Car Ownership and Status

Implications for Fuel Efficiency Policies from the Viewpoint of Theories of Happiness and Welfare Economics

Erik T. Verhoef [a)], Bert van Wee[b, c)]
[a)] Free University Amsterdam, Department of Spatial Economics, The Netherlands
[b)] National Institute of Public Health and the Environment (RIVM), The Netherlands
[c)] Utrecht University, Faculty of Geographical Sciences, The Netherlands

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Research on 'happiness' suggests that once an average per capita income of around US$ 10,000 is achieved in a country, further increases in income will not lead to a significant increase in happiness. Additional income will probably often be spent on the satisfaction of mainly 'relative' needs, of which 'status goods' would be one example. From that perspective, an overall shift to more fuel-efficient cars (i.e. smaller cars with less power) would not necessarily, or only to a limited extent, result in less happiness. From a welfare economic perspective, the satisfaction of the relative needs pertaining to consumption can be considered as a form of consumption externalities. This creates a welfare economic basis for government intervention. A model in which these consumption externalities are studied is presented here. Government intervention would include stimulating consumption of lower-status goods and discouraging consumption of higher-status ones. We speculate, however, that to achieve a significant increase in the fuel efficiency of a country's car fleet through pricing policies, huge price increases may often be needed. As acceptance of price increases as a policy instrument is often low, 'fee-bates' and tradeable permits may be more preferable instruments.

1. Introduction

Climate change has a prominent position on the research and policy agenda in many countries. CO_2 is the most important greenhouse gas. In many western countries transport has a share in CO_2 emissions of around 20%. In almost all western countries the CO_2 emission of transport is increasing, whereas according to the Kyoto protocol greenhouse gas emission will have to be reduced in the next decades.

Several researchers have suggested that the transport sector is not the first candidate sector for introducing measures to reduce CO_2 emissions (see for a discussion on this subject, for example, Peake, 1997). The most often mentioned reasons are the relatively poor cost-effectiveness of technical measures for cars and other vehicles, and the relatively low price elasticity. Besides, levies on road fuels are relatively high and further increases would reduce the consumers' surplus of car use.

It is questionable whether technical measures in transport have a poor cost-effectiveness. Decicco and Ross (1996) found that many available technologies in the USA for improving fuel efficiency of cars are not (yet) applied to cars, and have a pay-back period much shorter than the lifetime of the average car. From the private car owner's perspective, many options will pay themselves back within three years, assuming a discount rate of 13%. Their middle estimate is that car fuel efficiency can be improved by 65% for US$ 770 per car, corresponding with a cost level of only $0.53 per gallon (prices of 1993, assuming a discount rate of 5% and assuming that a car will be driven for 12 years). On the other hand, Plotkin and Greene (1997) conclude that cars could be about 60% more fuel efficient (4.4 *l* /100 km vs. 7 *l* /100 km), with an increase in the price of US$ 1500. Plotkin and Greene do not consider this an attractive option. The dominant reason for differences between studies is the disagreement in costs of fuel economy technologies (Greene and Decicco, 2000). Besides, studies on fuel economy technologies generally do not assume declining costs with cumulative production, due to learning and scale effects (Greene and DeCicco, 2000), whereas these declines have been observed in the past (Adler and Clark, 1991). In most European countries fuel prices are much higher than in the USA. Therefore additional fuel economy technologies might be more attractive for the consumer than in the USA, despite the somewhat lower annual number of kilometers driven per car in European countries compared to the USA.

Data from several western-European countries show that the fuel efficiency of the car fleet has not improved in the last few years (Sweden, Italy), while in other countries the improvement continues, but at a much lower speed than up to the late eighties (UK, Denmark) (Davis, 1997; Schipper and Marie-Liliu, 1998). For instance, since 1990 the fuel efficiency of the Dutch car fleet has remained almost constant: the increase in fuel efficiency due to technical improvements has been compensated by an increase in power and weight. The increase in weight is almost completely the result of an upgrading of what manufacturers call the same car type (e.g. Volkswagen Golf): the 1999 Golf is a more up-market model than the first Golf model (Van den Brink and Van Wee, 1999). The current Polo (type positioned below the Golf) offers even more space and performs better than the Golf Mk 1 (1974-1983). Probably, the changes in the supply of cars (upgrading) has influenced demand, and *vice versa*. The relatively constant fuel efficiency of the car fleet, however, contradicts Dutch government policy: in 2010, CO_2 emissions of cars will probably be higher than in 1986, whereas the government is striving for a reduction in CO_2 emissions (RIVM, 1997).

In this paper, we focus on the consequences of a shift towards more fuel-efficient cars for the 'happiness' or well-being of people. The question we study is whether a shift towards more fuel-efficient cars would lead to a decrease in happiness, and if so, to what extent. We use the results of research on happiness, as well as welfare economic theory to study this question.

2. Research on happiness: the relationship between income and happiness

Research on happiness has been carried out by a relatively small group of researchers. The central issues or questions are 'how happy are people?' and 'which factors influence happiness?'. Researches measure the level of happiness by asking people how happy they consider themselves to be. One of the explanatory factors usually considered is income (including distributions). These questions have been studied primarily by sociologists. Nevertheless, economists too have recently focused on this subject (Jol and Otten, 1997; Kooreman, 1998; Veenhoven and Timmermans, 1998). An important distinction is made between comparisons *within* and *between* countries. Some researchers have concluded that in a country people with higher incomes are happier than people with lower incomes (Plug, 1997; Jol and Otten, 1997). Others did not find this relationship (Veenhoven and Timmermans, 1998). It seems that within a country, the influence of income on happiness is limited, but possibly significant. Studies comparing happiness between countries lead to different conclusions. Easterlin (1973, 1974) concludes that an increase in average income per capita does not (significantly) increase happiness. Veenhoven (1989) concludes that Easterlin's analyses are misleading. Using the same data Veenhoven concludes that an increase in average income leads to an increase in happiness, but the increase of happiness diminishes as incomes increase. From a certain level onwards, called the saturation level, an increase in the average income does not seem to lead to a further increase in happiness at all. Veenhoven and Timmermans (1998) conclude that the saturation yearly income level is at about US$ 10,000 per capita. This conclusion is consistent with time-series data of western countries. Since 1945 US average incomes have more than tripled but the level of happiness has remained constant. Since 1970 in the Netherlands the average level of happiness has remained constant but incomes have increased significantly (Veenhoven and Timmermans, 1998). Kooreman (1998) also concludes that once a certain saturation level is achieved ('once the first needs are fulfilled') a further increase in average per capita income does not increase happiness. Veenhoven (1996) concludes that factors that influence happiness are related to 'certainty of existence' (social security, physical safety and legal certainty/security), freedom (political freedom, freedom to live one's own life), the cultural climate (education, level of information, value orientation, participation in societies/associations) and modernism (people in modern societies are happier than people in traditional societies).

The literature on happiness suggests therefore that in high-income countries, a further increase in average incomes either does not, or hardly, results in an increased level of happiness.

3. Absolute and relative needs

In economic and sociological literature different levels of needs are sometimes used (e.g. Maslow, 1943; Deaton and Muellbauer, 1980). Two extremes would be goods that satisfy 'purely absolute' needs *versus* those that satisfy 'purely relative' needs. In reality, such a clear distinction can probably not be made, and goods may be positioned on a continuous scale which reflects the 'degree of absoluteness' of the needs they fulfill. Nearly absolute needs would be needs like food, clothes and a (basic) dwelling. Relative needs are the result

of the desire to distinguish oneself from other people – or, the opposite, to identify oneself with others. Focussing on the former possibility: people are willing to pay more for expensive (makes of) clothes from certain manufacturers, because of the status attached to these clothes. Buying a high performance, luxurious car instead of a cheaper one is probably also often more related to status than to transport needs.
As the scale implies, the distinction between absolute and relative needs is not sharp. A very basic dwelling is an absolute need, but a little more than basic dwelling is probably still an absolute need. The difference between a spacious, comfortable house and a very luxurious one is relative, so will probably satisfy mainly relative needs. Food is a primary need, but caviar instead of chicken is not. For the distinction between absolute and relative needs, time and space are relevant. Among the very first people that bought a car were probably many that were fulfilling relative needs (see Sachs, 1984; Bierbaum, 1903; Tengström, 1993). Today the car fulfils an absolute need for transport of many people: without a car people would be 'disabled', from a mobility point of view, unless they changed their home location or jobs and/or adapted to the public transport system or the bicycle. Car ownership in remote rural areas is probably more related to absolute needs than in the centre of London, Paris or Amsterdam. At the same time, however, the choice of a specific brand or type may often reflect the desire to fulfill relative needs, as will be substantiated below. In particular, we suspect that one of the important charms of a car with a large engine would be the possibility to accelerate faster than others at traffic lights. Leaving others behind (a clear example of a relative need) might be a more important reason to buy such cars than the pure time gain enjoyed from such faster acceleration (which is closer to an absolute need).

4. Rich countries: extra income for relative needs?

On the basis of the foregoing, it may be inferred that beyond a certain income level, additional average income does not lead to an increase in average happiness; this is because (nearly) all extra income is spent on relative needs. Anecdotal evidence strongly suggests that this may be the case for cars. Many people are prepared to pay for extra power, expensive accessories like alloy wheels and a bigger car. Although a bigger car might have practical advantages and be more comfortable it is questionable whether people would be prepared to pay the additional money for a big, powerful and expensive car if status aspects did not exist. The engine choice might also be influenced by a comparison with other cars. Although accelerating rapidly might be an independent joy factor, the acceleration capacities of other cars probably function as a reference. Thirty years ago, acceleration from zero to 100 km/h in 10 seconds was almost like magic; only expensive sports cars had this capacity. Today, several middle-class cars with more than average power can accelerate that rapidly. The joy of acceleration probably depends on the possibilities of the rest of the car fleet.
This anecdotal evidence is supported by literature from psychological sciences (Steg *et al.*, 1998; Diekstra and Kroon, 1997). For instance, Steg *et al.* (1998) distinguish between instrumental and social comparison motives for car use and car ownership. Instrumental motives refer to the effectiveness, (in)convenience and (dis)comfort of car use. This especially concerns the cognitive-rational, more or less objective and easily measurable consequences of car use. Social comparison motives refer to the possibility to express yourself by using a motor car, and to compare your behavior with that of others. Social

comparison with others may result in feelings of superiority or inferiority. 'Social comparison' is a term very often used in psychology and is related to what economist describes as 'status'. In this paper we use the term 'status' for all aspects related to relative position of a persons car in the total car fleet or the relative position within a certain group of people that is of importance for the person. We realize the social comparison processes will be very complex. For simplicity we do not discuss this subject extensively but *assume* that status aspects are relevant for the choice of the engine, as far as power is concerned (see also Kroon, 1998). Nevertheless, extra power may be functional, e.g. for people making frequent long trips on the German motorways, who can then actually reduce travel time. However, most cars in most Western countries have engines with much more power than needed, given the characteristics of infrastructure, speed limits and travel distances. We assume that the increase in power of the car fleet of the past decades has more to do with relative than with absolute needs.

In short, from psychological literature it can be concluded that social comparison influences the choice of car. Therefore, besides functional characteristics related to the transport function, the characteristics of the total car fleet in a country are important for people's choice of a car type. Assuming that everyone else drives a VW Polo (small car), a VW Golf (middle-class car) owner might be more satisfied than a VW Passat (upper-middle class car) owner when everyone else drives a Mercedes or Jaguar.

5. Status effects as consumption externalities

From a welfare economic perspective, the relative needs and status effects in consumption described above could be viewed as reflecting a particular type of market failure, namely consumption externalities. In this section, we provide a graphical analysis of the welfare economic properties of such consumption externalities; the next section presents an analytical model. In other words, we will explore the welfare economic consequences of the psychologists' conclusion that social comparison influences the choice of car.

Standard micro-economic models typically assume that an individual's utility derived from consumption depends only on the composition and size of the individually consumed 'bundle of goods'. This assumption is consistent with the welfare-economic benchmark of efficient markets. In the event that the utility derived from consumption also depends directly on the consumption of other agents, free markets will no longer achieve Pareto-efficient consumption patterns. In this and the next section, we will present a welfare economic analysis of this type of market failures applied to the example of 'status effects' in car use.

Our analysis links in with the economic literature on consumption interdependencies. Already in the 19th century, Veblen (1899) considered 'conspicuous consumption', where people like to 'show off', by buying goods without any apparent use against a very high price. Similar to the problem we study below, Frank (1985) focuses on 'local status' as it is derived from one's position in a firm's income distribution, and identifies the inefficiencies that follow from the resulting 'income race'. Stigler and Becker (1977) consider 'fashion goods', and recently, Frijters (1998) considered fashion cycles in a dynamic setting.

It is important to emphasize that in our analysis the existence of consumption externalities is taken as given, and that these externalities are presupposed to reflect status effects. Fully in line with definitions of external effects as given by, for instance, Baumol and Oates (1988)

and Mishan (1971)[1], we thus assume that the utility derived from the use of a certain variant and quantity (typically 0 or 1 on the individual level for automobiles) of a good partly depends directly on the variants and quantities used by all other consumers. Consumers then choose quantities and variants which also depend on consumption patterns of all others. In doing so, each individual consumer in turn marginally affects the utility from consumption enjoyed by others, but does not take these effects into account when deciding on the particular variant and quantity to be consumed. A consumer simply selects the most preferred vehicle, given the composition of the total fleet. The individual consumer's influence is reflected as being infinitesimally small relative to the size of the market. Note that just as in the case of congestion externalities, each consumer brings about externalities and suffers from them. The latter effect is taken into account in individual decision-making; the former is ignored.

5.1 A simple model with one homogeneous good

The simplest possible example of consumption externalities concerns the case with one single homogeneous good (good '1'), where the utility that a consumer derives from consumption depends partly on the consumption levels of other consumers (as is standard practice in partial equilibrium analyses, we implicitly assume that all other markets operate under first-best conditions). In the case of status goods, perceived exclusiveness would normally decline when the total consumption in the market increases. Therefore, the utility derived by an individual from consumption decreases in the total level of consumption.[2] As a consequence, the marginal social benefits (MSB) of consumption are below the marginal private benefits (MPB), because the marginal consumer does not take into account the reduction in welfare (s)he causes for other users through reduced exclusiveness. Assuming that no other market failures exist, the free-market equilibrium level of consumption, where MPB equals the market price, and – by assumption – the marginal social costs (MSC) will then be excessive from the social perspective because MSB will be below MSC in that equilibrium. The difference between MPB and MSB can be viewed as negative marginal external benefits (MEB), so, in fact, as marginal external costs. In contrast to the standard case, the free market therefore fails to achieve the welfare maximizing consumption level.

[1] Verhoef (1996, p. 12) has formulated these definitions as follows: 'an external effect exists when an actor's (the receptor's) utility (or production) function contains a real variable, whose actual value depends on the behaviour of another actor (the supplier), who does not take this effect of his behaviour into account in his decision-making process'.

[2] A reverse example is where the utility of consumption *increases* in consumption by other agents. One example would be the 'bandwagon effect', as described by Veblen (1898), where the perceived attractiveness of a good increases as more people consume it. Another example involves positive network externalities. Such externalities often occur with access to communication networks (telephone, fax, email): the more people who can be reached by, for instance, telephone, the more valuable one's own connection becomes.

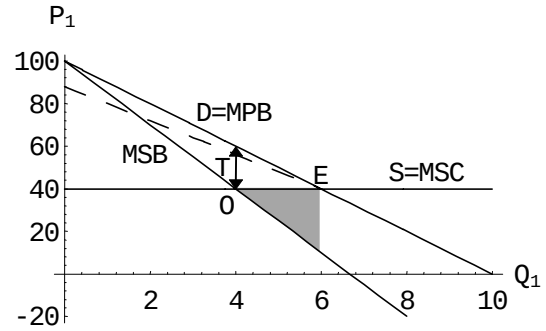

Figure 1. Negative consumption externalities for a homogeneous good

Figure 1 provides an illustration in a standard market diagram. For convenience, we assume a perfectly elastic supply S, at a price level equal to MSC. The market demand, D, is identical to marginal private benefits (MPB): the willingness to pay for the marginal consumer given the consumption of others ('to the left of this consumer'). The free-market equilibrium, E, is found where D=S and MPB=MSC. For simplicity, we assume that all consumers are equally sensitive to the consumption externality.

Due to this externality, the actual benefits for an arbitrary non-marginal consumer (any consumer to the left of E) will have become smaller than what they would have been if this consumer were the marginal consumer himself, which is given by the D=MPB curve. Instead, the benefits derived from consumption will, for example, amount to those given by the dotted curve. Note that for each consumption level considered, we must draw another dotted curve; for graphical clarity only the one applying to the free market equilibrium is shown. The MPB curve thus overestimates the consumers' surplus (the difference between the 'monetized' value attached to consumption and the market price). Taking the consumption externality into account, a curve like MSB (below MPB, with an intersection at the vertical axis) represents the marginal social benefits of consumption. MSB is found by correcting MPB for the negative welfare effect for all non-marginal consumers; *i.e.* by considering the marginal impact on the area as bounded by the vertical axis, the dotted curve and D.

The optimum is then found at a lower consumption level O, where MSB=MSC. This optimum can be realized by applying a consumption tax T equal to the marginal value of the externality (MPB–MSB) in the optimum. This 'exclusiveness tax' internalizes the negative effect of one's own consumption on the well-being of others, and results in a welfare gain having the size of the shaded triangle. Note that where the consumption externality does not exist so that MPB=MSB, O and E will coincide, and the optimal value of T will be zero.

Some further remarks on such a tax can be made. First, the tax is likely to be progressive, as higher (lower) status goods are likely to be consumed by higher (lower) income groups. Secondly, it is not inconceivable that status effects become more pronounced after introduction of this tax, as the tax itself works as a strong signal, actually identifying status. However, this may lead to the paradoxical situation where the local optimum with a tax produces a lower welfare than the no tax equilibrium – a complication that we will ignore in

the remainder of the paper.[3] Thirdly, as more goods would become status-sensitive, an increasing tax base is created, that may reduce the need for using other, distortionary taxes. Last but not least, it ought to be acknowledged that the measurement and valuation of the externality – as holds for most external effects – will be extremely difficult. We therefore emphasize that we are interested primarily in the identification of the case for regulatory policies, rather than making any definite statements about the empirical optimal tax levels that may result.

5.2 A model with two product variants

Figure 2 shows the simplest possible example of the case that we actually want to consider, namely where the consumption externality reflects that the utility from consumption depends in part on the amounts of different *variants* of the good consumed by others. The diagram assumes two variants: a standard good '1', and a close luxurious variant '2'. For graphical clarity, we now ignore consumption externality within the two variants.

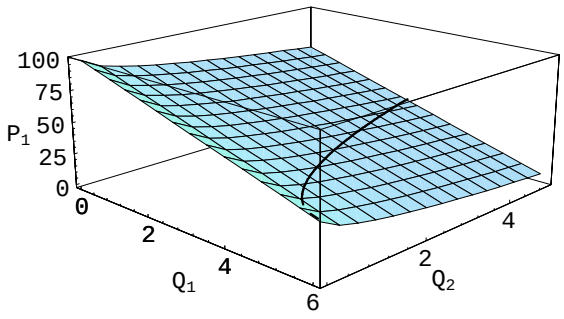

Figure 2. A 'demand surface' with consumption externalities in a 2-variant setting

When the consumption of the luxurious good Q_2 increases, the benefits of consumption of good 1 decrease. This can reflect that the variant 1 is becoming less attractive, relative to the average product quality (i.e., variants 1 and 2 together). In the case of automobiles, a smaller vehicle yields smaller benefits when an increasing number of larger and faster cars use the road. As a result, the demand curve for good 1 shifts down when Q_2 increases. In this way, we can construct the three-dimensional demand surface depicted in Figure 2.

Observe that as a result of the consumption externality, the demand for good 1 at a given price for good 1 will decrease when Q_2 increases. This is shown by the curved line at $P_1=MSK_1(=40)$, showing the equilibrium demand for good 1 at a given price (40) for varying levels of Q_2. It is important to distinguish clearly between this consumption externality (reduced benefits of consuming good 1 because of the implication that the consumption of good 2 causes the relative quality of good 1 to decrease), and what could be called 'normal' cross-elasticity of demand. In the latter case, the consumption of good 1 would decrease with an increase in Q_2 simply because those consuming good 2 do no longer prefer to consume good 1 (at least not in the same quantity), since the goods are close substitutes. However, this would not affect the benefits that the remaining consumers of good 1 derive from their consumption. With the consumption externality, in contrast, these consumers do suffer from

[3] In particular, this risk is smaller if differentiated taxes are already in existence, which they are for cars.

a loss in benefits derived from consuming good 1, for the reasons outlined earlier. Therefore the negative externality represents the negative effect on the benefits of consuming good 1; the reduced consumption of good 1 is a consequence of this externality. The difference between the two cases (consumption externalities *versus* normal cross-elasticities) is therefore subtle but important. A consequence of the subtlety is that in reality, it will be difficult to identify statistically the empirical existence of consumption externalities in a multi-commodity context – the cross presence of prices in estimated demand functions is certainly not yet a guarantee – despite, for instance, the evidence from the psychological literature on the possible relevance of consumption externalities in the market for automobiles. Nevertheless, given the policy implications, such an identification may be important. In the next section, we will discuss these policy implications, using an analytical model with three variants.

6. Welfare aspects of consumption externalities

An important subsequent question is whether the consumption externalities described above have any policy implications. Should the government intervene in a market where status externalities are important? The answer in principle is 'yes': with consumption externalities, the free market process will not lead to a Pareto efficient consumption pattern. To illustrate this, we will now consider a market with three product variants: low (1), medium (2) and high (3) quality; given the topic of our paper, this will concern the automobile industry.
For convenience, we maintain the assumption of a perfectly elastic supply for each variant, so that market prices P_1, P_2, and P_3 are given. This would be relevant for a small automobile importing country such as the Netherlands.[4] We consider a generalization of the graphs in Figures 1 and 2, where marginal private benefits will depend on the consumption of each of the three variants; consumption externalities may also occur within a variant. We assume that if consumption externalities occur, an individual's benefits of consumption *increase* in the consumption of inferior qualities, and *decrease* in the consumption of superior qualities. The consumption externality within a variant may differ in sign. We assume it to be negative for high quality cars and positive for low quality cars. These assumptions would reflect the following type of status effects on consumption: it is attractive to be an exclusive consumer of a high-end automobile, and particularly unattractive to be one of the few drivers left with a low-end, poor-quality car. Basically, the assumptions would reflect an individual's benefits as being partly dependent on the relative ranking of his/her car in the total fleet. Because only three variants are considered in the present case, this approach could be operationalized by assuming that every individual considers him- or herself to be the median of his/her group. Consistent with this interpretation, we leave the sign of the externality within the medium quality market ambiguous.

[4] One possible extension of the present model would be to endogenous the car suppliers' behaviour, assuming an oligopolistic market. We leave this issue aside. The assumption of a competitive supply of cars allows us to isolate market failures due to consumption and environmental externalities in an otherwise first-best world. Nevertheless, the extension would be interesting for future work, as one relevant question would involve the degree to which ologipolistic suppliers would internalize status externalities.

The inverse demand functions for the three variants are again equal to the marginal private benefits, and can thus be written:

$$D_1 = D_1(Q_1, Q_2, Q_3); \quad \frac{\partial D_1}{\partial Q_1} < 0, \frac{\partial D_1}{\partial Q_2} \leq 0, \frac{\partial D_1}{\partial Q_3} \leq 0 \tag{1a}$$

$$D_2 = D_2(Q_1, Q_2, Q_3); \quad \frac{\partial D_2}{\partial Q_1} \geq 0, \frac{\partial D_2}{\partial Q_2} < 0, \frac{\partial D_2}{\partial Q_3} \leq 0 \tag{1b}$$

$$D_3 = D_3(Q_1, Q_2, Q_3); \quad \frac{\partial D_3}{\partial Q_1} \geq 0, \frac{\partial D_3}{\partial Q_2} \geq 0, \frac{\partial D_3}{\partial Q_3} < 0 \tag{1c}$$

Keeping the consumption of other variants fixed, the inverse demand functions are assumed to be downward-sloping to guarantee an equilibrium with fully elastic supply.
For every unit of a variant consumed, q_i with $0<q_i \leq Q_i$, the actual willingness to pay in equilibrium with Q_1, Q_2 and Q_3 will be denoted $B_i(q_i,Q_1,Q_2,Q_3)$. Under our assumptions:

$$B_1(q_1 = Q_1, Q_2, Q_3) = D_1(Q_1, Q_2, Q_3); \quad \frac{\partial B_1}{\partial Q_1} \geq 0, \frac{\partial B_1}{\partial Q_2} \leq 0, \frac{\partial B_1}{\partial Q_3} \leq 0 \quad \forall q_1 \leq Q_1 \tag{1d}$$

$$B_2(q_2 = Q_2, Q_1, Q_2) = D_2(Q_1, Q_2, Q_3); \quad \frac{\partial B_2}{\partial Q_1} \geq 0, \frac{\partial B_2}{\partial Q_2} \gtrless 0, \frac{\partial B_2}{\partial Q_3} \leq 0 \quad \forall q_2 \leq Q_2 \tag{1e}$$

$$B_3(q_3 = Q_3, Q_1, Q_2) = D_3(Q_1, Q_2, Q_3); \quad \frac{\partial B_3}{\partial Q_1} \geq 0, \frac{\partial B_3}{\partial Q_2} \geq 0, \frac{\partial B_3}{\partial Q_3} \leq 0 \quad \forall q_3 \leq Q_3 \tag{1f}$$

Equations (1d)-(1f) show how the benefits attached to any vehicle of a certain class vary with marginal changes in total class sizes, and that the willingness to pay for the marginal vehicle is equal to the monetary value of the benefits attached to that vehicle.
Next, we assume that the three variants may differ with respect to environmental quality. Specifically, the purchase of a vehicle of quality i will cause environmental external costs with a value E_i. Note that we assume that the actual use of vehicle after its purchase is given. In the context of the present exposition, this is a simplifying, but non-essential, assumption that could easily be relaxed, but one that is less relevant for the main line of thought. As stated, the product price P_i is treated as a constant, reflecting a small-country situation.[5]
We can then write the social surplus, our measure for welfare, as the sum of total benefits, minus the costs of vehicles, minus environmental costs:

$$\begin{aligned} W(Q_1,Q_2,Q_3) = &\int_0^{Q_1} B_1(q_1,Q_1,Q_2,Q_3)dq_1 + \int_0^{Q_2} B_2(q_2,Q_1,Q_2,Q_3)dq_2 + \int_0^{Q_3} B_3(q_3,Q_1,Q_2,Q_3)dq_3 \\ &- Q_1 \cdot (P_1 + E_1) - Q_2 \cdot (P_2 + E_2) - Q_3 \cdot (P_3 + E_3) \end{aligned} \tag{2}$$

[5] There is some evidence that car manufacturers tend to ask lower prices for cars in countries were taxes are higher. As stated, market power and price setting will be ignored in this paper.

The first three terms (in integral form) denote the benefits attached to each unit q_i within a specific class (note that the q_i's are the integration variables), given Q_1, Q_2 and Q_3. Note that the total benefits are separable into three type-specific terms, because in the integral for each type i, only the upper limits for the other two types (Q_j) appear, and not the associated integrating variables (q_j). For each (Q_1,Q_2,Q_3), W(Q_1,Q_2,Q_3) is therefore uniquely defined. We can then determine the necessary first-order conditions for an optimum by setting the partial derivatives of W with respect to Q_1, Q_2 and Q_3 equal to zero:

$$\frac{\partial W}{\partial Q_1} = D_1 + \frac{\partial \int_0^{Q_1} B_1(\cdot)dq_1}{\partial Q_1} + \frac{\partial \int_0^{Q_2} B_2(\cdot)dq_2}{\partial Q_1} + \frac{\partial \int_0^{Q_3} B_3(\cdot)dq_3}{\partial Q_1} - P_1 - E_1 = 0 \quad (3a)$$

$$\frac{\partial W}{\partial Q_2} = \frac{\partial \int_0^{Q_1} B_1(\cdot)dq_1}{\partial Q_2} + D_2 + \frac{\partial \int_0^{Q_2} B_2(\cdot)dq_2}{\partial Q_2} + \frac{\partial \int_0^{Q_3} B_3(\cdot)dq_3}{\partial Q_2} - P_2 - E_2 = 0 \quad (3b)$$

$$\frac{\partial W}{\partial Q_3} = \frac{\partial \int_0^{Q_1} B_1(\cdot)dq_1}{\partial Q_3} + \frac{\partial \int_0^{Q_2} B_2(\cdot)dq_2}{\partial Q_3} + D_3 + \frac{\partial \int_0^{Q_3} B_3(\cdot)dq_3}{\partial Q_3} - P_3 - E_3 = 0 \quad (3c)$$

Next we assume that the government can try and achieve this optimum by using differentiated vehicle taxes T_i. For each class, the market equilibrium will be reached when the marginal private benefits D_i is equal to the price of the vehicle P_i plus the tax T_i:

$$D_1(\cdot) - P_1 - T_1 = 0 \quad (4a)$$

$$D_2(\cdot) - P_2 - T_2 = 0 \quad (4b)$$

$$D_3(\cdot) - P_3 - T_3 = 0 \quad (4c)$$

By subtracting (4abc) from (3abc), we can finally determine the following optimal taxes necessary for a social optimum:

$$T_1 = E_1 - \frac{\partial \int_0^{Q_1} B_1(\cdot)dq_1}{\partial Q_1} - \frac{\partial \int_0^{Q_2} B_2(\cdot)dq_2}{\partial Q_1} - \frac{\partial \int_0^{Q_3} B_3(\cdot)dq_3}{\partial Q_1} = pos - pos - pos - pos \quad (5a)$$

$$T_2 = E_2 - \frac{\partial \int_0^{Q_1} B_1(\cdot)dq_1}{\partial Q_2} - \frac{\partial \int_0^{Q_2} B_2(\cdot)dq_2}{\partial Q_2} - \frac{\partial \int_0^{Q_3} B_3(\cdot)dq_3}{\partial Q_2} = pos - neg - amb. - pos \quad (5b)$$

$$T_3 = E_3 - \frac{\partial \int_0^{Q_1} B_1(\cdot)dq_1}{\partial Q_3} - \frac{\partial \int_0^{Q_2} B_2(\cdot)dq_2}{\partial Q_3} - \frac{\partial \int_0^{Q_3} B_3(\cdot)dq_3}{\partial Q_3} = pos - neg - neg - neg \quad (5c)$$

where *pos*, *neg* and *amb.* indicate positive, negative and ambiguously signed terms, respectively. The tax T_3 is the only one to be clearly positive; T_2 and T_1 have positive (or ambiguously signed) terms subtracted from a positive tax, and may thus turn out to be negative (hence: a subsidy).

Regardless of the question on whether luxurious cars cause higher environmental externalities (we leave the relative size of E_1, E_2 and E_3 undetermined), equations (5abc) demonstrate that status effects, in the interpretation of consumption externalities, affect the optimal taxes. In particular, we find a downward adjustment for low-quality cars, an upward adjustment for high-quality cars, and an ambiguously signed adjustment for the middle category.

The conclusion is that, from the welfare economic perspective, status effects leading to consumption externalities will provide a basis for corrective taxation. On the free market, consumers would inefficiently strongly stimulate each other to purchase more luxurious variants. Corrective taxes may protect consumers against such treadmills. Certainly, heterogeneity as such would generally still be welfare enhancing: note that in the optimum, each of the variants will normally still be traded, although the relative shares will be different. In particular, there will be more lower-class and fewer higher-class vehicles in the optimum.

7. Effects of a shift towards more fuel-efficient cars on the environment and welfare: policy conclusions

Two important policy aspects are related to the issues presented in the previous sections. First, an overall shift to more fuel-efficient cars (that are smaller, weigh less and have less power) may result in only a limited loss of welfare. This is because the possibilities for people to distinguish from others remain the same and mobility needs are satisfied (almost) at the same level as without the shift. The reason that this shift is not be realized by the free market is the result of consumption externalities: the relatively small decrease in welfare for one individual buying a more fuel-efficient car will only be realized if all other car owners ‘down-grade’ and buy a more fuel-efficient car, too. Such an overall down-grading can only be realized through government policy.

The second aspect is related to the question: which is the first-best policy instrument to realize the shift to more fuel-efficient cars? Many economists prefer pricing instruments because–assuming the market works well–only these instruments would lead to a maximization of welfare. The shift towards more fuel-efficient cars can be realized by pricing instruments, e.g. by increasing fuel taxes, or differentiating taxes on new cars or annual taxes (lower taxes for more fuel-efficient cars). The consumption externalities discussed above would require the latter type from an efficiency perspective; environmental externalities, which strongly depend on total kilometrage driven and fuel used, would typically require the former.

However, to realize a significant shift to more fuel-efficient cars by pricing instruments, much opposition from society can be expected (Verhoef, 1996). Regulation may be an alternative. For efficiency reasons, regulations should preferably be based on sound economic principles. The first option for regulations may be a fee-bate system. Generally

speaking smaller vehicles have a lower status and larger cars are less energy-efficient. This means that optimal tax differentiation should be greater than what is suggested by differences in environmental costs alone. Instruments like fee-bates may then become an attractive policy option (Davis *et al.*, 1995). A fee-bate is a system where car buyers get a rebate when they buy a car that is more fuel-efficient than average, and have to pay a fee when they buy a car which is less fuel-efficient than average. If desired, fee-bate schemes can be designed such that they are budget neutral from the government's perspective. Because most countries already have taxes on cars, the fee-bate system results in lower (but still positive) taxes for fuel efficient cars and additional taxes for cars with a relatively high fuel consumption level. In case of no taxes on cars such budget-neutrality may induce inefficiencies when the scheme is intended to regulate external costs such as environmental pollution: ideally, all polluters should face a positive tax. However, for the consumption externality considered above, budget-neutral fee-bates may (nearly) be optimal, as we found a subsidy for low-end cars and a tax for high-end cars. Finally, note that physical regulations (like prohibition of certain types of cars) will normally be less efficient than price instruments. To see why, it is sufficient to observe that in the optimum, all types of cars may still be used, albeit in different proportions.

Apart from the fee-bates we suggest a second possibility: tradeable permits. Experience with the American CAFE (Corporate Average Fuel Economy) standards, first introduced in 1978, shows them to be a possibly attractive option. All manufacturers are subject to standards for the average fuel economy of all the cars they sell in a certain year. Manufacturers who do exceed the standards have to pay (Dings and Janse, 1996). The CAFE standards between 1975 and 1995 were especially influential in decreasing the fuel use of the American car fleet by almost 40% per kilometre (Davis, 1997). This decrease was realized mainly in the period up to 1983; after this the standards have hardly been tightened. Verhoef *et al.* (1997) give an overview of possible and current use of tradeable permits related to road transport externalities.

The shift to more fuel-efficient cars may be realized by a system in which every manufacturer or importer selling cars in a certain country has to meet a certain fuel-use standard for all cars sold in a certain year. 'Permits' can be made tradeable: a manufacturer or importer whose average is below the standard can sell the difference (between standards and realization) to a manufacturer or importer who can then sell cars that (on average) do not meet the standard. Such a system can be fiscally neutral and may improve the fleets energy efficiency without a (great) loss in welfare but, with the related environmental advantages.

8. Conclusions

Once a certain average per capita income is achieved in a country, further increases in average income do not lead to an increase in happiness. This average income level is much lower than current average incomes in Western countries. An important reason for these further increases in income not improving happiness might be that additional income will be spent mainly on goods that fulfill relative needs (and are related to status/social comparison). A shift to more fuel-efficient cars (i.e. smaller cars with less power) may result in only a limited reduction in 'happiness' when this shift does not decrease possibilities to satisfy status related needs, and will not decrease the fulfillment of mobility needs.

The satisfaction of relative needs results in market inefficiencies, because consumption externalities exist. Therefore, a welfare-economic basis for (regulation) policies exists, with the aim to make lower-status goods more attractive and higher status goods less so. Possible instruments for such a policy, with a further derived benefit of improving a car fleet's fuel efficiency, are price increases, fee-bates and tradeable permits. To achieve a significant increase in the fuel efficiency of a county's car fleet through pricing policies, huge price increases may be needed. As acceptance of price increases as a policy instrument is low, fee-bates and tradeable permits may be preferable instruments. Both can be made fiscal-neutral and are therefore likely to meet lower resistance from society.

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