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Dieselization in Sweden

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HIGHLIGHTS

- This paper tries to explain the fast dieselization of the new Swedish car fleet.
- It identifies changes in supply and the impact of tax benefits.
- Finally it studies the impact on the annual average mileage.

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ABSTRACT

In Sweden the market share of diesel cars grew from below 10 per cent in 2005 to 62 per cent in 2011 despite a closing gap between pump prices on diesel oil and gasoline, and diesel cars being less favored than ethanol and biogas cars in terms of tax cuts and other subsidies offered to "environment cars". The most important factor behind the dieselization was probably the market entrance of a number of low-consuming models. Towards the end of the period a growing number of diesel models were able to meet the 120 g CO_2 threshold applicable to "environment cars" that cannot use ethanol or biogas. This helped such models increase their share of the diesel car market from zero to 41 per cent. Dieselization appears to have had only a minor effect on annual distances driven. The higher average annual mileage of diesel cars is probably to a large extent a result of a self-selection bias. However, the Swedish diesel car fleet is young, and the direct rebound effect stemming from a lower variable driving cost may show up more clearly as the fleet gets older based on the assumption that second owners are more fuel price sensitive than first owners.

1. Introduction

Sweden has experienced a strong increase in diesel car registration in recent years. As shown in Fig. 1, the diesel share of new registrations grew tenfold from 6.3 per cent in 2000 to 62 per cent in 2011. The objective of this paper is limited to trying to explain what caused such a fast dieselization and to discuss the extent to which it may result in a rebound effect in terms of increasing annual average mileage.

It is difficult to fully explain the fast shift away from gasoline engines. The way diesel fuel and diesel cars are taxed has only undergone minor changes during the recent decade. Prior to Sweden's entry to the European Union, all diesel-fuelled vehicles were subject to a kilometer tax (based on distance driven), and the excise duty on diesel oil was a great deal lower than the tax enforced on gasoline. When kilometer taxation was abolished in 1993, the government decided that the annual vehicle tax on diesel cars should be set at a level so much above the tax on equally large gasoline cars that the difference would balance the benefit of enjoying a lower fuel tax for diesel drivers. The idea was to make diesel and gasoline cars break-even from a fiscal point of view at approximately 15,000 km per annum. Since then the diesel oil tax has been raised somewhat more than the tax on gasoline, and diesel drivers have been compensated by a reduction in annual vehicle tax.

However, a somewhat more profound change in taxation took place when the government in 2005 decided to relate part of the annual vehicle tax to each car model's emission of CO_2 per kilometer. From 1 January 2011, the tax formula is a basic charge of SEK 360 to which SEK 20 is added for each gram CO_2 per km above 120 (SEK 1 = USD 0.15). Cars that can use E85 or biogas pay SEK 10 per gram. Diesel cars in addition pay a fee of SEK 250 aimed at internalizing excess emissions of regulated substances (compared to gasoline cars). The sum of the basic charge and the CO_2 penalty is multiplied by a "fuel factor" of 2.55 to compensate for the difference in fuel tax.

The Volvo V70 has in recent years been the most popular passenger car in Sweden, represented by 17,718 new diesel and 4547 new gasoline registrations in 2011. The most sold diesel V70

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emits 137 g CO_2/km (with manual gearbox), while the most common gasoline V70 accounts for 157 g when driven according to the European test cycle. The nominal annual circulation taxes for these two sub-models are SEK 1,100 and SEK 2,422 respectively.

In January 2012, the incremental cost of buying a diesel car instead of an almost identical gasoline model (with approximately the same power and performance) was on average SEK 32,800 (USD 5000) for the five most popular models in the Swedish market in 2011 (Volvo V70, Volkswagen Passat, Volvo V50, Volvo V60, and Volkswagen Golf). However, there are less high-performing diesel models (Volvo DRIVe and Volkswagen BlueMotion) which cost less and emit less than those that equal the gasoline version in performance.

2. The role of subsidies

It is probably more important that consumer preferences have been strongly influenced by large tax breaks and other benefits to "environment cars". According to a government regulation adopted in 2004, "environment cars" are flexible-fuel vehicles that can run on ethanol (E85) or biogas provided that they, when driven on gasoline, do not emit more than 218 g CO_2 per km. For cars equipped with automatic transmission there is no upper limit so long as the same model with manual gears meets the 218 g threshold. In addition, diesel cars and gasoline cars (not equipped for E85 or biogas) that emit less than 120 g CO_2 per km are also labeled "environment cars".

"Environment cars" have enjoyed free parking in most cities, and cars able to use E85 or biogas registered between 2007 and 2009 were exempt from the Stockholm congestion tax until 2012 regardless of fuel consumption per km. Between 1 April 2006 and 30 June 2009 the government subsidized all new "environment cars" registered by private citizens by SEK 10,000 ($ 1500). After 1 July 2009 all new "environment cars" are exempt from annual vehicle tax for five years following the first registration. A consequence of this (see taxation data above) is that diesel cars are more subsidized than equal gasoline cars and that high emitting ethanol and biogas cars get a larger tax break than cars running on the same fuels that emit less!

Company cars used by employees for private purposes have during the period in question been offered large reductions in the tax on this benefit in kind. Electric hybrids and gas-fuelled cars have been allowed a 40 per cent tax reduction (but not amounting to more than SEK 16,000/y) and ethanol cars one of 20 per cent (not exceeding SEK 8000/y). These rebates have been given regardless of fuel consumption. Low-emitting diesels have not been subject to any reduction.

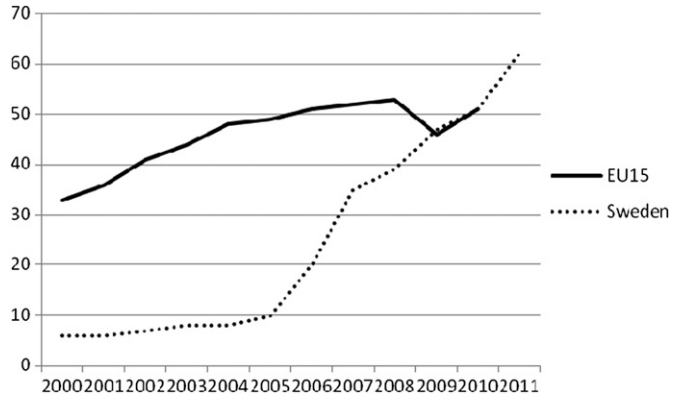

Fig. 1. Diesel shares of new passenger car sales in Sweden and EU15 (in per cent). *Source*: ACEA and Bil Sweden.

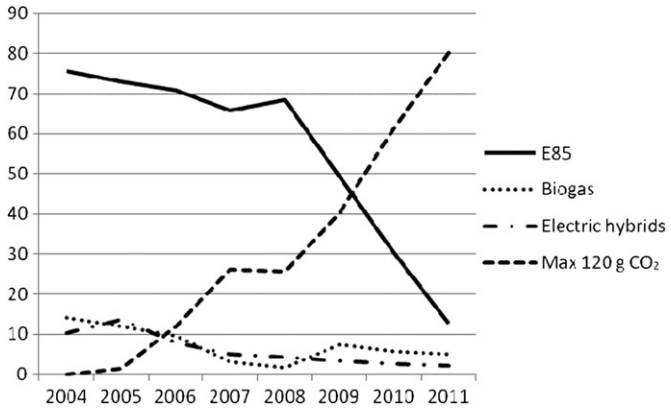

Fig. 2. The Swedish "environment car" market by type of car (in per cent). *Source*: Bil Sweden.

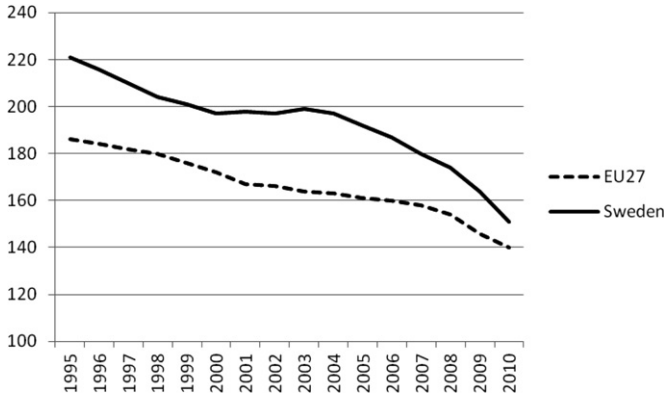

Fig. 3. Average CO_2 emissions per km for new cars in Sweden and EU 27. *Source*: European Commission and Swedish Transport Administration.

The large incentives provided by national and local government affected consumer preferences strongly. The share of "environment cars" among new registrations grew from 3 per cent in 2004 to 40 per cent in 2011. As shown in Fig. 2, ethanol (flexible-fuel) cars dominated the scene until recently, while low-emitting diesels and gasoline cars starting from zero in 2004 accounted for 80 per cent of the "environment cars" in 2011 (three quarters of the latter being diesels).

3. Worst in class

For many years Sweden had the highest fuel consumption in new cars (and in the total fleet) in the European Union. Lately the difference between Sweden and the Community has diminished, but Sweden is still highest among the old Member States (EU15). Fig. 3 shows the development which for Sweden, after 2005, to a large extent, is an effect of dieselization.

From Fig. 4 it is clear that the specific emissions of CO_2 from new cars do not show a normal distribution in Sweden. Back in 2004 there was one significant peak around 220 g per km, which in the following years gradually diminished and was supplemented by a second peak around 170 g. This peak reached its highest value in 2008 and now appears to be in the process of shrinking. A third peak started to emerge in 2007 and has since shot-up significantly. The first peak represents the old habit of buying large and powerful cars without thinking much about fuel consumption. The second is, to a large extent, the result of subsidizing ethanol cars that emit less than 218 g, and the third consists mainly of fuel efficient diesel cars and represents a trend

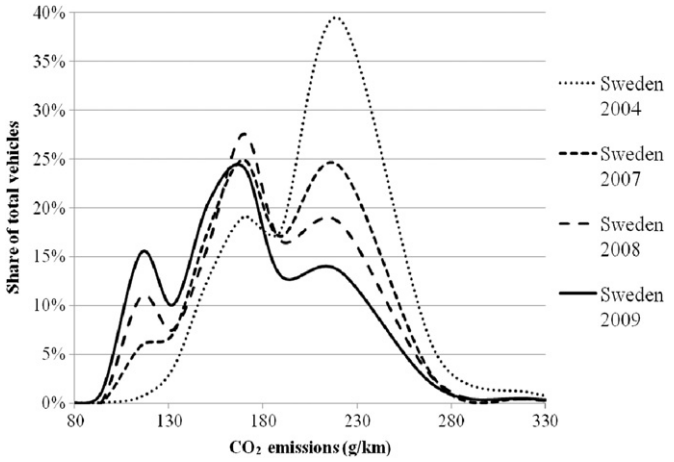

Fig. 4. New registrations in Sweden, distribution by gram CO_2 per km. *Source*: Swedish Transport Administration.

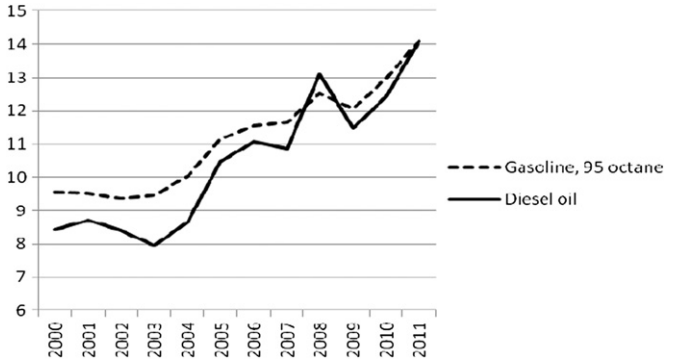

Fig. 5. Average annual price at the pump (manned stations) (in SEK per liter). *Source*: Swedish Petroleum Institute.

that is fuelled by a growing international supply of low-consuming diesel models and by the benefits tied to cars that emit less than 120 g per km Fig. 5.

4. Reasons for choosing a diesel car

The share of all new diesels that emit less than 120 g CO_2 grew from nil in 2005 to 41 per cent in 2011. In recent years Volvo and VW, the two largest suppliers to the Swedish market, have introduced a number of diesel models that emit less than 120 g per km. It started with cars in the smallest segments, but both companies (and some others) now market large cars that fall within this category.

However, dieselization does not appear to have changed the Swedish demand much where size is concerned. Between 2000 and 2008, the mass of new vehicles remained at the same level for gasoline cars and increased modestly for diesel cars (+1.8 per cent). However, the average power of new diesel cars registered in Sweden grew by 27 per cent in the same period, while the power of gasoline cars increased by only 4 per cent. Engine volume dropped slightly for both categories.

The fact that the untaxed cost of diesel oil has increased faster than that of gasoline appears not to have dampened the interest for diesel cars. During 2008 the price at the pump was on average slightly higher than for gasoline. However, on average one liter of gasoline has been priced 3 per cent above one liter of diesel during the last seven years.

According to expertise at Bil Sweden, the country's motor industry organization, the second hand value of diesel cars has improved in recent years, reflecting a greater trust in diesel technology and a market approval of diesel cars that have become less noisy and better performing in terms of acceleration and top-speed.

5. The size of the rebound effect of dieselization

Reducing fuel consumption per km makes it cheaper to use the car and results in additional mileage. The magnitude of the direct rebound effect is not exactly known. However, the results from numerous studies of fuel price sensitivity indicate that the fuel elasticity for mileage accounts for about half of the total elasticity, i.e. about −0.3 (Goodwin, 1992; Jansson and Wall, 1994; Johansson and Schipper, 1997; Kemel et al., 2009). If the response to rising and shrinking fuel cost is symmetric, this figure indicates an upper limit of the direct rebound effect. Sorrell (2007), referring to a number of international studies, concludes that the direct long-run rebound effect is likely to be less than 30 per cent in the household sector and may be closer to 10 per cent for transport. Part of the explanation for this difference is the opportunity cost of time. A large decrease in variable cost is not going to make us want to use much more time at the wheel. The time that humans spend on mobility per day is relatively constant over time and across cultures (Schafer and Victor, 1997).

The best estimate of recent years, based on American data, suggests that the long-term direct rebound effect erodes 10–22 per cent of the improved fuel efficiency (Small and Van Dender, 2007). One should be aware of the direct rebound effect but its existence is no valid argument against investing in improved fuel efficiency.

Another factor to consider is the likely possibility that those, mostly companies, who can afford to buy new diesel cars, in particular in the premium segments, are less sensitive to fuel cost than the private individuals that will later become the second, third and fourth owners of these vehicles. Small and van Dender (2007) estimated that the direct rebound effect declines considerably with rising income. This may argue in favor of the hypothesis that the rebound effect, percentagewise, is larger for old diesel cars than for new.

Assuming that the fuel cost of diesel cars is on average 30 per cent lower than for gasoline cars, one could expect the rebound effect to raise the annual mileage of the cars concerned by no more than 5 per cent. This may, however, be statistically difficult to verify as the increase of the diesel fleet so far represents less than 15 per cent of the total Swedish passenger car fleet.

Available data on annual distances driven in Sweden do not allow for a conclusive statement about the size of the rebound effect. However, they can be used to shed some light on the issue. Fig. 6 displays the average distance in passenger cars by curb weight and owner. It shows that large company cars are driven much longer distances than privately owned cars of the same size. In the segments below 1500 kg the difference between company cars and private cars is small.

The average annual mileage in 2009 for all cars is estimated to have been 13,210 km for privately owned cars and 18,770 km for company cars. However, new company cars are on average driven 80 per cent longer than new private cars. After a few years the difference is small and for 12 year old cars the annual mileage is larger for the private cars. New cars in 2009 were split 62/38 per cent between institutional owners and households. 83 per cent of five year old cars were owned by private citizens.

Data from the mandatory periodical inspections of vehicles allow for a break-down of the annual mileage of the total passenger car fleet on vehicle type and owner. Diesel cars are on average driven 145 per cent longer annual distances then

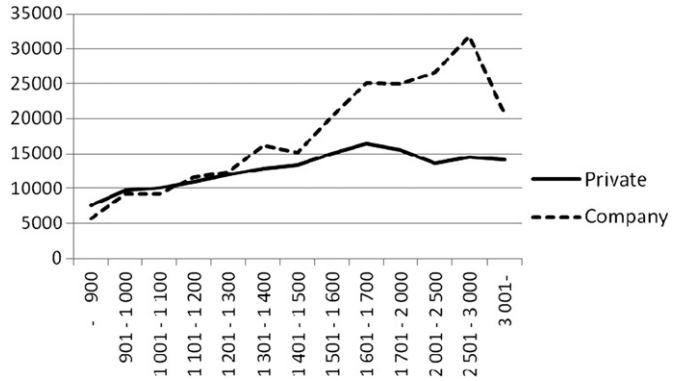

Fig. 6. Mileage (km) of passenger cars in 2009 by kerb weight (kg) and owner category.
Source: Transport Analysis (www.trafa.se).

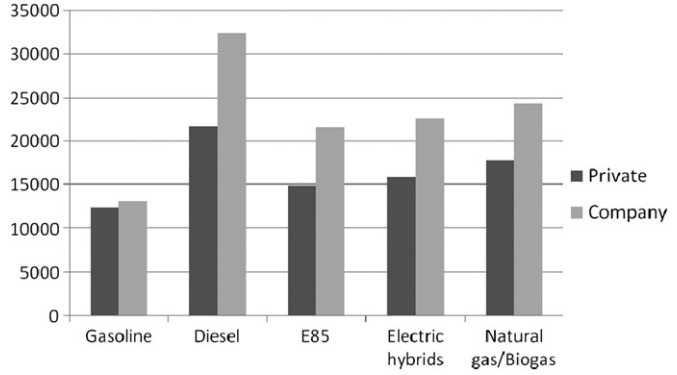

Fig. 7. Annual mileage (km) by vehicle type and owner for the total Swedish car fleet in 2009.
Source: Transport Analysis (www.trafa.se).

gasoline cars when owned by companies and 75 per cent longer when privately owned. If ethanol and biogas cars, which are powered by flexible-fuel otto engines, are counted as gasoline vehicles, the difference between diesel and gasoline-fuelled cars on average (all owners) is 110 per cent. However, here one must recall that the average age of the Swedish diesel car fleet in 2009 was only 4.3 years, while cars with otto engines were on average 10.2 years old. At the same time one must also keep in mind that the total annual mileage is known to decline with the age of all cars, regardless of engine and fuel. In Sweden the mileage of a ten year old car is typically about half of that of a new car.

An open question is to what extent the differences displayed in Fig. 7 are the result of a self-selection bias. It is well known that new diesel cars are preferred by buyers who expect themselves to drive a lot, and the same selection probably takes place in the second hand market. This may explain why the divergence is larger than could be expected from differences in fuel cost alone.

One way of trying to find out how much dieselization has caused mileage to expand is to compare the trend for annual mileage with the growth of the diesel fleet. Fig. 8 shows how the average annual mileage of all cars (based on periodical inspections) grew by only 9 per cent between 2000 and 2009 despite an increase in average income per capita of 14 per cent and the fast growth of the diesel passenger car fleet in recent years. By comparison, estimates made by the Swedish Transport Administration (based on traffic monitoring) show that total traffic by car grew by less than 7 per cent.

Interestingly, both types of traffic estimates show a faster increase during the first half of the decade, when the diesel car fleet remained constant, than during the latter part, when the fleet doubled. However, it should be recognized that the diesel

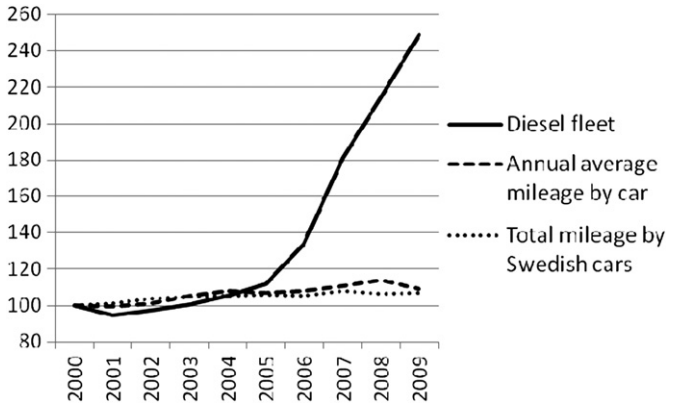

Fig. 8. Trends in dieselization, annual average mileage and total traffic by car. Index 2000=100.
Source: Transport Analysis (www.trafa.se).

share of the total fleet in 2009 was only 11.3 per cent, up from 4.9 per cent in 2000. The recession is a factor that may have influenced the outcome. The annual average mileage by car dropped by 4.3 per cent between 2008 and 2009, probably caused by the economic down-turn.

The estimates of annual distance driven for the various categories of car are associated with considerable uncertainty. The periodical inspections of vehicles, on which they are based, are mandatory only for vehicles older than three years, and flaws and uncertainties in the reporting are known to be large. However, the same model has been used throughout the last decade and the uncertainty has, according to the staff of Transport Analysis, the state agency in charge, remained at an almost constant level. Whether errors are random or systematic is not known. Transport Analysis has declared its intention to start an in-depth assessment of the model and how the results are interpreted.

The monitoring of road traffic that is carried out by the Swedish Transport Administration is limited to a selection of roads and streets and has essentially been unchanged throughout the decade. However, changes in traffic patterns may have affected the results to some, probably rather small, extent. A minor difference between the two models is that estimates based on periodical inspections include distances driven abroad by cars registered in Sweden, while traffic monitoring data cover all traffic in Sweden regardless of where the vehicles are registered.

In addition to the direct rebound effect, there may exist different types of indirect effects on energy consumption from shifting from gasoline to diesel-fuelled cars. The amount of energy embodied in manufacturing may differ, although probably not by much. A potentially more important indirect effect may result from consumers using the cost savings from energy efficiency improvements to purchase other goods and services which require energy. However, in the case of dieselization a substantial part of the fuel cost saving will have to be used to pay for the incremental cost of the diesel engine and the annual vehicle tax. The five most popular diesel cars in Sweden currently cost on average approximately 14 per cent more than their counterparts among gasoline cars. Assuming that most of the incremental cost will have to be borne by the first owner (Greene, 2010), the potential indirect rebound effect will appear during the later part of the life of the vehicle and benefit the second and third owners rather than the initial buyer.

6. Strong growth in light diesel trucks

Yet another aspect of dieselization in Sweden is a strong trend of substituting passenger cars by light duty trucks. Fig. 9 shows

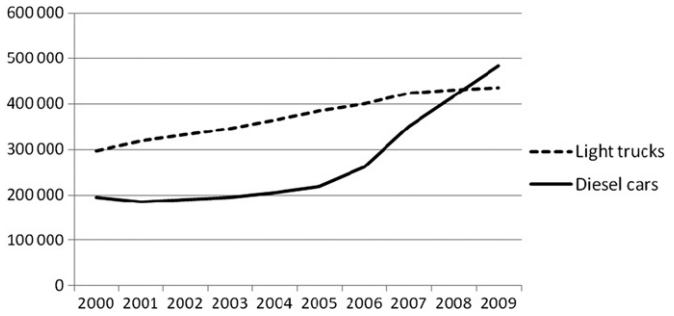

Fig. 9. Total fleet of diesel passenger cars and light trucks. Development between 2000 and 2009.
Source: Bil Sweden.

that for most of the decade the total fleet of light trucks grew faster than the diesel car fleet. It is only in the last few years that the number of diesel cars has outgrown that of light trucks. The increase was particularly strong for trucks weighing 2–2.5 t. This segment grew by 106 per cent. Traffic by light trucks is estimated to have increased by 80 per cent between 2000 and 2009, while growth in total mileage by passenger cars stopped at 6.8 per cent. In 2008, 93 per cent of the new light trucks were diesel-powered.

7. Conclusions

The fast dieselization of the new Swedish passenger car fleet that took place between 2005 and 2011 was the result of several factors. The most important among them was probably the market entrance of a number of relatively low-consuming diesel models, supplied by market leaders such as Volvo and Volkswagen. The fact that diesel cars became less noisy and better performing added to market acceptance and pushed second hand values upwards.

The market share of diesel cars grew from less than 10 to more than 60 per cent in seven years despite a closing gap between pump prices on diesel oil and gasoline. Diesel cars were less favored than ethanol and biogas cars in terms of tax cuts and other state subsidies offered to "environment cars". However, towards the end of the period a growing number of diesel models were able to meet the 120 g threshold applicable to "environment cars" that cannot use ethanol or biogas. This helped the 120 g (or less) models to increase their share of the diesel car market from zero to 41 per cent.

The reform of the annual vehicle tax regime towards promoting low emissions of CO_2, however, can only explain a small part of the shift to diesel cars. Flexible-fuel ethanol and biogas cars also benefitted from the reform.

Dieselization appears to have had only a minor effect on annual distances driven. The higher average annual mileage of diesel cars is probably a result of a self-selection bias to a large extent. People who drive extensively prefer diesel cars to gasoline cars. This tendency is strengthened by the Swedish tax system which tries to put an equal tax burden (fuel tax and vehicle tax) on diesel and gasoline cars at an annual distance of 15,000 km. The increase in average annual mileage and total car traffic has been small during the period concerned and shows no evidence of being significantly influenced by the ongoing dieselization. However, diesel cars still only make up a minor part of the total fleet, and the economic recession may have depressed car use in 2008–2009.

The Swedish diesel car fleet is young, a natural effect of fast growth in new registrations, and new cars, mainly owned by companies, are driven much longer annual distances than five or ten year old vehicles. Therefore the direct rebound effect stemming from a lower variable driving cost may show up more clearly as the fleet gets older based on the assumption that second owners are more fuel price sensitive than the first owners.

One way for the Swedish government to limit the rebound effect would be to tax diesel fuel on par with gasoline. The un-taxed product price of diesel is considerably higher than for gasoline (which partly reflects higher energy content per liter of fuel), so equal taxation would bring the price at the pump significantly above that of gasoline. However, the greater efficiency of the diesel engine would still result in a lower fuel cost per kilometer driven and cause a direct rebound effect.

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