Boom and bust of flex-fuel vehicles in Sweden

Frances Sprei
Chalmers University of Technology
Energy and Environment
412 96 Göteborg
Sweden
fsprei@chalmers.se

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Abstract

Until 2008 the introduction of flex-fuel vehicles in the Swedish new vehicle market seemed to be a success. Each year sale shares increased, reaching in 2008 almost 25 % of the market. But since then the sales have dropped to 5 % of new sold cars in 2011. This paper explores and explains both the rise and fall of this new technology. Flex-fuel vehicles have been highly subsidized both from a vehicle and fuel perspective. Incentives for consumers have been offered at national level as well as municipal. At the same time the focus of the media has shifted questioning the benefits of ethanol as an alternative fuel.

The analysis is based on two sets of sales statistics: monthly sales of vehicles in Sweden divided per fuel type and type of consumer, i.e., private person or company for the years 2002–2011; yearly sales per municipalities divided per fuel type and purchaser type between 2006 and 2011. Economic factors, such as income and fuel prices; infrastructure, such as number of fuel stations; incentives; and media, such as share of negative articles covering ethanol, are used as dependent variables.

Findings show that changes in the rebate structure, E85 losing its economic advantage and the removal of the exemption of the congestion charging have been the most significant factors for the decline. This has been paralleled with an increasing negative media coverage and the availability of a substitute, i.e., conventional vehicles that get labelled green by the official definition (less than 120 g CO_2/km).

Policymakers in many countries are facing the challenge of phasing out fossil fuels from the vehicle fleet. Insights from this papers show that a successful development at first may easily be overturned the economic as well as the environmental picture is altered. The availability of highly efficient and thus more environmentally friendly conventional vehicles, may also hamper the alternatives' sales.

Introduction

In 2002 Ford introduced the first flex-fuel vehicle (FFV)[1] in Sweden. Initially the market was quite tepid but by 2006 sales numbers increased and by 2008 almost 25 % of new sold cars in Sweden were FFV. After that the trend broke and sales numbers continued to decrease to 5 % of new sold cars in 2011. This paper analysis and tries to explain this development through economic factors, including incentives at local and national level as well as media and the improvements of incumbent technology, i.e., more efficient diesel and gasoline vehicles.

The high dependence on oil and the relative higher share of CO_2 emissions from the transport sector have caught the attention of the Swedish government several times. In 2006 the role of ethanol was highlighted in a report aiming at making Sweden an oil-free society by 2020 (Commission on Oil Independence 2006) and in 2012 the aim was to create a fossil fuel independent fleet by 2030. What that really entails is currently under investigation. Ethanol, or rather alternative fuels, have thus received a lot of support from the Swedish authorities, from mandating an alternative fuel at gas stations to subsidizing sales of vehicles. The different incentives are discussed in section Factors. Despite this major support FFVs have still not managed to create a sustainable market share.

1. A vehicle that can drive on any blend of ethanol and gasoline.

Sweden and other countries still have to face the challenge of shifting their vehicle fleet. What lessons can be learned from the case of FFV in Sweden? While explaining the development of FFV sales this paper aims at finding some key lessons that can be applicable to the introduction of other alternative fuelled vehicles such as plug-in electric vehicles.

While FFVs are relatively similar to conventional vehicles there are still some barriers for their adoption. First of all gasoline and diesel vehicles have been the standard for about 100 years and are thus a well-known technology for consumers, thus just the novelty and the insecurity connected with any alternative are barriers. Consumers might be asking questions such as: Will it work as well? Drive the same way? Do I have to refuel it more often? How do they handle cold weather? FFVs have had a slightly higher purchase price compared to the equivalent gasoline vehicle and they need to be serviced more frequently. They do also have a slightly shorter range when fuelled solely with E85.

Other researchers have looked at specific incentives related to "green" cars in Sweden. Huse (2012) studies specifically the rebate to private consumers and finds that it has pushed the market for vehicles that meet the definition. For FFVs, this means mainly larger, high emitting vehicles. Borup (2009) analyses the shift in annual circulation tax and its benefit in reducing fuel consumption of the new car fleet. Borup also notes the establishment of the concept of a "green" car and the importance in the general public of this idea. Beser Hugosson and Algers (2012) look at a number of policies that explain the increase sales of "green" cars in Sweden. They find that the reduction of fringe tax benefit, tax exemption for biofuels and the exemption from congestion charging have been important. None of these authors however, try to explain the decrease in sales of FFVs as is done in this paper.

Method

For sales of FFV vehicles two data sets were used, both retrieved from the Statistics Sweden: monthly sales of vehicles divided by fuel-type and type of owner for all of Sweden between 2002 and 2011; yearly sales of vehicles divided by fuel-type and type of owner per municipality in Sweden, 2006-2011. The explanatory variables used in the regression are shown in Table 2.

Sales shares of FFV are regressed on a set of dependent variables. The base case equation is:

$$\log(Sh_t) = k + \log(I_t) + \log(Pr_t) + Re_t + \varepsilon_t \qquad (1)$$

Where *Sh* is the market share of FFV for new sold cars; *I* is the income, *Pr* is the ratio between the gasoline pump prices and E85 pump prices, and *Re* is the national incentive. The subscript *t* is the time: year or month. To these other dependent variables are added; see Table 2 for the full list.

The form was chosen since it performed the best regarding test such as heteroscedasticity as well as providing coefficients with the intuitive signs. Log form of a dependent variable expressed as shares is also recommended in the econometric literature (Kennedy 2008).

Four different cases were calculated, differing on time, type of owner and geographical coverage as presented in Table 1.

The cases Nc and Np were pooled and calculated with Ordinary Least Square (OLS) with a differentiation of the rebate since this differed between the two series.

Panel regression for Mc and Mp were calculated with fixed effects. Panel regressions with random effects were also calculated but Hausman test showed that the fixed effect was the most suitable for both sets. In these cases Pr was lagged one year.

MEDIA ANALYSIS

Retriever research database for digital print archives is the source for the media analysis. This comprises 498 journals, including both national and local press as well as the news from the Swedish national public radio (*Sveriges Radio Dagens Eko*). In the first step of the media analysis the database was used to search for the occurrence of the word "ethanol" per se and in combination with other words. The search tool enabled to specify the distance between the words, and to limit the search to title and preamble.

In the next only articles with "ethanol" in the title were selected and based solely on the title they were categorized as negative, positive or neutral/ambiguous. While an article may be more nuanced the title many times sets the tone as well as one can suppose that many people will not read the whole article but may look at the title. Besides the direct environmental impact articles mentioning the building of plants and industry in Sweden were labeled as positive since they are presuming to contribute to economic growth and employment.

A deeper analysis was done of a major Swedish newspaper (*Dagens Nyheter*) to identify for each article if it was positive, negative, neutral or a combination. Major themes were identified as well. The coding was done manually and may be seen as pre-study to a more comprehensive coding. Placement in the journal was also observed.

Results

For the national data the share of FFV among company and private owners are pooled, differentiating for the national rebate. Two different models are calculated. One base case where income, price ratio between E85 and national incentives are included and one full case in which other factors such as the influence of media and the number of models of diesel and gasoline vehicles that are considered "green" are included. For the base case income, price ratio of fuels and the national rebate are all significant. All the coefficients have the expected sign. The elasticities are quite high but considering that these are differences in shares and that the variations in the dependent variable have been quite high, while for both income and price ratio they have not, this is expected. The sensitivity to the rebate is very similar between company and private owners. The full case does not change the coefficients for the three first variables and the other added variables are not significant. In the section factors we discuss the possibility of these factors to have contributed to development anyway. The actual effect may be hard to capture in a simple quantified variable. E.g., the number of models per se might not have influenced the sales of FFV but rather that they were in the popular segments.

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Table 1. The four different cases described by time span, time interval, geographical span and type of owner.

Case	Time span	Time interval	Geographical span	Type of owner
Nc	2002–2011	Monthly	National	Company
Np	2002–2011	Monthly	National	Private
Mc	2006–2011	Yearly	Municipality	Company
Mp	2006–2011	Yearly	Municipality	Private

Table 2. Description of data used for the dependent variables and their source.

Variable	Data	Source
I	Average disposable income. *Nc, Np*: national data per year; *Mc, Mp*: per municipality per year	Statistics Sweden
Pr	Ratio of pump prices between E85 and gasoline. *Nc, Np*: national, 6 months average; *Mc, Mp*: national, yearly average, lagged 1 year	SPBI and OKQ8
Re	National incentives	*Nc, Mc*: Swedish Tax Agency *Np, Mp*: Swedish Transport Agency
Pa	*Mc, Mp*: dummy variable, 1: any kind of parking subsidy in a municipality	Municipal websites and personal communication
C	*Mc, Mp*: Exemption from congestion charging: 2 for Stockholm; 1 for surrounding municipalities	Swedish Transport Agency
Fs	*Mc, Mp*: Number of fuelling stations providing E85 per municipality	Etanol.nu
MeNeg	*Nc, Np*: share of negative articles with "ethanol" in the title, 6 month average	Retriever research database
120 g	*Nc, Np*: number of models of diesel and gasoline vehicles with CO_2 emissions below 120 g, i.e. "green vehicle"	Bilsweden (2006–2011) and bilstart.se (2002–2005)

The time series has also been divided into two separate ones, one for the increase in market share and one for the decrease. However, no significant insights are given by this.

For municipal data besides the base model with income, fuel price ratio and national rebate, a dummy for municipalities with parking subsidies, congestion charging and number of fuelling stations providing E85 are added. The fuel price ratio is lagged a year. For the case company owners, Table 4, as in the national case, income and the rebate are statistically significant. The elasticity for income is lower, while the one for fuel price ratio is of the same magnitude. The rebate coefficient is a factor three higher. In the full model the coefficients of these variables do not change. Of the so called local incentives the exemption from congestion charging is the most significant, followed by fueling stations providing E85. The parking subsidy is not significant, however it should be noted that the data is only for 2006 onward and there might have been an effect during the very first years.

For private owners, Table 5, in the base case income and the national rebate are significant but not the fuel price ratio. This differs from the case of company owners maybe implying that private owners are not as economically rational. The coefficient for the rebate is of the same magnitude as in the national data, while income is slightly lower. In the full case these three coefficients remain fairly constant. Of the added variables only the exemption from congestion charging in Stockholm has had a significant effect on sales. As in the case for company owners it should be added that the data is from 2006 onward and this may imply that fueling stations and parking has had an effect during the first years.

For both private and company owners other variables that might explain the variation were added such as educational level and share of votes for the Green Party, however neither of these had any significant effect on the results.

Factors

THE MARKET OF FLEX-FUEL VEHICLES

Ford Focus was the first FFV introduced in Sweden in 2002. Until 2005 it was the only model available on the market. The price premium compared to the equivalent gasoline vehicle was USD 1,000 when the vehicle was introduced, but in 2003 the premium was removed (*DN* 030930), resulting in the first push on FFV sales. From 2005 Saab and Volvo chose to enter the market and Ford introduced two more FFV models. The following years the number of models continued to increase and by 2010 there were 74 different models to choose from. However in 2011 the number decreased to 42. The models available have been mainly in the upper segments. The most popular ones have been the Volvo and Saab station wagons.

Calculating the price premium of a FFV is not always straight forward since there is not always an equivalent gasoline vehicle. In the case of SAAB FFV e.g., the horsepower is higher

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Table 3. Pooled *Nc* and *Np*, monthly market shares FFV among company owners and private owners, 2002–2011; Ordinary Least Square estimates. Base case: income (I), ratio between E85 and gasoline pump price, calculated as an average from previous six months and national incentive. The full case: adding share negative media articles; number of vehicle models with CO_2 emissions below 120 g and an interaction term between the media and number of models. T-values within parenthesis.

Nc, Np- Variable	Base	Full
Intercept	-278 ***	-254.6 ***
	(-11.7)	(-10.17)
I	21.9 ***	20.0 ***
	(11.5)	(9.91)
Pr	-2.16**	-2.92 ***
	(-2.83)	(-3.86)
Re – Company	1.10 ***	1.03 ***
	(8.52)	(8.09)
Re – Private	1.22 ***	1.05 ***
	(6.26)	(5.39)
MeNeg		0.58
		(1.05)
120g		-0.01
		(-1.57)
MeNeg :120g		0.02
		(1.95)
Adj - R^2	0.63	0.66

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 4. Case *Mc*, yearly market shares of FFV among company owners, 2006–2011. Fixed effect estimation. Base case: income (I), ratio between E85 and gasoline pump price (*Pr*) lagged one year and national incentive (*Re*). Full case: parking subsidies (*Pa*), congestion charging (*C*) and number of fuelling stations (*Fs*) are added. T-values within parenthesis.

Mc	Base	With *Pa, C, Fs*
I	8.05 ***	7.17 ***
	(7.72)	(6.17)
Pr	-1.86 ***	-1.96***
	(-5.16)	(-5.16)
Re	3.73 ***	3.76 ***
	(21.6)	(21.05)
Pa		0.07
		(0.47)
C		0.39 **
		(2.72)
Fs		0.02*
		(2.08)
Adj R^2	0.25	0.18

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 5. Case *Mp*, yearly market shares of FFV among private owners, 2006–2011. Fixed effect estimation. Base case: income (I), ratio between E85 and gasoline pump price (*Pr*) lagged one year and national incentive (*Re*). Full case: parking subsidies (*Pa*), congestion charging (*C*) and number of fuelling stations (*Fs*) are added. The number of fuelling stations are truncated at 5. T-values within parenthesis.

Mp	Base	With *Pa, C, Fs*
I	14.4 ***	15.35***
	(12.89)	(13.9)
Pr	-0.54	-0.23
	(-1.46)	(-6.29)
Re	1.15 ***	1.13 ***
	(23.5)	(23.3)
Pa		-0.081
		(0.54)
C		1.13 ***
		(7.51)
Fs		-0.00071
		(-0.26)
R^2	0.37	0.39

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

since the engine takes advantage of the higher octane level of ethanol. On average however the extra price has been roughly around SEK 5,000 (USD ~700) and has not changed markedly over time. Since the price premium did not fluctuate over time and the large heterogeneity between models this variable was not included in the regression analysis.

FUEL PRICES

Fuels in Sweden are subjected to both a carbon and an energy tax, biofuels have however been exempt from these taxes to make them more price competitive and thus increase the uptake (Sandebring 2004). From 2002 the prices of E85 have slowly been rising, however of more interest is the relation to gasoline prices. Figure 1 shows the development of monthly average pump prices in SEK/l of E85, gasoline and their ratio. Pump prices have been chosen because these are the ones that the customer can observe directly. While E85 has lower energy content and thus a volumetric comparison does not give the same service, this is what the costumer observes at the station. In average FFV are said to consume about 30 % more E85, there are however difference between the models available on the market, depending on how the engine is optimized. One observation to be made is that the fluctuation of the ratio is mainly related to the fluctuation of the gasoline prices, i.e., when gasoline prices drop the ratio dramatically increases. The risk for endogeneity is thus low in the regression. Ratios have varied between 0.9 and 0.6. Until the end of 2008 the trend was a downward slope, piking thereafter and slowly decreasing again and reaching a level around 0.7. The regression results show that the price ratio has affected the sales of FFV for all cases except municipal data for private owners. So it is credible that the pike in ratio has scared off consumers from FFV or at least shown that E85 may not always be a cheaper option and thus contributing to the downward slope. There was also an effect on refueling rates, e.g. there is a clear dip in E85 sales in conjunction with the increased spike in 2009[2].

NATIONAL INCENTIVES

Nationally there have been financial incentives for both categories of buyers. Company provided cars for an employee is taxed as a fringe benefit. The calculation of the economic value to be taxed is solely based on the monetary value of the car. For FFV and biogas vehicles this value was reduced by 16 %, but capped at SEK 8,000. The value is also calculated on the equivalent gasoline vehicle that many times has been cheaper. The exact value of this reduction varies between individuals, depending on their tax-level (e.g., 30 % versus 50 %). In special cases there is also a nonlinear effect if the employee is close to the threshold for the higher tax value. It should also be mentioned that no specification on the vehicle were set, such as restrictions on fuel consumption or fuelling requirements. The reduction in fringe tax value has been in place 2002–2011, however during the last years the insecurity about its continuation has lessened its benefit. The regression analyses show that the national incentive has been significant in determining the sales of FFV among company owners. And the fact that it was discontinued after 2012 has been contributing to the down turn.

For private owners in April 2007 a rebate of SEK 10,000 was introduced for so called "green" vehicles. FFV with a gasoline consumption below 9.2 l/100 km were included. The rebate was handed out until the end of June 2009. The cost for the rebate exceeded the predicted amount and besides the annual SEK 100 million that were budgeted for the proposal an ad-

2. www.spbi.se

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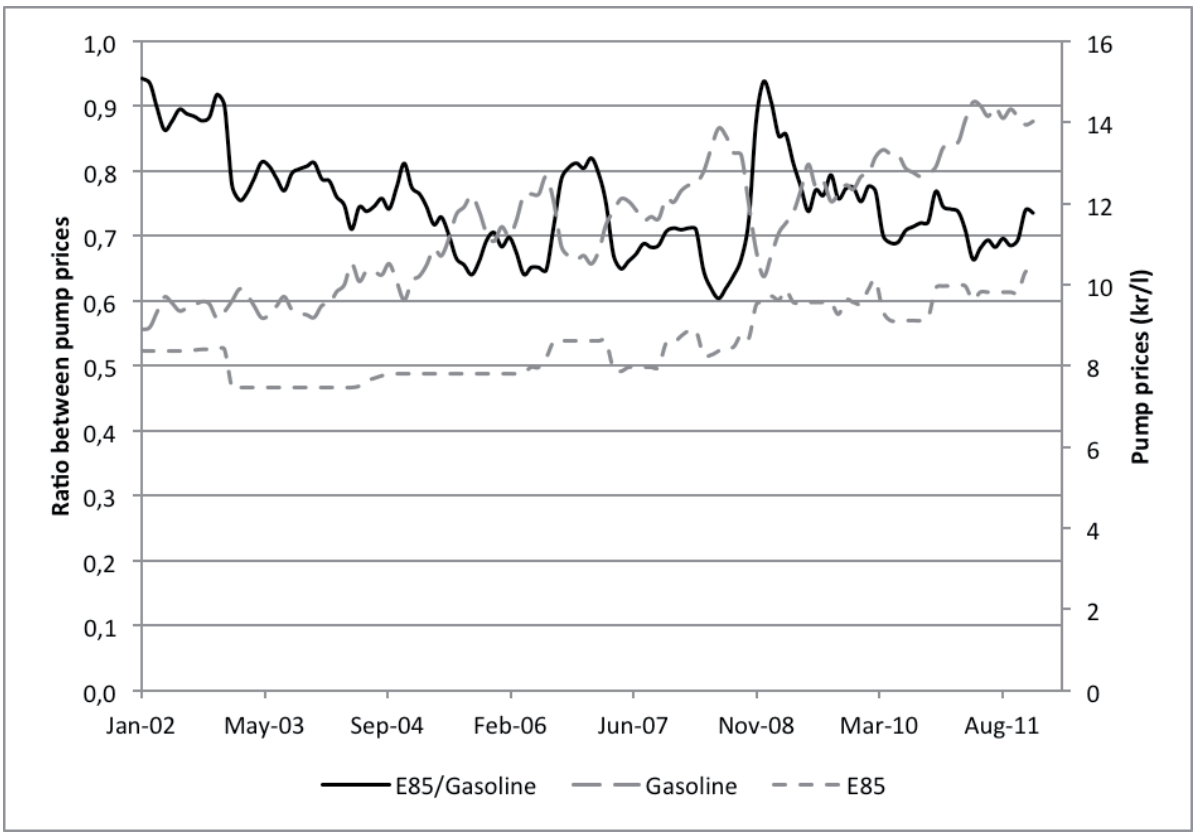

Figure 1. Development of monthly averages of pump prices for gasoline and E85 in Sweden, 2002–2011, (left axis) in SEK/l and the ratio of these (right axis).

ditional SEK 565 million were in total added[3]. The rebate was thus interrupted six months prior to what it had previously been announced. Instead it was replaced by a five year exemption from the annual circulation tax. This tax is based on the CO_2 emissions of the vehicle, thus varies from model to model. For most FFV the annual circulation tax is somewhere between SEK 1,000 and 1,500. This means that the total financial value of the incentive is reduced to half or two thirds of the original rebate. Distributing it over 5 years also lessens its value and salience through discounting (Greene, Patterson et al. 2005). Regressions made with both the national and municipal data set show that the national incentive has been significant, thus part of the reduction in sales among private owners can be explained by the change in rebate structure. However, the total sales of "green" vehicles have continued to increase, thus it seems like conventional vehicles with emissions under 120 g CO_2/km have not been as affected by the change in rebate structure (see discussion about "Other green vehicles").[4]

LOCAL INCENTIVES

About 40 municipalities have offered some kind of parking subsidy for FFVs, no matter what type of owner. These have however varied in magnitude. For some there has been an administrative cost for applying for the parking permit, some have only given 2 hour parking in the commercial centers while others have included free residential parking. Thus the economic value of the parking subsidy has varied. To ensure the environmental benefit some of the municipalities also tied the free parking with an enforcement of a certain percentage of refueling with E85. Refueling receipts had to be saved for random controls. The peak in number of municipalities offering some kind of subsidy was in 2008 since then the number has decreased to slightly over 30. The reasons for discontinuing the subsidy have varied from a perception that they are not needed anymore, to being afraid that they might increase use of vehicles and thus conflict with other environmental goals. It should also be noted that the majority of municipalities in Sweden do not charge at all for parking. The regression analyses do not show any significant effect of the parking subsidy. However, the data set used is from 2006 and onwards, thus it might not capture the early years when they might have been more effective. At this stage all parking subsidies have been treated equally, future research includes differentiating for the different levels to see if more generous subsidies have had any significant influence.

When the congestion charging was set in place in Stockholm FFVs were exempt from the charge. This exemption was in place until 2009. In the analysis it's supposed that this has the largest effect in Stockholm, and an influence in the neighboring municipalities. For both owner types the regression results show that the congestion charging has had a significant effect with a slightly higher value for private owners. For company owner the coefficient should be interpreted that the effect of the congestion charging increases the share by 39 %; so if the share of FFV was 10 % in the effect would be an increase to 14 %.

3. www.di.se "Slut för miljöbilspremien" 2008-09-08. Accessed 2012-10-29.

4. Diesel vehicles have a higher annual circulation tax, thus for some of these the change of rebate may have entailed a higher subsidy.

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FUELLING STATIONS

In 2003 there were about 93 fuelling stations providing E85 in Sweden. Since then the number of stations have grown, especially after the introduction of the pump-law, in 2006, mandating fuelling station over a certain capacity to provide an alternative fuel (Swedish Parliament 2009). The mandate was supposed to be technology neutral since it did not specify which fuel should be provided, but since the cost of providing E85 was the absolute lowest, the majority of gas-stations chose this alternative. Today about 2/3 of the fuelling stations provide E85. The number of fuelling stations is only significant for company owners and with a fairly low value. It is possible that more companies had as a policy that the vehicle should be refueled with E85 and thus there is some kind of effect for this group. It should be noticed that the data set is from 2006 onward and that there might have been an effect previously. However, this is also the year that the law was put into place. Even if the number of stations has had a low affected on the sales of FFV they have probably had a larger effect on refueling rates.

MEDIA

Ethanol as a fuel and consequently FFVs, have received a lot of attention in the Swedish news media. Figure 2 shows the number of articles in the printed press that mention ethanol. The number of hits follows the trend of vehicle sales as well and since the causality is not easily determined these have not been included in the regression.

The nature of the coverage and the picture of ethanol have shifted during the years. In Figure 2, the red bars illustrate the mention of ethanol combined with food as an example of the increased negative coverage connected with ethanol.

Closer analysis of a major Swedish newspaper (*Dagens Nyheter*) shows that in the first years ethanol was mainly portrayed in a positive way. Many advantages were seen with the fuel: it had the possibility to easily reduce CO_2 emissions; the potential of national fuel production both through wheat ethanol and lignocellulosic ethanol; providing the owner with an economic benefit when gasoline prices increased. By the end of 2007 more negative voices started to be heard questioning the environmental advantages of the fuel and when food prices started to increase globally the connection to increased biofuel use was swiftly made. An example of the shifting image of ethanol is the shift of wording from "ecofuel" (*miljöbränsle*) to the more neutral wording "alternative fuel" (*alternativbränsle*). Two visual examples that got a lot of attention was the picture of the year in 2008 which was taken of an ethanol production site in Brazil, showing black smoke stacks, thus questioning how "clean" the fuel actually was. Another image was a baker filling a flex-fuel Volvo V50 with loaves of bread on the major Swedish newspaper (DN). The paper had calculated how much wheat was needed to fill the tank of the vehicle and converted this to loaf of bread. This was done in amidst increasing food prices and various articles about food crisis around the world.

Articles from mid-2007 on ranged from still being positive to negative but many of them trying to depict a more nuanced picture of the fuel giving room to different perspectives. The idea that there was difference between different types of ethanol started to come out. Some feedstock such as Brazilian sugarcane might actually reduce carbon emissions, while other such as corn or wine residue might not. However, there was no possibility for the purchaser to know what ethanol they were actually fuelling their car with. In 2009 gasoline prices also fell and the ration between E85 and gasoline pump price to drastically increase leading to articles that highlighted that the financial savings for the individual owner were no longer obvi-

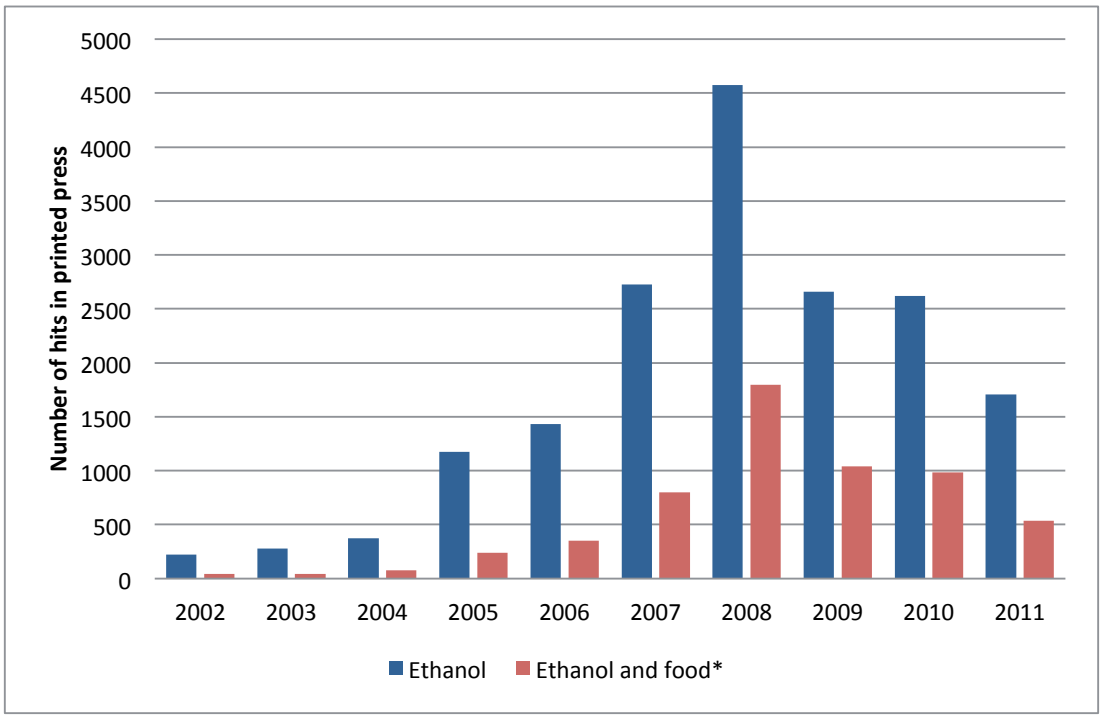

Figure 2. Number of articles in printed Swedish press that mention Ethanol and Ethanol and food (in any combination). Search made in Retriever research database.

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ous. Emissions connected to indirect land use change, such as deforestations, and other production related emissions were highlighted and weakened even more the image of ethanol as a "green" fuel.

To create a variable to include in the regressions a search was made of articles containing ethanol it the title. A total of 1,277 titles were classified as positive, negative or ambiguous/neutral. The share of negative articles has varied between 18 % in 2003 to over 60 % in 2010. While in the early years the share is lower, 2005 stands out with a share of almost 40 % negative articles, most of these are about the pump-law that met a lot of resistance. Besides the environmental effect of "ethanol" the faith of various industries and possible developments of local production of "ethanol" are a common theme. The establishment of a new industry has been categorized as positive and consequently the closure of any such facility is treated as negative. The regression results do not show any significant effect of this variable, implying that the overall coverage in the media has not had an effect on sales. However this does not exclude that some major events such as releases of highly negative reports or the increased coverage of high food prices have contributed to the decrease of sales.

The level of environmental awareness and willingness to do something about environmental issues and especially climate change is high in Sweden. In 2009 more or less every Swede had heard about climate change and 72 % believed that it is important that Sweden does something to mitigate climate change. Looking specifically at car purchases the 86 % were willing to purchase a more environmentally friendly vehicle (Swedish Environmental Protection Agency 2009). Sprei and Wickelgren (2011) found that by 2007 that the environmental criteria has increased in importance among vehicle purchasers. Taking into consideration this high environmental awareness and willingness to action is not surprising that the questioning of ethanol as environmentally appropriate has affected sales of vehicles whose main advantage compared to conventional vehicles is their "cleanness".

OTHER "GREEN VEHICLES"

When the Swedish government decided to create a rebate in 2007 to enhance the sales of certain vehicles they also created a definition of what vehicles would be included and these became labeled as "green". Besides FFVs and gas vehicles even conventionally fueled vehicles with emission below 120 g CO_2/km were included. Besides the pure monetary value of the rebate they also established what was to be considered as a "green" vehicle (*miljöbil*). This concept has become a norm and a general reference point (Borup 2009).When the rebate was introduced the number of models below 120 g CO_2/km was limited and these were in the smaller classes. In 2010 however the picture had changed and a number of larger vehicles, specially the diesel fuelled ones, would meet the standard. To try to capture this development the number of vehicle models that meet the emission roof was added as a dependent variable to the national regression. This variable however turned out to be non-significant. Still it may be that the variable actually did not capture the true effect, i.e., that not only have the number of models increased but also models within the popular segments.

Noticeably Volvo came out with diesel versions of their V70 and V50 that both met the standard. The V70 is the top selling vehicle model in Sweden. And the V50, V70 and V60 had together in 2009 constituted almost 25 % of new sold "green" cars. Figure 3 illustrates how the market share for FFV with the Volvo station-wagons decreased when the more efficient diesel models were introduced in 2009. In total in the market share of "green" vehicles was over 40 % in 2010 and 2011. Thus while until 2008–2009 if a customer wanted to purchase a larger or family size "green" vehicle their only choice was a FFV or a gas vehicle in 2010 the choice set had increased to include diesel vehicles as well.

When it comes to company provided vehicles these are often chosen by the employee, however the company may set some kind of restriction may this be financial, environmental or based on brand. In 2006–2008 companies that wanted to set an environmental criterion often chose to mandate that the vehicle

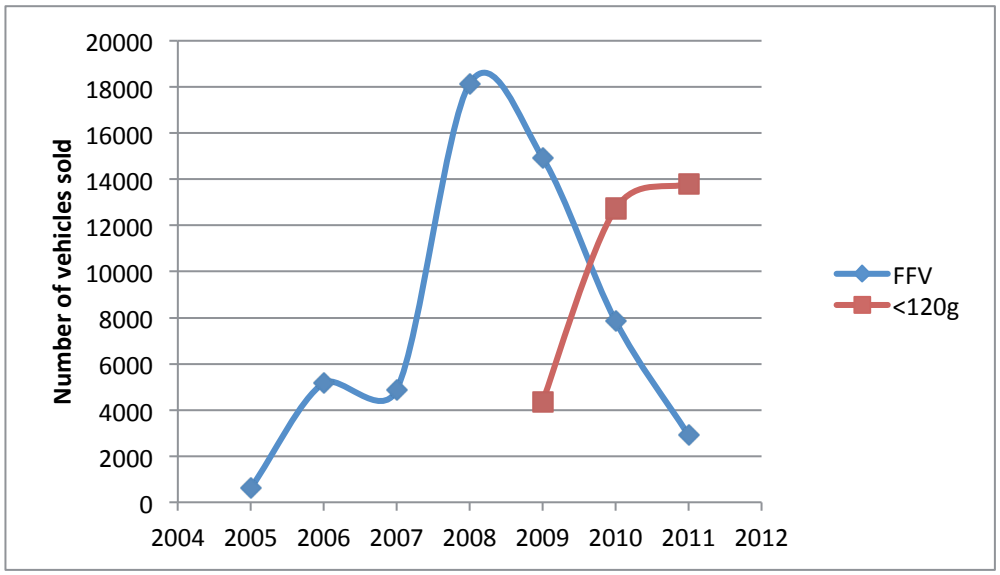

Figure 3. Sales of Volvo's station-wagons, i.e., V50, V70, V60. The blue is the sum of flex-fuel models and red the sum of models with CO_2 emissions below 120 g/km.

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should be able to be driven on an alternative fuel, however by 2009 many shifted to setting limits on CO_2 emissions per km driven, e.g., 140 g CO_2/km. These changes in rules combined with the increased availability of diesel vehicles meeting the criteria have contributed to the decline of sales of FFV.

Conclusions

Sweden's strong push for ethanol and FFV is unique, at least from a European perspective. One could see it as an experiment, but one that didn't follow through. What initially seemed like a successful market penetration, backlashed instead, despite mandates and subsidies. From 2002 and to 2008 the national incentives, some local initiatives like the exemption from congestion charging in Stockholm, the prospect of environmental and economic gain for the owner and the lack of a "green" alternative helped spur the growth of the market share of FFV. Other initiatives such as parking subsidies and fuelling stations providing E85 have been less decisive. Thus, at least in the case for FFV, which can be fuelled on the gasoline the importance of fuelling infrastructure can be questioned, at least for sales of vehicles.

The development of sales of FFV has been influenced by the price ratio between E85 and gasoline, the national incentive structure as well as the exemption from the congestion charging in Stockholm. When the drop in market shares occurred, in 2009, a number of factors happened. First of all the incentive structure for private owners changed, from a point of sales rebate to a smaller subsidy dispersed over five years. For company cars the incentive was still in place but insecurities concerning its renewal decreased its influence. At the same time companies' policies vehicle policies started to move away from alternative fuels to carbon emissions limits instead. Gasoline prices fell while E85 prices did not, making fueling with E85 less economically attractive. The exemption from congestion charging was removed in Stockholm, one of the major markets for FFV and vehicles in general in Sweden.

The image of "ethanol" in the media changed from an "eco-fuel" with the potential to create "clean" vehicles, domestic jobs and lower driving costs to an "alternative fuel" that increased food prices and whose environmental performance was strongly questioned. At the same time diesel vehicles that met the criteria of being "green" started entering the market and offered a possibility to substitute FFVs. This was especially pertinent in the upper middle segment vehicles that have a large share of the Swedish new car market.

FFVs in Sweden are an example of how difficult it can be to truly enter a market that has been established and stable for more than half a century. Looking at FFVs from a consumer perspective the main advantages that they offer have been improved environmental performance and lower driving costs. However, both of these have been challenged. The price of E85 has not been low enough to clearly compete with gasoline, despite the high subsidies. When the environmental benefits started to be questioned then there were few compelling arguments left for choosing a FFV compared to a low emitting diesel.

The lesson learned for other alternative vehicles such as EVs is that they have to provide the owner with some clear advantage compared to the conventional vehicle. It is also important to take into consideration that the environmental performance of gasoline and diesel vehicles will continue to improve and thus to truly compete with these there must be other advantages as well. Subsidies may manage to create a market at first but can't be sustained for a long time and thus there needs to be something more appealing in the long run. In the case of EVs it might be the silence of the drive as well as the driving experience that can make them stand out.

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