Henrique Pacini[a,1] , Semida Silveira[a]

[a] Division for Energy and Climate Studies, KTH

Brinellvägen 68, 100 44 KTH Stockholm, Sweden.

Work presented at the 3rd International Scientific Conference on Energy Systems with IT, part of the Swedish Energitinget, which took place on 16-17 March 2010 at Stockholmsmässan in Älvsjö, Sweden.

*****EXECUTIVE SUMMARY*****

1. Introduction

Bioethanol fuel is considered by a number of countries as a tool to reduce the carbon intensity of the transport sector, improve energy security and promote rural development. (Macedo et al., 2008; Hoekman, 2009; Goldemberg, 2007). This has been reflected by the broader move towards biofuels taken by leading economic blocks. The European Union and United States have both manifested their intention to increase the share of biofuels in their final energy consumption (European Commission 2009; US Congress 2007). Most fuel-grade ethanol in the world is used as an oxygenate into gasoline (low blend) which allows the utilization of conventional fuel infrastructure. On the other hand, some countries opted for high-blend ethanol (E100 and E85) in their fuel pools as a way to offer a "green" alternative to gasoline. However, biofuels can only deliver an effective contribution to climate change mitigation if, at the end, they prove to be an attractive choice for consumers.

This summary is based on work presented at the 3rd International Scientific Conference on Energy Systems with IT, part of Energitinget 2010. It consists of a summary of an initial investigation from Pacini and Silveira (upcoming), with a deepened focus on a further examination on how gasoline pricing systems can be important in determining the attractiveness of high ethanol blends for the consumer (Pacini and Silveira, 2010).

2. Ethanol fuel in Brazil and Sweden

Market lessons can be drawn from countries with early experience in large scale adoption of bioethanol. The countries analyzed were Brazil and Sweden, both of which use fuel ethanol in two main forms: as a blend with gasoline (gasohol E25 in Brazil and E5 in Sweden) and as a high blend (E100 in Brazil and E85 in Sweden). In other words, the biofuel is sold either mixed with conventional gasoline or as a separate “green” option at tank stations. Our

[1] Corresponding author Tel. +46-8-7907431, Fax: +46-8-204161. E-mail addresses: Henrique.pacini@energy.kth.se (H. Pacini) ; Semida.silveira@energy.kth.se (S. Silveira)

investigation focuses on the attractiveness of bioethanol as a separate (high blend) fuel option for the consumer in comparison with gasoline.

In Brazil the high-blend ethanol infrastructure has been in place for more than 30 years, since the beginning of the pro-alcohol program in the late seventies. Since 2003, the car market dynamics have changed with the introduction of flex-fuel cars, which then allowed consumers to freely shift their fuel choice between gasoline and ethanol, based on perceived advantages.[2]

In Sweden, bioethanol is a relative newcomer, having been introduced broadly only after 2005 as a consequence of the National Climate Policy in Global Cooperation bill which, in turn, addressed requirements set by the 2003 EU biofuels directive (European Commission, 2003). Since then, most of the country's tank stations started to offer a high ethanol blend (E85) as an alternative fuel for flex-fuel car drivers.

In the period between 2005 and 2009, ethanol consumption represented a large economy for Brazilian consumers, when compared to gasoline. Brazilians saved an average of 15,42% when choosing to tank their vehicles with E100. The same cannot be said about Swedish consumers, who experienced an average price-advantage of only 0,2% when consuming ethanol between 2007 and 2009. So ethanol was a better deal for the consumer in Brazil than for consumers in Sweden.

3. Fuel choice

Given considerations of energy content of ethanol and engine performance, we consider the attractiveness of ethanol as a function of its relative price compared to gasoline. We build on the hypothesis that price is the key determinant of fuel choice (Pindick and Rubinfeld, 2004; Ferreira et al, 2009; Popp et al, 2009). Previous studies have also indicated that costs are, in fact, the main factor determining the consumer choice for environmentally-friendly solutions in transport (Kim et al., 2007; The Royal Society 2008). Although other preferences may exist, we assume they are less important.

By picking the fuel that gives the best performance per monetary value, the consumer determines fuel demand. Thus the success of bioethanol in a market depends on its ability to compete with gasoline. In this sense, the alternative fuel (E100) is expected to be used in Brazil only if it has a price of up to 70% of that of gasoline. This relates to the performance relation given energy content and engine performance of both fuels (Goetemoeller 2007; MME 2010). In Sweden, given the different blend characteristics (E85), the consumption of ethanol pays off until it costs up to 74,44% of the gasoline price per liter (Goetemoeller 2007; West et al., 2009; Roberts 2007). Our hypothesis is that the consumer will choose either ethanol or gasoline depending on which delivers the best fuel economy, or the fuel option that allows driving the longest for the same cost.

Thus, we assume that the consumer makes his/her choice in favor of ethanol based on the relation between price and performance of the fuel according to the following set of rules.

[2] We consider advantage to be price-advantage, given previous literature backing price as the key determinant for fuel choice (Ferreira et al., 2009; Popp et al., 2009).

If, for a moment in time:

$$\frac{\text{Pr}\,iceofEthanol}{\text{Pr}\,iceofGasoline} \leq 0.70 \text{ (in the case of Brazil)}$$

or

$$\frac{\text{Pr}\,iceofEthanol}{\text{Pr}\,iceofGasoline} \leq 0.74 \text{ (in the case of Sweden)}$$

Than the high-blend ethanol will be preferred.

According to analysis from Pacini and Silveira (2010) the price-attractiveness of ethanol for the consumer was higher in Brazil than in Sweden, during the periods analyzed (2005-2009). This brings up the question as to why ethanol was so price-attractive in Brazil and not equally attractive in Sweden.

In Brazil, ethanol has been a large industry since the late 1970s. Both production scale and learning curves favoured a more cost-competitive biofuel production in that country. Adding to that, Brazil has geographic conditions which favor large-scale sugarcane production, the basis for high-yield ethanol production. Sweden, on the other hand, is mostly dependant on imports to supply its ethanol usage. Other constraints for Sweden include geographical disadvantages for native production of the bioethanol, import tariffs and cold weather which limits the productivity of agriculture. Even though a significant part of these disadvantages are compensated through differentiated taxation and other incentives (Wiesenthal et al., 2008), ethanol (E85) has been less price-attractive in Sweden than in Brazil.

But the attractiveness of ethanol as a fuel choice is dependent on the dynamics in two markets: (1) of ethanol itself and (2) of gasoline. Both fuels have price fluctuations based on a number of factors. For ethanol, some important issues are harvest yields, storage capacities, local and international demands. For gasoline oil prices and gasoline pricing systems are of high importance. Given that ethanol can become more attractive either by becoming cheaper itself or via increases in gasoline prices, the next section focuses specifically on gasoline pricing systems. Cross-subsidies which arise from the different gasoline pricing systems presently in place in Brazil and Sweden and which could have made ethanol more or less attractive to consumers are of particular interest to our analysis.

4. Fuel pricing systems

In a separate study, Pacini and Silveira (upcoming) analyzed the behavior of Brazilian and Swedish ethanol consumers in face of price variations. A different consumer behavior was noticed in the two countries, in face of different opportunity costs of ethanol usage over time. The Brazilian consumer kept using ethanol even when this was not the most advantageous in terms of energy content, while the Swedish consumer sharply reduced the use of ethanol in similar circumstances. This suggests higher price elasticity for E85 in Sweden than for E100 in Brazil. Here, we analyze how the fuel pricing mechanisms which determine gasoline prices vary between Brazil and Sweden and how this contributes to the final attractiveness of ethanol versus gasoline.

According to the German Technical Cooperation Agency (GTZ), Brazil has an *ad-hoc* pricing system for gasoline, meaning that changes in international oil prices are only seldom relayed to final gasoline prices at the pump (GTZ, 2008). This reduces the price volatility

experienced by the final user but also can represent large gains for the *de-facto* monopoly held by the Brazilian oil company Petrobras when oil prices are low, at the expense of consumers.

In Sweden, GTZ (2008) classifies the pricing system as *liberalized*, meaning that fluctuations in international oil prices are quickly relayed to final gasoline prices at the pump. Contrary to *ad-hoc* logic, the system in Sweden allows the consumer to pay less for gasoline when international oil prices fall, given the continuous price adjustment at the pump. Under this context, we are interested in analyzing how different gasoline pricing systems operate to increase or reduce the attractiveness of ethanol to the consumer.[3]

In order to assess the attractiveness of ethanol in face of different gasoline pricing systems, Pacini and Silveira (2010) present three scenarios which are used to test the attractiveness of Brazilian ethanol (2005-2009) subject to three different gasoline pricing systems. The first scenario (A) represents the actual gasoline prices observed in Brazil. The second scenario (B) transforms the fluctuations in gasoline prices in Brazil as to correspond to the fluctuation of gasoline prices in Sweden. The third scenario (C) transforms the fluctuation in gasoline prices in Brazil as to correspond to the full fluctuation of oil prices (West Texas Intermediate). [4]

Table 1: Absolute and percentage advantages of ethanol when compared to gasoline.

	Scenario A A*d-hoc* (Actual data for Brazil)	**Scenario B** *Liberalized market* (Proxy: Swedish index)	**Scenario C** *Liberalized market* (Proxy: Oil index)
Net gains from ethanol usage** (USD/nov 2008)	6.391 bi	6.416 bi	7.912 bi
Average gain of ethanol as a percentage of gasoline prices (2005-2009)	15.42% SD*=0.069	15.05% SD*=0.0891	8.37% SD*=0.26

* Standard Deviation. ** Considering past consumption of ethanol (E100) in Brazil.

[3] We are by no means suggesting that the pass-through of oil prices into prices of gasoline is the only phenomena determining competitiveness of bioethanol in a market. Taxation has, in fact, played a major role in supporting climate-friendly alternatives, and has proven to be the most powerful instrument to curb emissions from gasoline via demand reduction (Sterner, 2006 p. 7). At the same time, some authors have warned that generous tax-exemptions to promote the competitiveness of ethanol should be applied with caution, as this could have adverse environmental and energy security implications (Vedenov and Wetzstein, 2007). An excessively benevolent taxation policy directed towards ethanol could reduce tax revenue allocated to legitimate usages, creating problems in different sectors. In addition, direct subsidies could jeopardize the true competitiveness of ethanol by sending distorted signals to the industry and reducing the incentive for innovation (Clausen, 2009).

[4] It should also be pointed out that the quantitative results (in USD) are based on the assumption that the historical consumption of ethanol in Brazil would have been the same. In face of different price fluctuations (A, B and C), historical consumption would probably have varied, but this paper does not attempt to incorporate demand elasticity.

A full list of data sources is presented after the bibliography. **Table 1** shows the net gains from ethanol usage and average gains as a percentage of gasoline prices. The absolute results point to higher gains for ethanol with liberalized gasoline pricing systems. Such gains, however, are at the expense of higher volatility. Standard deviation values for the percentual results show higher fluctuations in average gains when using the Swedish and oil proxies. As a result, Sweden experienced a strong reduction in ethanol consumption despite a 0.2% average advantage over time (Standard Deviation = 0.112). This happened amid a system of *liberalized* gasoline pricing.

Brazil experienced a steady increase in ethanol consumption between 2005 and 2009, in face of a 15.42% average advantage over time with low volatility (Standard Deviation = 0.069). This happened in a context of ad-hoc pricing for gasoline.

A comparison between the empirical cases of Brazil and Sweden with the scenarios under different price mechanism offer interesting insights. The scenarios demonstrate that although liberalized pricing systems for gasoline could make ethanol even more price-attractive, this would happen at the cost of higher price volatility. Looking into the empirical case of Sweden, consumption fell sharply in a context of high price volatility.

This suggests the consumer might not be only sensitive to the gross benefit of ethanol consumption over a long period of time, but also react in a negative way to high short term volatility of the price-attractiveness of ethanol. In this sense, price stability – in which gasoline pricing systems play a role – seems relevant for the successful adoption of a high blend of ethanol in a country over time.

5. Conclusion

This summary presented the main insights from Pacini and Silveira (2010) which was first presented at the 3rd International Scientific Conference on Energy Systems with IT, part of the Swedish Energitinget 2010.

By considering that the consumer choice for fuel is mainly based on their relative prices, data was analyzed for two countries with widespread high-ethanol blend infrastructure (Brazil with E100 and Sweden with E85). An analysis of the relative price series indicated that, in Brazil, ethanol (E100) prices were more attractive than Sweden (E85), when compared to local gasoline. Attractiveness is defined by a relation which incorporates energy content and engine performance (compression rate) of a fuel (ethanol or gasoline), in other words, the mileage delivered per monetary unit. The attractiveness of bioethanol as a separate fuel depends on how much cheaper (or expensive) it is to drive with the biofuel when compared to conventional gasoline. Although the price-attractiveness depends on a number of factors, gasoline pricing systems applied in the country play an important role.

In order to analyze how different gasoline pricing systems influence the attractiveness of ethanol for the consumer, and based on classification proposed by GTZ, three price indexes were created to illustrate different types of gasoline price fluctuations: (A) based on the Brazilian system (*ad-hoc*) (B) based on Swedish system (*liberalized*) and (C) an hypothetical, based on a full pass-trough of oil price fluctuations into gasoline prices. The price indexes were used to adjust historical ethanol prices in Brazil to create "what if" scenarios, specially

aiming to analyze how the attractiveness of ethanol would have been under a liberalized gasoline pricing system in that country.

Results showed that the global attractiveness of ethanol would have been higher for (C) and (B) meaning the full relay of oil fluctuations and the system in Sweden. By using three scenarios, we have analyzed variations in the attractiveness of ethanol under three different price mechanisms for gasoline. Considering the total monetary benefit in the period between 2005 and 2009, ethanol would have remained competitive in Brazil even if gasoline prices had fluctuated in the same way as in Sweden. Perhaps more surprisingly, ethanol became even more competitive when gasoline prices in Brazil were adjusted to represent the full fluctuation of international crude oil prices. One explanation for this is that high oil prices observed in 2008 would have made ethanol extremely attractive if gasoline prices had reflected the full oil price fluctuation in Brazil.

However, volatility over time in the level of attractiveness was much lower in the Brazilian system, possibly indicating price-stability as a key component for successful high-blend biofuel adoption in new markets. Our analysis suggests that the consumer might prefer more constant price-advantages (such as in the case of Brazil) while reacting negatively to very volatile markets (such as in the case of Sweden).

***

References

ANP (2010a) Agencia Nacional do Petróleo, Gas Natural e Biocombustíveis- *Annual statistical information 2009*.

ANP (2010b) Agencia Nacional do Petróleo, Gas Natural e Biocombustíveis- *Annual statistical information2009* Section 2: National Industry of Oil and Natural Gas. Table 2.24: Refinnery capacities. Avaliable at: http://www.anp.gov.br/?pg=8240#Se__o_2

Clausen, Tommy H. (2009) Do *subsidies have positive impacts on R&D and innovation activities at the firm level?* Structural Change and Economic Dynamics. Vol 20, Issue 4. pp. 239-253.

GTZ (2008) *International Fuel Prices Data*, November 2008. pp 4-5. Avaliable at: http://www.gtz.de/de/dokumente/en-international-fuel-prices-data-preview-2009.pdf

Wagner, Armin. Ebert, Sebastian. (2009) *Energy Security and Transport*. Deutsche Gesellschaft für Technische Zusammenarbeit – GTZ Energy and Transport Eschborn.

European Commission (2003) Directive 2003/30/EC of the European Parliament and of the Council on the promotion of the use of biofuels or other renewable fuels for transport.

European Commission (2009) Directive on the promotion of the use of energy from renewable sources. Directive 2009/28/EC.

Ferreira, Alex Luiz. Prado, Fernando Pigeard de Almeida. Silveira, Jaylson Jair da. (2009) *Flex cars and the alcohol price*. Energy Economics 31 p. 13. Elsevier

Goettemoeller, Adrian (2007). *Sustainable Ethanol: Biofuels, Biorefineries, Cellulosic Biomass, Flex-Fuel Vehicles, and Sustainable Farming for Energy Independence*. Praire Oak Publishing, Maryville, Missouri. p. 42

Goldemberg, Jose. (2007) Ethanol for a sustainable energy future. Science pp. 808-810.

Hoekman, S. Kent. (2009) Biofuels in the U.S. – Challenges and Opportunities. Renewable Energy 34 Issue 1 pp. 14-22

Honavar, Afshin. (2009) *Asymmetry in retail gasoline and crude oil price movements in the United States: An application of hidden cointegration technique*. Energy Economics Vol. 31 Issue 3 pp. 395-402.

Hosken, Daniel. McMillan, Robert S. Taylor, Christopher T. (2008) *Retail gasoline pricing: What do we know?. International Journal of Industrial Organization*. Volume 26 Issue 6 pp. 1425-1436.

Kim, Yeonbae., Jeong, Gicheol. Ahn, Jiwoon. Lee, Jeong-Dong. (2007) *Consumer preferences for alternative fuel vehicles in South Korea*. International Journal of Automotive Technology and Management.

MME (2008) – Brazilian Ministry of Mines and Energy: National Energy Balance 2008.

MME (2010) – Brazilian Ministry of Mines and Energy: Monthly bulletins of renewable fuels. February 2010.

Macedo, Isaias. Seabra, Joaquim E.A. silva, Joao E.A.R. (2008) Green house gases emissions in the production and use of ethanol from sugarcane in Brazil: The 2005/2006 averages and a prediction for 2020. Biomass and Bioenergy 32, Issue 7 pp. 582-595.

Pacini, Henrique. Silveira, Semida (2010). Consumer choice between ethanol and gasoline: lessons from the cases of Brazil and Sweden. Paper submitted for publication in *Energy Policy.*

Pacini, Henrique. Silveira, Semida (2010) Ethanol or gasoline? Consumer choice in face of different fuel pricing systems in Brazil and Sweden. Accepted for publication in the September issue of *Biofuels.*

Pindick, R. Rubinfeld, D. (2004) *Microeconomics*, 6th edition. Macmillan Publications, New York.

Pop, Michael. Van de Velde, Liesbeth. Vickery, Gina. Van Huylenbroeck, Guido. Verbecke, Wim. Dixon, Bruce. (2009) *Determinants of consumer interest in fuel economy: Lessons for strengthening the conservation argument*. Biomass and Bioenergy 33. Elsevier.

Radschenko, Stanislav. (2005) *Lags in the response of gasoline prices to changes in crude oil prices: The role of short-term and long-term shocks*. Energy Economics Vol. 27 Issue 4. pp. 573-602.

Roberts, Matthew (2007) *E85 and Fuel efficiency: An empirical analysis of 2007 EPA test data*. Energy Policy 36 p. 2. Elsevier.

Sterner, Thomas. (2006) *Fuel taxes: An important instrument for climate policy*. Energy Policy 35. Issue 6. 3194-3202.

Swedish Petroleum Institute (2009) Break-out of the gasoline price in different components between 2008-2009. Available at: http://www.spi.se/statistik.asp?art=90

The Royal Society (2008) *Sustainable biofuels: prospects and challenges*. Policy document 01/08 p. 41

United States Congress (2007) *US Energy Independence and Security Act*. Avaliable at: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:h6enr.txt.pdf

Vedenov, Dmitry. Wetzstein, Michael. (2007) Toward *an optimal U.S. ethanol fuel subsidy*. Energy Economics. Vol. 30. Issue 5. pp. 2073-2090

West, Brian H. López, Alberto J. Theiss,Timothy J. Graves, Ronald L. Storey, John M. Lewis , Samuel A. (2007) *Fuel Economy and Emissions of the Ethanol-Optimized Saab 9-5 Biopower* . Oak Ridge National Laboratory. Avaliable at: http://www1.eere.energy.gov/biomass/pdfs/analysis_saab2007.pdf

Wiesenthal, Tobias. Leduc, Guillaume. Christidis, Panayotis. Schade, Burkhard. Pelkmans, Luc. Govaerts, Leen. Georgopoulos, Panagiotis. (2008) Biofuel support policies in Europe: Lessons learnt for the long way ahead. Renewable & Sustainable Energy Reviews 13, pp.794-796.

Data sources:

ANP – Agência Nacional do Petróleo, Gás Natural e Biocombustíveis

Economagic commodity time-series

European Central Bank Statistical Data Warehouse

IBGE – Brazilian Institute for Geography and Statistics (price indexes)

JET – Time series of fuel prices

OKQ8 – Time series of fuel prices

Preem – Gasoline price formation in Sweden.

SPI – Swedish Petroleum Institute. Statistics section (2009) (price indexes)

Statistika Centralbyrån – Swedish Statistical Agency

Statoil - Time series of fuel prices

All electronic references successfully accessed on August 16th , 2010.