On modeling energy demand vs service demand for individual motorized mobility in Austria

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ABSTRACT

The current problems arising from motorized individual transport – e.g. greenhouse gas emissions – lead to an urgent need for implementing efficient and effective policy measures. To get a reliable appraisal of the effects of different types of policies it is very important to know the impact of different parameters like prices, investment costs, fuel intensities on increases in energy and underlying service demand (more vehicles, larger cars, more total km driven).

The major results and conclusions of this analysis are:

(i) The chosen parameters provide very good estimates for explaining the consumption of the energy service "individual mobility" in Austria.

(ii) The analyses of underlying service demand parameters and efficiency provides additional and deeper insight on the impact of different economic parameters. Actually, all components of short-term and long-term service demand depend significantly on income. The long-term components – number of new vehicles and the power index – also depend on fuel prices and investment costs.

(iii) Most important is to state that fuel price increases lead to significant efficiency improvements and straightforward energy savings. However, these effects are – if prices drop – outweighed by increases especially in short-term km driven.

(iv) A significant impact of cross-border "tank tourism" is identified

(v) The share of new diesel vehicles is significantly dependent with best fitting on service price and demand for total km driven.

1. INTRODUCTION

Energy consumption in individual motorized transport is still increasing and so are the resulting problems e.g. air pollution, increasing greenhouse gas emissions, rising dependency on oil imports from politically unstable countries and looming peak-oil. These problems lead to an urgent need for implementing efficient policy measures.

To get a reliable appraisal of the effects of different types of policies it is very important to know the impact of different parameters like income, prices, vehicle investment costs on energy consumption. More precisely, it is of interest to get some insight how these economic parameters impact increases in service demand (more vehicles, larger cars, more total km driven) and decreases in efficiency respectively fuel intensities.

This paper focuses on the development of the key indicators responsible for growth in energy consumption in individual transportation in Austria. The core objectives are:

- With respect to overall energy consumption in individual transport in Austria: to identify the impact of major economic and efficiency parameters – changing fuel prices, households income; intensity of fuel use;
- With respect to the underlying parameters of service demand – overall demand for vehicles, changes in size and power, mobility (km driven): what is the impact of fuel prices, income, investment costs of cars?
- Efficiency, intensity: What is the impact of fuel prices, service demand and time trends?

In the literature Dahl/Sterner (1991) provided the first comprehensive survey on estimates of price and income elasticity in transport. Howarth et al (1991), Schipper et al (1997) and Haas et al (1998) depict the decomposition of energy consumption into structure, intensity and activity components. Walker/Wirl (1993) and Orasch/Wirl (1997) introduced the concept of estimating service demand rather then energy consumption and they argued that irreversible efficiency improvements may play an important role in estimating energy demand. Sterner (2007) shows that energy taxes are an effective policy instrument in transport. Dargay et al (2007) debate by building a model that explicitly models the vehicle saturation level as a function of observable country characteristics: urbanisation and population density. This model is estimated on the basis of pooled time-series and cross-section data for 45 countries. The impact on the fuel economy standards for new vehicles have been analysed by Fischer et al (2007). This analysis encompasses a wide range of scenarios concerning consumers' valuation of fuel economy and the full economic costs of adopting fuel-saving technologies.

2. SOME BACKGROUND

In this chapter some background information is provided. Fig. 1 depicts the development of gasoline vehicle stock and new gasoline vehicles in Austria between 1970 and 2007. It can be seen that the total number of vehicles is continuously increasing between 1970 and 1995. After 1995 is total number of gasoline vehicles in Austria rapidly decreasing. The number of new gasoline vehicles is rather volatile especially until 1991. Lowest sale of gasoline vehicles was in 2003, only 87.197 vehicles.

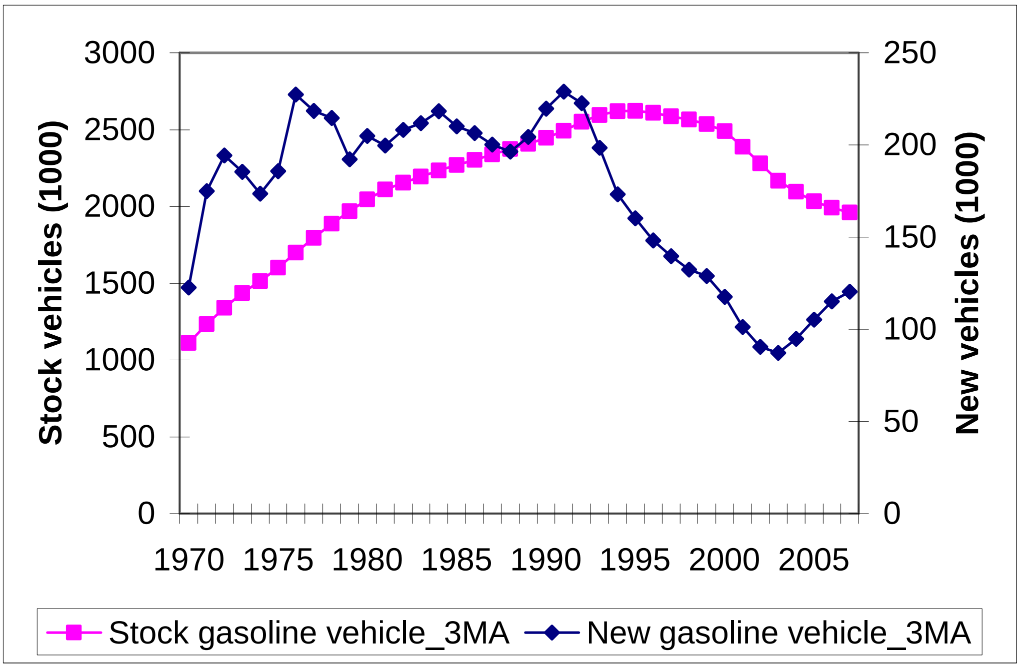

Fig. 1. Development of gasoline vehicle stock and new gasoline vehicles in Austria between 1970 and 2007

The development of diesel vehicle stock and new diesel vehicles in Austria between 1970 and 2007 is shown in Figure 2. It can be noticed that the total number of diesel vehicles is rapidly increasing specially after 1985. In 2007 the share of diesel vehicles in total vehicle stock was 53,8% and in 1985 this share was only 5,3%, see Figure 3. The number of new diesel vehicles was in 2005 for the first time decreasing.

The private passenger vehicle stock in 1970 in Austria was about 1 Mill vehicle, and now there is more then 4 Mil vehicles.

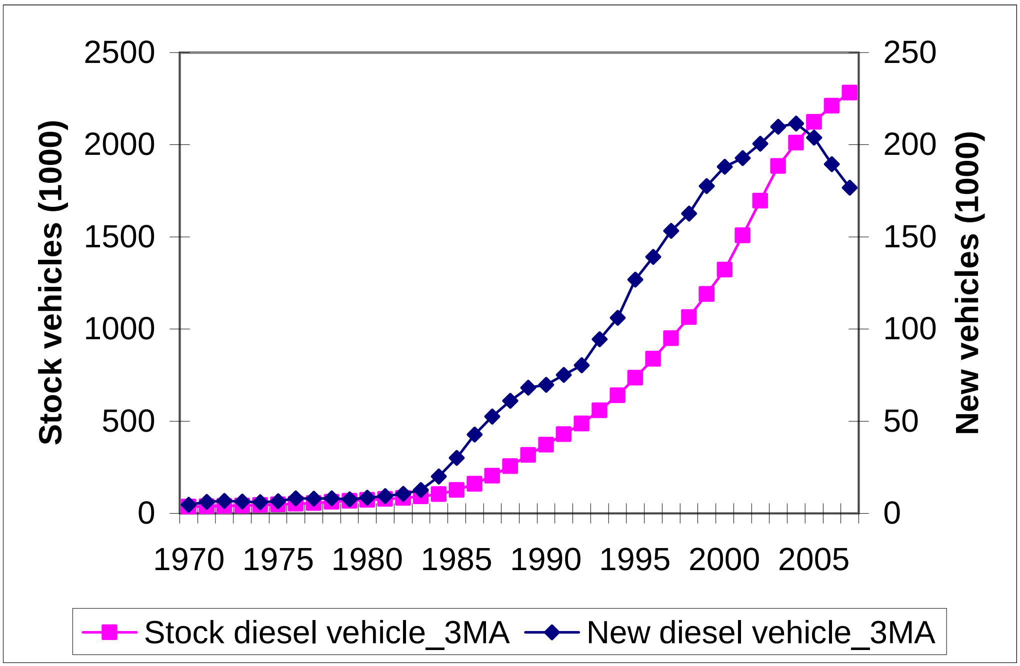

Fig. 2. Development of diesel vehicle stock and new diesel vehicles in Austria between 1970 and 2007

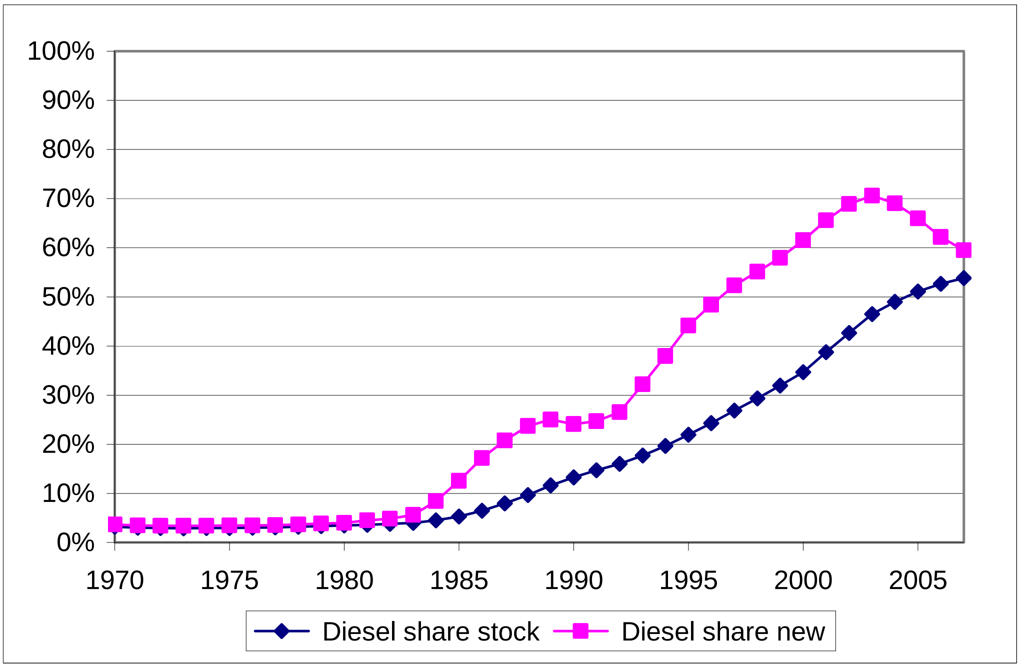

Fig. 3. Development of diesel vehicles share in Austria between 1970 and 2007

In Fig. 4 the number of overall driven person-km is shown as well as the specific distance driven per car and year from 1970 to 2006. It can be seen that the amount of the overall driven km is increasing, but the specific distance driven per car is slowly decreasing. Decrease in specific distance driven was much higher during the high oil price period from 1973 to 1985. After that period decrease slowed down. The average driven distance in Austria is currently about 15000 km per year.

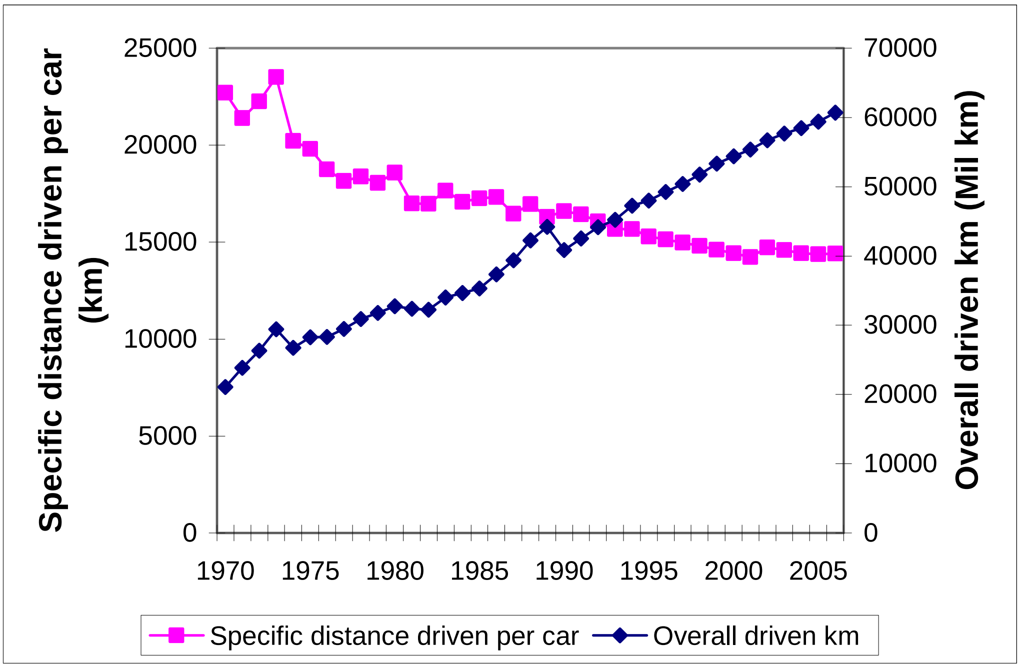

Fig. 4. Number of overall driven person-km and specific distance driven per car and year from 1970 to 2006 in Austria

The number of overall driven person-km as well as the specific distance driven per car and year from 1970 to 2006 split on gasoline and diesel vehicles is shown in Fig. 5 and Fig. 6. It can be seen that the amount of the overall driven km by gasoline vehicles was since 1989 rapidly decreasing and by diesel vehicles the overall driven km are continuously increasing.

The specific distance driven by diesel vehicles is about 17.000 km and by gasoline vehicles 12.000 km.

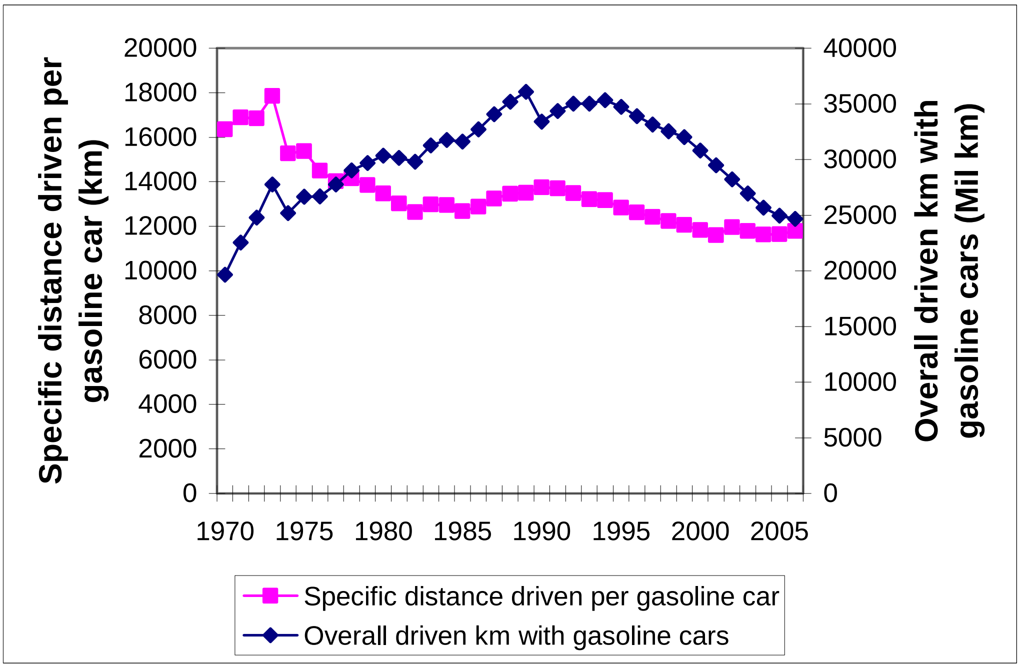

Fig. 5. Number of overall driven person-km and specific distance driven per gasoline car and year from 1970 to 2006 in Austria

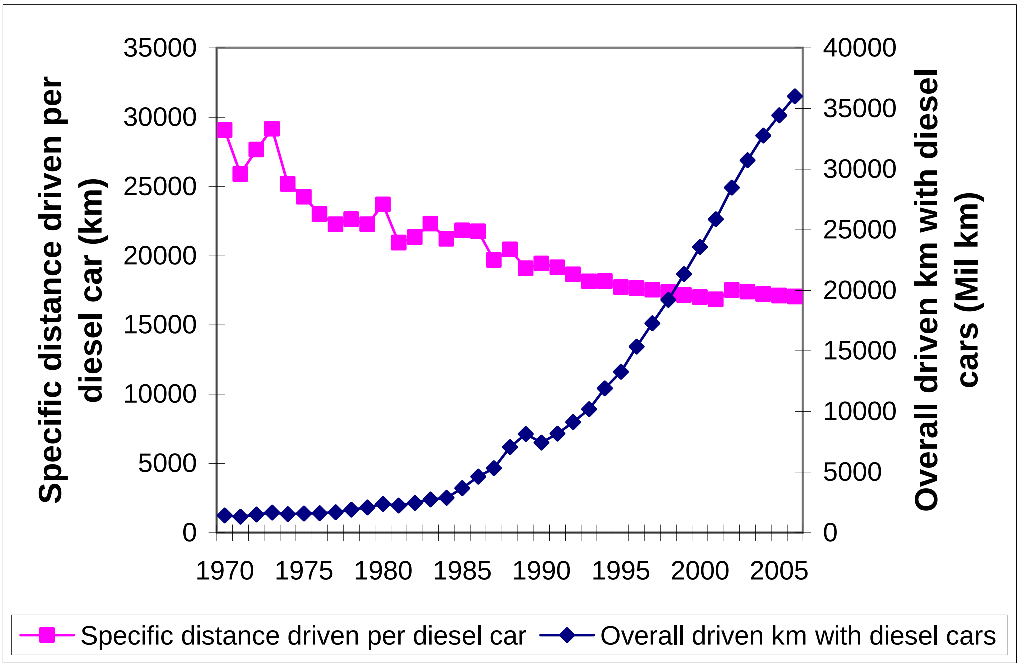

Fig. 6. Number of overall driven person-km and specific distance driven per diesel car and year from 1970 to 2006 in Austria

A comparison of the growth in overall energy consumption in individual transport as well as the private final consumption expenditures is provided in Fig. 7. It can be noticed that private final consumption expenditures in Austria was continuously increasing and this increase is followed by increase in overall energy consumption in individual transport. Currently energy consumption in individual transport is about 300 PJ.

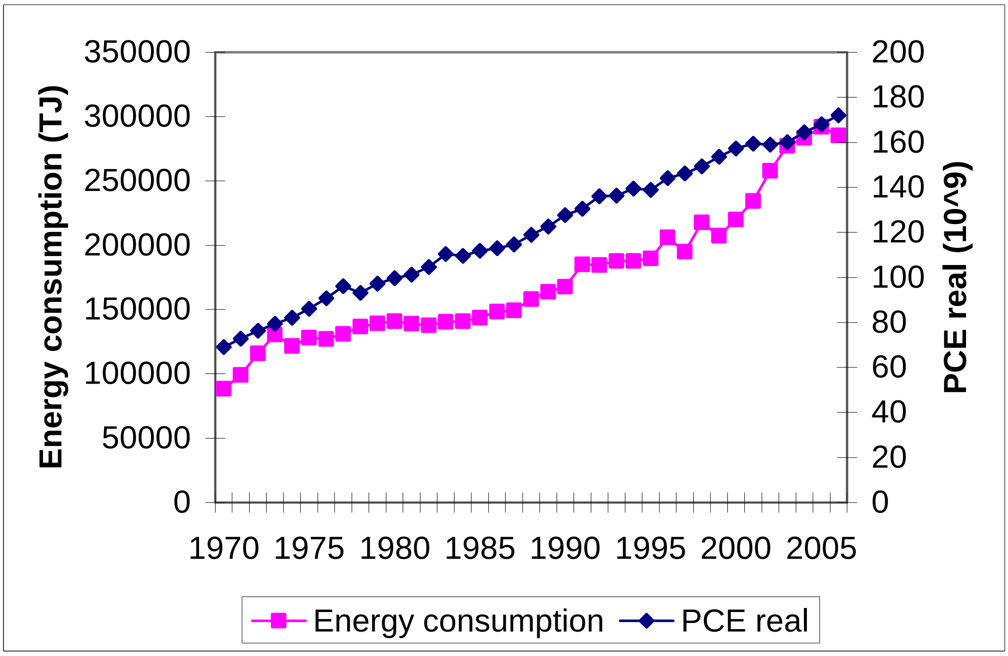

Fig. 7. Development of energy consumption in individual transport and private final consumption expenditures in Austria between 1970 and 2006

In Fig. 8 the development of the size of cars is depicted by means of showing the cylinder categories of the stock and in Fig. 5 of new vehicles. As shown the number of cars is rapidly increasing, but it is important to notice trend toward larger and heavier cars. The share of the passenger vehicles in Austria by performance category (cylinder capacity) is shown in Fig. 8.

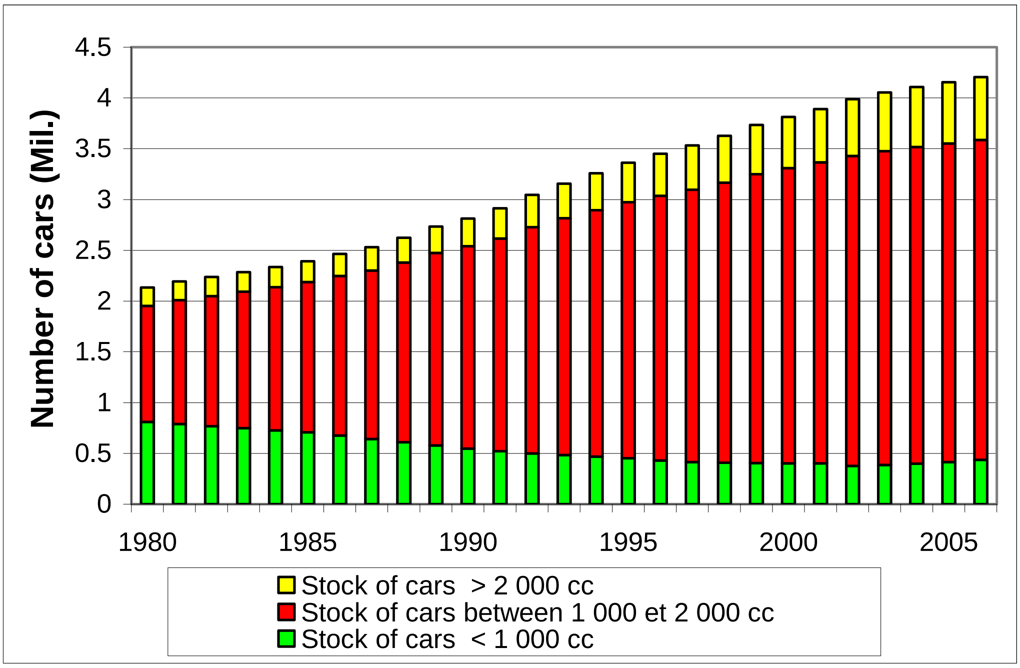

Fig. 8. Development of the size of cars showing the cylinder categories of the vehicle stock from 1980 to 2007 in Austria

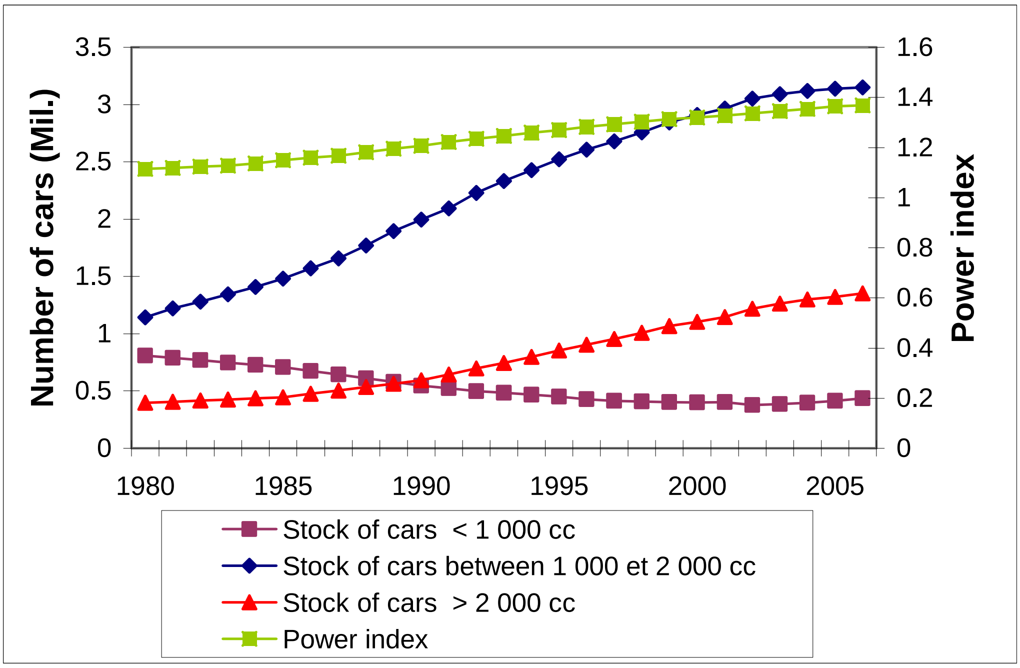

Fig. 9. Development of the size of new cars showing the cylinder categories from 1980 to 2007 in Austria

3. METHOD OF APPROACH

Firstly the method of approach builds on conventional estimation of energy consumption depending on price and income.

Next the method of approach is based on the premise the customers do not intend to consume gasoline or diesel per se but rather the energy service individual motorized mobility.

If in the short-term sufficient infrastructure is available the demand for this service S can be explained as (see Walker/Wirl (1993)):

$$S = E\eta(T) \tag{1}$$

With:

E….energy input

η(T)…. technical efficiency (of the technologies; the term "technology" encompasses conversion technologies but also aspects like systems and infrastructure).

In the following for service demand a more detailed decomposition approach is applied. In principle short-term and long-term components of service demand exist, see equ. (2). Short-term service demand considers consumer behavior with respect to kilometers driven, long-term service demand takes into account parameters like size and quality of cars and number of vehicles, see also Haas et al, 2008.

$$S = S_{LR} S_{SR} \tag{2}$$

S_{SR} ….short-term service demand e.g. distance driven

S_{LR} ….long-term service demand e.g. number of vehicles, and size of cars,

Moreover long-term service demand can be described as:

$$S_{LR} = Z\pi \tag{3}$$

Z… number of vehicles (long-term quantitative service demand);

π …specific power/quality index e.g. size of capacity of vehicles

$$S_{SR} = d \tag{4}$$

With:

d … short-term service demand e.g. distance driven per car.

The level of service demand of e.g. of a household with respect to purchase of new vehicles depends on available income Y, the price of energy service p_s, capital costs of vehicle CC, and the individual utility derived from using this service u(s):

$$S = f(p_{s,} CC, Y, u(s)) \tag{5}$$

p_s ... service price ($p_s = p_E / \eta$)

p_E ... energy price

CC .. capital costs

So the change in long- term service demand e.g. number of new vehicles, power quality index can be described as:

$$S_{LR\_t} = C \ p_t^{\alpha} PCE_t^{\beta} CC_t^{\delta} \tag{6}$$

With:

PCE ... Private final consumption expenditures
α... price elasticity of change in service demand
β... income elasticity of change in service demand due to an increase in PCE
δ... capital cost elasticity of change in service demand

Change in short-term service demand (e.g. distance driven per car):

$$S_{SR\_t} = C \ p_t^{\alpha} PCE_t^{\beta} \qquad (7)$$

For the decomposition of energy consumption it is furthermore necessary to identify indicators for efficiency, see equ. 1. In practice there are several possibilities. The most common one is to take aggregated intensity. The problem with this indicator is that it encompasses also a component of long-term service demand the power/quality index and hence may lead to a considerable distortion, see "Average fuel intensity" in Fig. 10.

In the following for efficiency we will use figures for intensity which are corrected by the power index, see also corrected intensity in Fig. 11.

Note, that endogenous efficiency increases were the source of the benefits (see Walker/Wirl 1993) – more services available – and that growth in π just captures a part of long-term service demand, see example in Fig. 10!

$$INT_{Corr} = INT_{Average} / \pi \qquad (8)$$

and

$$\eta = 1 / INT_{Corr}$$

Fig.11 depicts these different intensities as well as the intensity for small, medium and large cars separately.

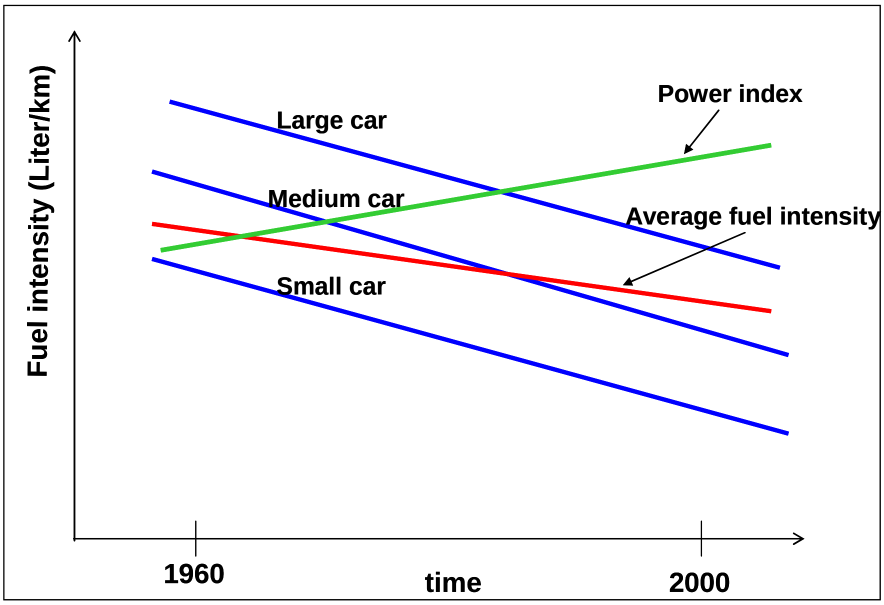

Fig. 10. Index of power increase of cars and average fuel intensities vs specific fuel intensity for small, medium and large cars in individual automotive transport

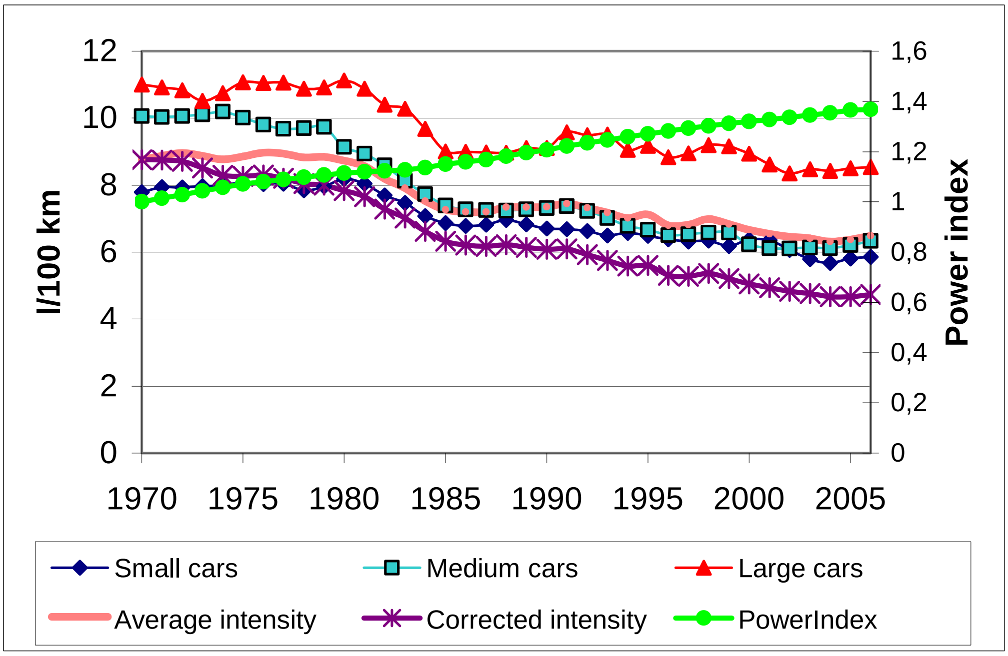

Fig. 11. Different fuel intensities in Austria 1970 to 2006

In Figure 12 is shown the specific consumption of gasoline and diesel private cars. In 2006 the average fuels intensity of diesel vehicles was for 21% lower comparing to gasoline vehicles.

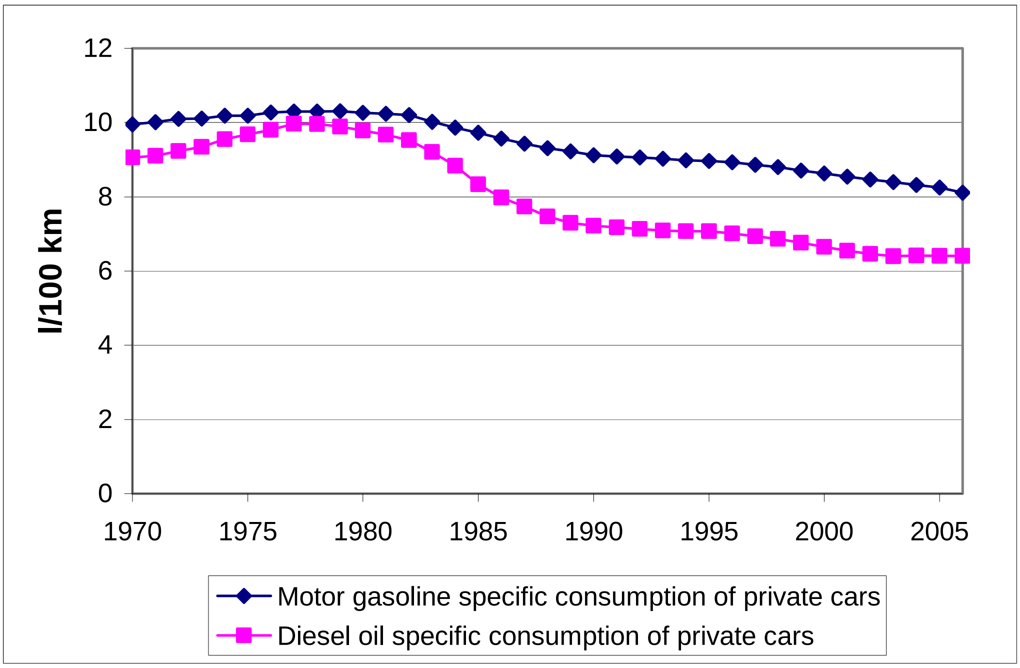

Fig. 12. Fuel intensities of gasoline and diesel vehicles in Austria 1970 to 2006

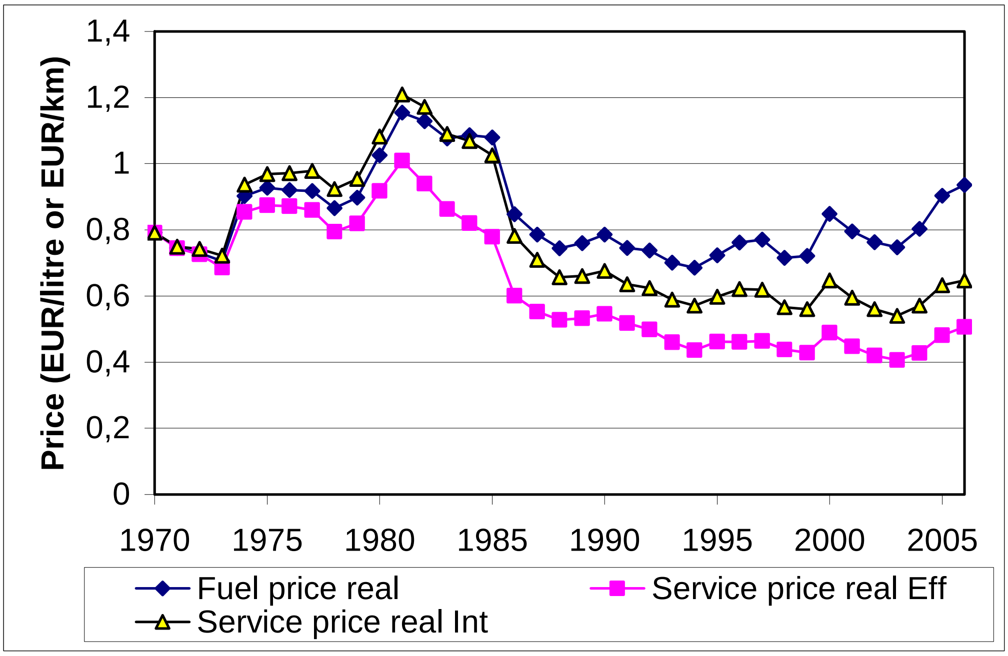

Fig. 13. Fuel prices vs service prices in Austria 1970 to 2006

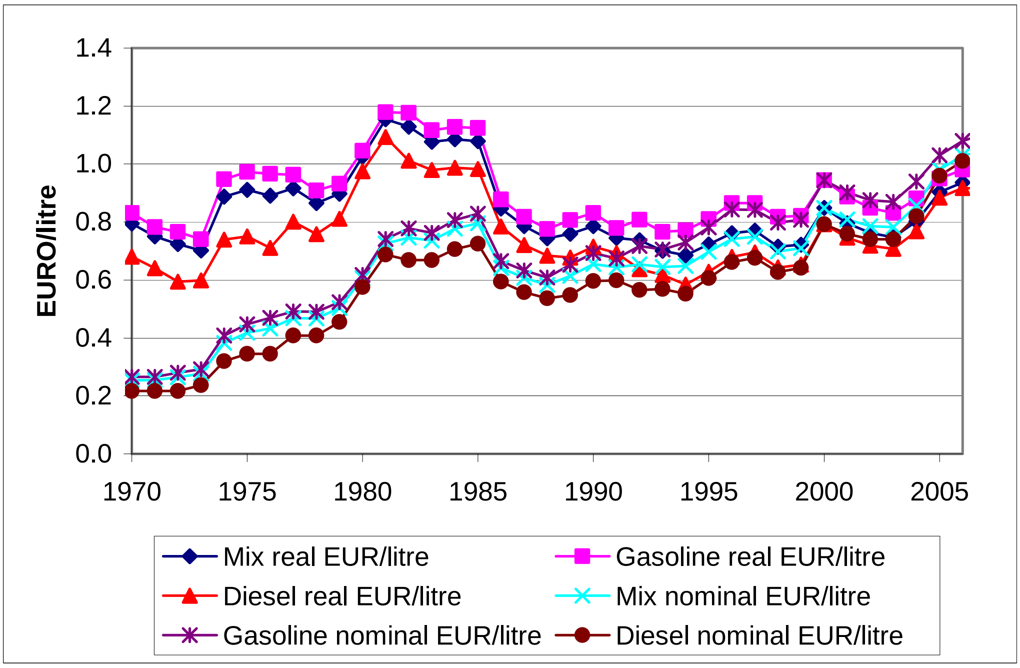

Fig. 14. Fuel prices prices in Austria 1970 to 2006

Another potential point of interest is tank tourism. That is to say, whether at times when in Austria fuel prices were cheaper than in Germany, the German purchased a considerable amount of fuels in Austria. This is considered by means of including the relationship of prices in the econometric analysis.

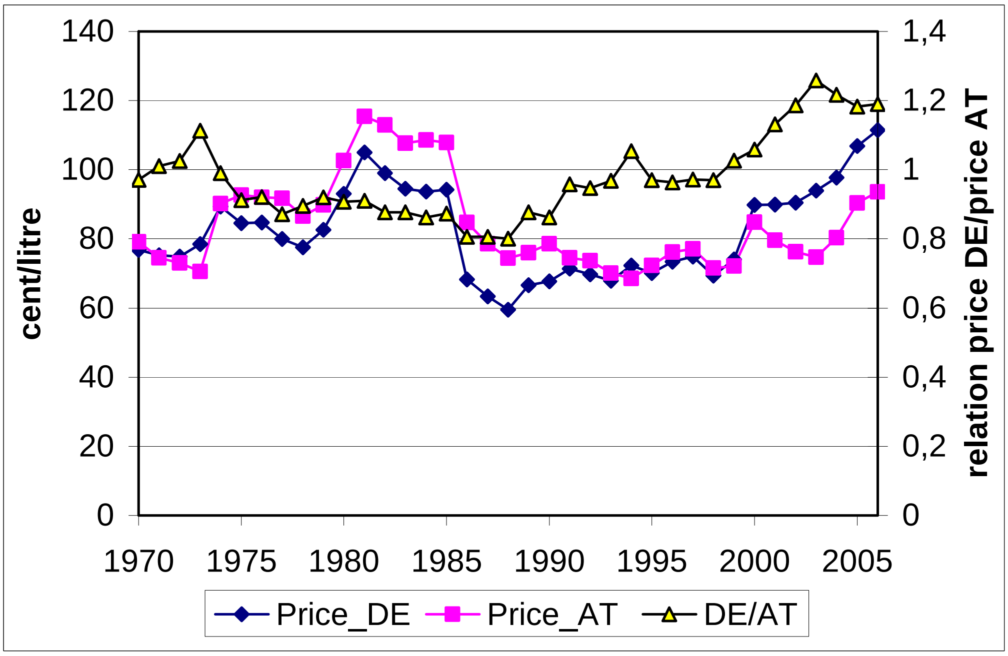

Fig. 15. Fuel prices in Austria vs Germany 1970 to 2006

4. RESULTS OF THE ECONOMETRIC ANALYSES

The focus of this work is to identify a new concept of explaining drivers (and slowers?) of energy consumption in the transport sector. We simply apply the concept of ordinary least-squares. In a next step we will also apply more sophisticated methodological techniques like cointegration and ECM.

4.1. Energy consumption

First, total energy consumption is estimated using the conventional approach:

$$E_t = C \ p_t^A PCE_t^B E_{t-1}^{\lambda}$$

As mentioned before tank tourism especially from Germany (DE) may have a significant impact. This is considered by means of including a variable p_{DEATt} representing the relationship between German und Austrian fuel prices p_{DE} / p_{AT} :

$$E_t = C \ p_t^A PCE_t^B p_{DEATt}^D E_{t-1}^{\lambda}$$

Short-term elasticises A, B and D are calculated from long-term elasticity as:

$$\alpha = \frac{A}{1-\lambda} \ , \ \beta = \frac{B}{1-\lambda} \ , \ \gamma = \frac{D}{1-\lambda}$$

The results are presented in Table 1.

Table 1. Estimates for over-all energy consumption 1970-2006 (t-Statistics in parentheses)

	Energy consumption (1970-2006)				
Model:	**1**	**2**	**3**	**4**	**5**
α (long-term price elasticity)	-0.08 (0.78)			-0.13*)	-
β (long -term income elasticity)	1.07 (17.2)	1.08 (18.3)	0.94 (24.3)	0.84*)	0.90*)
γ (long -term intensity elasticity)			-		
δ (long-term price relation to Germany elasticity)			0.68 (8.66)	0.8*)	0.84*)
λ (Lag)			-	0.55 (4.70)	0.49 (4.55)
Θ (Trend)					
A (short -term price elasticity)				-0.06 (1.24)	
B (short -term income elasticity)				0.38 (3.11)	0.44 (4.00)
C (short -term intensity elasticity				-	
D (short short-term price relation Germany elasticity)				0.36 (3.99)	0.41 (5.01)
R^2 korr	0.90	0.91	0.97	0.98	0.98
F – Test					
DW	0.35	0.37	1.12	2.47	2.34
Durb. H					-1.35
ESS					

*) Calculated from: $\alpha=A/(1-\lambda)$, $\beta=B/(1-\lambda)$, $\delta=D/(1-\lambda)$

The major results are:

Neither estimates with a trend nor estimates with including intensities nor price elasticities were significant. This may lead to the conclusion, from an overall estimate it appears that energy consumption does neither depend on efficiency nor prices!

However, as can be seen later, a more detailed analysis reveals that it is outweighed by an increase in short-term service demand (total km driven). Intensity decreases (=efficiency increases) if prices increase, but service demand increases significantly if (service) prices decrease, see Table 3 and 4 later.

In a next step we analyse whether there might be differences for the elasticities for different periods of time.

Table 2. Estimates for over-all energy consumption 1970-1985 and 1985 – 2003 (t-Statistic in parentheses)

	Energy consumption (1970-1985)			**Energy consumption (1985-2003)**		
Model:	**1**	**2**	**3**	**1**	**2**	**3 (2006)**
C (Constant)						
α (long-term price elasticity)	-0.79	-0.23 (1.12)	-0.62	0.03 (0.23)		
β (long-term income elasticity)	1.07	1.28 (6.38)	1.18	1.45 (12.1)	1.44 (13.51)	0.94 (4.14)
γ (long-term intensity elasticity)						
δ (price relation Germany elasticity)		0.74 (1.99)	0.22 (1.0)			0.67 (3.09))
λ (Lag)	0.58 (5.07)		0.55 (4.6)			
Θ (Trend)						
A (short-term price elasticity)	-0.33 (2.99)		-0.28 (2.4)			
B (short -term income elasticity)	0.45 (3.09)		0.53 (3.19)			
D (relation short-term Germany price elasticity)						
R^2 korr	0.92	0.84	0.92	0.9	0.91	0.945
DW	2.54	0.82	2.85	0.99	0,96	1.18
Durb. H				-		

*) Calculated from: $\alpha=A/(1-\lambda)$, $\beta=B/(1-\lambda)$, $\delta=D/(1-\lambda)$

The key perceptions are:

- The price impacts energy consumption only if prices are increasing or high → period 1970-1985; there is no impact over the period 1985-2003 (decreasing or low prices); see also Fig.10
- The estimation over the whole period 1970-2006 does not provide useful results for the price elasticity because it is diluted!
- The elasticity considering the price relation German/Austrian prices is significant in every estimate over the period 1970-2006 and 1985-2003. It is not relevant over the period 1970-1985
- Total energy demand is depending significantly on income in every model (income elasticity between 0.9 and 1.4).

4.1. Long-term and short-term service demand

Now it is of interest to look behind the aggregates. This can be done by a decomposition of the energy consumption into service and efficiency components.

In this context it is important to understand the concept of decomposition of energy consumption into service shares and efficiency. E.g. Howarth et al (1991), Schipper et al (1997) and Haas et al (1998) depict the split up of energy consumption into structure, intensity and activity components.

From equ. (1), (2), (3), and (4) energy consumption depending on service demand and efficiency can be described as:

$$E = \frac{S}{\eta} = \frac{S_{LR} S_{SR}}{\eta} = \frac{Z\pi d}{\eta} = Z\pi d \ \ INT_{Corr} \quad (9)$$

First the analysis for the long-term components of service demand is conducted.

The major results of the analysis with respect to long-term service demand-number of vehicles and power index- are depicted in the Tables 3 and 4:

Table 3. Long-term service demand: Estimates for total vehicle stock and purchase of new vehicles: 1970-2006 (t-Statistics in parentheses)

	Total vehicle stock (1970-2006) – moving average over 3 years		**New vehicles (1970-2006) – moving average over 3 years**		
Model:	**1**	**2 PCE(-1)**	**1**	**2 (ICPI*)**	**3**
α (long-term price elasticity)	-		-0.15 (1.62)	-0.19 (1.26)	
β (long -term income elasticity)	1.40 (84.4)	1.35 (101.1)	0.63 (3.53)	0.61 (2.16)	0.67 (17.3)
δ (long-term investment cost elasticity)	-		-0.24 (0.52)	-0.30 (0.41)	
λ (Lag)	-				
R^2 korr	0.995	0.997	0.88	0.75	0.90
DW	0.99	1.40			
Durb. H					

*) ICPI-investment with power factor correction

Total car stock is depending significantly only on income (elasticity: 1.40).

The number and size of new cars per year is depending significantly on fuel prices (price elasticity: -0.15), income (income elasticity: 0.63) and the changes in investment costs of new cars (elasticity: -0.24).

Table 4. Long-term service demand: Estimates for overall power/quality index

	Power/quality index of stock		
Model:	**1**	**2**	**3**
α (Long-term energy price elasticity)		-0.05 (4.4)	-0.03 (3.75)
β (Long-term income elasticity)	0.31 (13.2)	0.29 (13.2)	0.12 (4.13)
ζ (Long-term investment cost elasticity)	-0.15 (-2.25)	-0.17 (-2.98)	-0.11 (-2.53)
Θ (Trend)			0.004 (5.82)
R^2 korr	0.987	0.994	0.996
DW			

Remark: λ (Lag) in the range of 0.92 does not lead to reasonable results

Major results: The overall power/quality index is depending slightly but significantly on fuel prices (price elasticity: -0.03), income (income elasticity: 0.12) and long-term investment cost elasticity (-0.11). Moreover there is a significant positive time trend of 0.4% per year indicating an autonomous trend towards larger cars.

The major results of this analysis with respect to short-term service demand are depicted in the Table 5.

Table 5. Short-term service demand: Estimates for vehicle-specific and total km driven per year (1970-2006)

	Average km per vehicle per year (1970-2006)	**Total km driven per year (1970-2006)**
Model:	**1**	**1**
C (Constant)		
α (long-term energy price elasticity)	-0.15 (3.25)	-0.38 (6.55)
β (long-term income elasticity)	0.61 (1.57)	1.16 (34.85)
ζ (long-term vehicle stock elasticity)	-0.72 (2.58)	
R^2 korr	0.85	0.978
DW		

Major results: Total short-term service demand expressed as total km driven per year is depending significantly on fuel prices (price elasticity: -0.38) and income (income elasticity: 1.16). The magnitude of the price elasticity indicates there is a considerable rebound in service demand if prices fall! The significance of the price elasticity is also an important sign that decreases in energy service price lead to a rebound in service demand. Note, that long-term vehicle stock elasticity was not significant in any model for total km driven per year.

Specific short-term service demand (average km per vehicle and per year) is depending significantly on fuel prices (price elasticity: -0.15) and income (income elasticity: 0.61) but it also depends significantly on the change in vehicle stock (-0.72). That is to say, the larger the vehicle stock is, the lower are specific km driven per vehicle!

4.3. Fuel intensity

With respect to the development of average weighted fuel intensity we expect dependence from a lag in price increases and the diluting effect of increases in π as well as possibly a general decreasing trend in intensity due to autonomous technological progress:

$$INT_{Average} = p_{rise}^{\alpha\_rise(-x)} \pi^{\varphi} e^{\Theta}$$

With :

p_{rise} …fuel price increases (price decreases are not considered)

x……years lagged

For estimating the development of pure fuel intensity INT_{Corr} – the reverse of efficiency, see equ. (8) – we expect a dependence from a lag in price increases and possibly a general decreasing trend in intensity due to autonomous technological progress

$$INT_{Corr} = p_{rise}^{\alpha\_rise(-x)} e^{\Theta}$$

Table 6. Estimates for weighted fuel intensity and efficiency (fuel intensity corrected) (1970-2002)

	Fuel intensity weighted (l/100 km per vehicle per year) (1970-2002)			**Efficiency (fuel intensity corrected by power index) (1970-2002)**		
Model:	**1**	**2**	**3**	**1**	**2**	**3**
α_rise (long-term price elasticity due to rising prices						
α_rise (-3)	-0.16 (1.85)	-	-	-0.22 (3.76)		
α_rise (-4)		-0.20 (-2.73)	-		-0.22 (4.12)	
α_rise (-5)		-	-0.16 (2.34)			-0.20 (3.33)
φ (power index)	2.61 (2.13)	2.42 (2.34)	2.9 (2.89)			
Θ (Trend)	-0.03 (2.6)	-0.03 (2.81)	-0.03 3.41)	-0.0155 (10.43)	-0.0150 (10.2)	-0.016 (9.4)
R^2 korr	0.942	0.950	0.946	0.978	0.98	0.976
DW						

Note, that because of the values for the power index between 2002 and 2006 were interpolated in this table we show only the values up to 2002.

The major results of table 6 are: For the average weighted fuel intensity we get a significant dependence on lagged fuel price increases with maximum likelihood for a lag of 4 years. The long-term price elasticity of the average weighted fuel intensity due to rising prices is about -0.20. Moreover, the dependence on the power index as well as the trend is also highly significant.

For the pure fuel intensity INT_{Corr} – the reverse of efficiency – we obtain a significant dependence on lagged fuel price increases with a maximum likelihood for a lag of also 4 years. The long-term price elasticity of the pure fuel intensity due to rising prices is about -0.22. Moreover, the dependence on the trend is also highly significant as expected.

4.4. Share of diesel vehicles

In the next step we analyze the share of new diesel cars in Austria for a period from 1970 to 2006.

The idea is that estimating the share of diesel cars by means of using service related parameters (service price, total km driven…) leads to better results than using the variable energy price and intensity separate. In the following we show estimates for share of new registered diesel cars.

We use the following formal framework:

$$SH_{diesel} = C\ PR_{GD} INTR_{GD} TDR_{GD}$$

$$PR_{GD} = \frac{P_{gasoline}}{P_{diesel}};\ INTR_{GD} = \frac{INT_{gasoline}}{INT_{diesel}};\ TDR_{GD} = \frac{TD_{gasoline}}{TD_{diesel}};\ PSR_{GD} = PR_{GD} INTR_{GD}$$

With:

SH_{diesel}……… The share of new diesel cars

PR_{GD}………..Ratio of fuels price

$INTR_{GD}$…….. .Ratio of intensity

TDR_{GD}……… Ratio of total kilometer driven per year

PSR_{GD}… …….Ratio of service price

Table 7. The share of diesel cars - new vehicle (1970-2006)

	The share of diesel cars - new vehicles (1970-2006)				
Model:	**1**	**2**	**3**	**4**	**5**
The ratio of energy price (gasoline to diesel price)	0,98 (1,09)		*-0,15 (-0,33)*		
The ratio of energy intensity (gasoline to diesel car intensity)		7,57 (10,71)	7,62 (10,34)		
The ratio of service price-mobility (gasoline to diesel service price)				2,31 (3,95)	
The lagged ratio of service price (gasoline to diesel service price) (-					1,93 (2,41)
The ratio of total km driven (gasoline to diesel cars)	-1,06 (-20,95)	-0,50 (-8,75)	-0,50 (-8,21)	-0,90 (-15,87)	
The lagged ratio of total km driven (gasoline to diesel cars) (-1)					-0,93 (-11,30)
λ (Lag)					
R^2 korr	0,92	0,98	0,98	0,95	0,91
DW	0,12	0,22	0,23	0,23	0,15
Durb. H					

The major results of table 7 are: The share of new diesel cars is depending on ratio of energy intensity, service price and total km driven. The impact of all these parameters is significant, as shown in Table 7. The estimates with lag were not significant. The share of new diesel cars is increasing if gasoline price as well as fuel intensity of gasoline cars is increasing. The same goes also for service price. If the number of diesel driven km increases – that is to say if the ratio, the gap between diesel driven and gasoline driven km becomes larger- the share new diesel vehicles increases.

5. CONCLUSIONS

The major conclusions of this analysis are:

In general, the chosen parameters provide very good estimates for explaining the demand for vehicles, mobility and energy consumption in Austria.

From an aggregated estimate of energy consumption over the period 1970-2006 it is not possible to extract the full set of explanations. Yet a more detailed analysis revealed that separating periods of rising/high prices (1970-1985) and the period of decreasing/low prices (1985-2003) shows that there is a significant price impact for rising prices but not vice versa.

Also, a significant impact of cross-border “tank tourism” is identified.

The analyses of underlying service demand parameters and efficiency provides additional and deeper insight on the impact of different econometric parameters. Actually, all components of short-term and long-term service demand depend significantly on income. The long-term components – number of new vehicles and the power index – also depend on fuel prices and investment costs.

The share of new diesel vehicles is significantly dependent with best fitting on service price and service demand.

Finally, it has to be stated that fuel price increases lead to significant efficiency improvements and straightforward energy savings. However, these effects are – if prices drop – outweighed by increases especially in short-term km driven.

With respect to the future development of the Austrian individual mobility system the perception is that only a broad portfolio of policy instruments – consisting mainly of tax policies for fuels as well as car investment and standards – will bring about major changes.

REFERENCES:

Dahl Carol, Sterner Thomas: Analysing gasoline demand elasticities – a survey, Energy Economics 13, 203-210, 1991.

Dargay J., Gately D., Sommer M.: Vehicle Ownership and Income Growth, Worldwide:1960-2030, The Energy Journal, 28, pp 143-170, 2007

Fischer C., Harrington W., Parry W.H.: Should Automobile Fuel Economy Standards be Tightened?, The Energy Journal, 28, pp 1-29, 2007

Haas Reinhard, Nebojsa Nakicenovic, Amela Ajanovic, Thomas Faber, Lukas Kranzl, Andreas Müller, Gustav Resch: Towards Sustainability of energy systems: a primer on how to apply the concept of energy services to identify necessary trends and policies, Energy Policy 36 (11), 4012-4021

Haas, R., Schipper, L. (1998), Residential energy demand in OECD-countries and the role of irreversible efficiency improvements - Evidence from the period 1970-1993, Energy Economics, 20, 421-442.

Howarth, R., Schipper, L., (1991), Manufacturing Energy Use in Eight OECD Countries: Trends through 1988- Decomposing the Impacts of Changes in Output, Industry Structure and Energy Intensity, The Energy Journal, 12(4):15-40.

IEA (2004), 30 years of energy use in IEA countries, Paris.

Orasch W. /Wirl F.: Technological efficiency and the demand for energy (road transport) Energy Policy, 25(14-15), pp 1129-1136, 1997.

Schipper L., Haas R., (1997) The Political Relevance of Energy and CO2 Indicators -An Introduction, *Energy Policy,* 25 **(**7-9), pp 639-650.

Sterner Thomas: Fuel taxes – an important instrument for climate policy, Energy Policy, 35, 3194-3202, 2007

Wirl, F., (1995), Impact of regulation on Demand-side Conservation programs, Journal of Regulatory Economics 7, 43-62.

Wirl, F., (1992), The Impact of Conservation, Technology and the New Registration Tax on Automobiles on Energy Consumption, *Empirica* **19**, 95-113, 1992.

Walker I. O./Wirl F.: Irreversible Price-Induced Efficiency Improvements: Theory and Empirical Application to Road Transportation. The Energy Journal 14(4), 183-205, 1993.