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ABSTRACT *A brief summary of road traffic-related elasticity estimates as reported in the international literature is given. An indication of the orders of magnitude of these elasticities is outlined and the variation in estimates commonly found is emphasized. The results of previous extensive surveys are collated, but a wider scope of traffic-related research is provided by reviewing recent work and including research that has received less attention. A variety of elasticity measures related to car travel, car ownership, freight traffic and fuel demand are reported. Based on the review, some important themes underpinning the demand for road traffic are revealed.*

1. Introduction

Elasticities associated with road traffic demand have recently received a great deal of attention in the academic literature. TRACE (1998) and de Jong and Gunn (2001) provide up-to-date surveys of research concerned with fuel price and car time elasticities of car traffic, while Graham and Glaister (2002a) review the international literature on fuel demand elasticity estimates.

A sound understanding of road user responses to changes in prices or in standards of living is crucial to making transport policy decisions. Such knowledge can inform attempts to achieve emissions reductions and help show how traffic levels might be manipulated by making some change to the cost of driving. It can help public policy-makers reach decisions about the allocation of investment and can be used to forecast how the demand for fuel and road travel will change as prices or standards of living change. It can also shed light on the implications of road-related fiscal policy for certain groups in society or certain geographical locations.

The purpose of the present paper is to build upon the recent literature surveys cited above, which are concerned with quite specific dimensions of road traffic demand, by collating and comparing their basic findings and by addressing their various omissions. Research not reviewed in these surveys is summarized, specifically emphasizing the demand for freight traffic that has received less

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attention in recent major survey articles. Also included within the scope of this paper is a much broader range of traffic-related research. Through doing so, this review provides a brief and substantially comprehensive review of the road traffic elasticity literature.

The paper is based upon research undertaken as part of a larger piece of work commissioned by the Department of Transport on road traffic demand (Graham and Glaister 2002b). The purpose of Graham and Glaister's report, along with that of the parallel study by Hanly *et al.* (2002), was to inform the Department of Transport about the likely magnitude of road traffic elasticities and ranges of estimated values that are found across studies, and to distinguish separate elasticities by traffic type and by different definitions of cost and price.

The paper is structured as follows. Section 2 summarizes the findings on the elasticities of car travel, and elasticities of car ownership are reviewed in Section 3. Section 4 addresses the demand for road freight services and is followed by a brief discussion of fuel demand elasticities in Section 5. A summary is then presented in Section 6 that synthesizes and compares these findings and draws out some important themes. Conclusions are offered in Section 7.

2. Elasticities of Car Travel

This section summarizes the results of two recent publications by TRACE (1998) and de Jong and Gunn (2001) that have provided comprehensive and up-to-date surveys of car time and fuel price elasticities of car travel. They reviewed evidence from more than 50 recent studies (1985 and later) for Member States of the European Union, reporting average unweighted values of short- and long-run elasticities for car trips and car-km. (The short run included only mode choice effects; the long run included some combination of mode choice, destination choice, travel frequency choice, relocation of population and retail and service activities.)

Regarding the effects of changes in fuel price, they found that in the short-run, car trips and car-km respond in much the same way. The short-run fuel price elasticity was –0.16 for both car trips and car-km. In the long run, the elasticity of car-km to fuel prices increases quite substantially, to –0.26, but only marginally for car trips (–0.19). Thus, the immediate consumer response to a fuel price change is to modify the number of trips made, but over time they make even more substantial changes to the distance travelled. De Jong and Gunn (2001) argued that this may be due to adaptations in some combination of mode choice, destination choice, relocation of population and retail and service activities. Note that the elasticities of car-km with respect to fuel price are broadly consistent with values quoted in previous surveys by Graham and Glaister (2002a) and Goodwin (1992) (–0.15 in the short run, –0.31 in the long run).

Regarding elasticities of car trips with respect to car time, they found that the short-run elasticity (–0.6) was substantially higher than that of the long run (–0.29). Thus, having made a change in destinations, travel frequency and land-use locations, car drivers begin to make more trips of lower duration, switching from long to short trips, while some public transport users switch back to the car for short trips. For car-km elasticities, however, the long-run travel time elasticity of car-km was more than three time greater in magnitude that for the short run, –0.74 compared with –0.20. This implies that drivers and perhaps land uses adjust over time to minimize travel distance.

Thus, comparing the fuel price and car time elasticities de Jong and Gunn's results show that in the long run the elasticity of car-km with respect to car time is much higher than the elasticity of car-km with respect to fuel price.

The effect of income on car travel has been reviewed by Hanly *et al.* (2002), whose results, again based on a literature survey, give a short-run mean elasticity of demand for car-km with respect to income (real GDP) (from seven estimates) of 0.30, and long-run mean figures (from seven estimates) of 0.73. These elasticities confirm the conventional wisdom that standards of living have a strong impact on the demand for road travel.

3. Demand for Car Ownership

Several studies have estimated elasticities of demand for car ownership as distinct from car use. Recent research in this area is reviewed here to give an indication of the relative influences of income, price and costs. One difficulty in drawing this research together is that the definitions of 'cost' and 'price' used are often not consistent across studies and this hinders proper comparability of estimates.

A good starting point in the present coverage of car ownership elasticities is the early survey of price responses provided by Goodwin (1992), which collected 93 elasticities of car ownership from a variety of countries. The mean unweighted price elasticity of car ownership was quoted as –0.89, with most estimates falling in the range –0.4 to –1.6. The survey did not distinguish short- and long-run effects and acknowledged that there were differing definitions of 'car price' across the studies.

Two recent studies of car ownership were conducted using British and UK data. (Britain comprises England, Wales and Scotland; the UK includes all of Britain and Northern Ireland.) First, Romily *et al.* (1998) estimated a model of car ownership for Britain based on time-series data from 1953 to 1988. Their model related per capita car ownership to real personal disposable income per capita and the real motoring cost index. Their estimated income elasticity was 0.34 in the short run and 1.14 in the long run. The short-run price elasticity was –0.29, the long run –2.19. Note that the average value of the short- and long-run price elasticities was –1.24, slightly higher than Goodwin's figure of –0.89.

A second recent study concerning car ownership in the UK carried out by Dargay and Vythoulkas (1999) was based on cross-sectional time series data. They applied a 'pseudo-panel' approach to estimate a dynamic model of car ownership for the UK based on repeated cross-sectional data from the Family Expenditure Survey (FES) between 1982 and 1993. For middle-income groups, they estimated a short-run elasticity of car ownership with respect to income of 0.24 and a long-run figure of 0.65. The elasticity of car ownership with respect to the cost of purchase was estimated at –0.12 in the short run and –0.33 in the long run, and with respect to running costs –0.19 and –0.51, respectively. Note that these values for both costs and income are generally low compared with those estimated by both Goodwin (1992) and Romilly *et al.* (1998).

It is worth considering how these results for Britain and the UK compare with those for other geographical areas from some notable recent studies. Johansson and Schipper (1997) estimated vehicle stock *per capita* elasticities as part of their analysis of fuel demand in 12 OECD countries between 1973 and 1992. They estimate a long-run income elasticity of approximately 1.0 and a long-run fuel price elasticity of about –0.1.

Table 1. Elasticities of car ownership

	Ramjerdi and Rand (1992)	Bjørner (1999)	de Jong (1990)
Disposable income	0.33	0.41	0.15
Variable costs	–1.33	–0.78	–0.41
Fixed costs	–2.65	–1.29	–0.80

Aggregate car ownership demand elasticities for Norway were examined by Fridstrøm (1998) using pooled data on a cross-section of countries between 1973 and 1994. The explanatory variables included personal income, interest rates, fuel cost (the real price of fuel times the average fuel consumption per vehicle-km driven), and vehicle taxes. The results give a long-run income elasticity of demand for cars of 1.2 averaged over the sample, and a total long-run fuel cost demand elasticity of –0.24.

Bjørner (1999) estimated the demand for car ownership in Denmark using data from surveys of Danish car use carried out in 1992 and 1993. Elasticity estimates based on this data were compared with estimates from two previous studies using the same model: one based on Dutch data by de Jong (1990) and one based on Norwegian data by Ramjerdi and Rand (1992). The model estimates elasticities of car ownership against variable costs (fuel, replacement, repairs and maintenance) and fixed costs (depreciation, annual ownership tax and insurance). No distinction was made between short- and long-run effects. The results (Table 1) were consistent with respect to sign, but they showed variation in the estimated elasticities of car ownership.

From the studies reviewed here, some observations on the demand elasticities of car ownership can be made. (Results from Johansson and Schipper (1997) are not included as their estimates were far outside the range indicated by the other studies.):

- Estimates of the long-run income elasticity of demand for car ownership fall within the range 0.3 to 1.1. The mean across the studies reviewed is 0.74.
- Short-run income elasticity was much smaller than the long run, taking a mean of 0.28 and falling within a fairly narrow range of 0.24 to 0.34.
- Ignoring for the moment the definitional issues surrounding 'price' and 'cost', the mean long-run price/cost elasticity of car ownership is –0.90 (range –0.24 to –2.65), while the short-run mean is –0.20 (range –0.35 to –0.09).

4. Freight Traffic Demand Elasticities

This section reviews evidence on road freight demand elasticities. It is often assumed that the demand for road freight is price inelastic, or at least more so than general traffic. The studies reviewed here indicate that in fact this may not be the case. The price demand elasticity estimates are, almost without exception, negative and in many cases exceed unity.

However, as regards the actual magnitude of price elasticity estimates, it must be stated at the outset that this section demonstrates the very wide variation that exists. This variation is almost certainly due to the differences between studies in the models estimated, in the type of data used (e.g. aggregate or disaggregate), in the level and definition of commodity group aggregation, in market coverage, and in demand definitions.

Owing to the small number of studies dealing with freight elasticities, it is extremely difficult to disentangle the influence of any of these particular effects. There is not enough evidence to form coherent grouping of studies according to these criteria, and thus we are constrained to compare estimates from one very specific study with those of another very specific study.

In what follows, we simply report the evidence we have collected and draw out the apparent common themes. The focus in freight demand studies has principally been on identifying different elasticities for different commodity groups. A small number of articles have estimated elasticities separately for different trip lengths, or have distinguished demand between freight transport (tonnage) and freight traffic (tonne-km). The treatment of time is generally ambiguous as there is little evidence on the distinction between short- and long-run effects.

Given the small number of studies, and with no obvious groupings to structure this survey, the articles are reviewed chronologically by year of publication.

Oum (1979) formulated a demand model for intercity freight transport as an intermediate input to the production and distribution sectors of the economy. He considered three modes of freight transport: railways, highways and waterway carriers (excluding ocean shipping). His data described the price indices and revenue share of the three modes of freight transport in Canada from 1945 to 1974. He found that the price sensitivity of trucking services increased over time. In fact, his estimates showed radically different effects over the years examined with an estimated own price elasticity for highway freight services of 1.11 in 1950 and –0.16 by 1970.

Friedlaender and Spady (1980) looked in more depth at the price effect by providing a breakdown of elasticity estimates by the type of commodity being carried. They analysed truck and rail transport demand using data from a cross-section of manufacturing industries in 1972 in five regions of the USA. Interestingly, they found that the estimates of own price elasticities of demand for freight truck services fell within a fairly narrow band across regions and commodities. The mean of their 44 estimates was –1.12 with a standard deviation of 0.2, and in fact with few exceptions, they found that estimates were generally close to unity.

Lewis and Widup (1982) found less elastic estimates for the US shipment of assembled automobiles using annual time series data for 1955–75. They estimated a translog transport demand model to measure price and quality-of-service demand elasticities for rail and motor carrier shipments of assembled automobiles. Their estimated own price elasticities for truck freight transport (share within total freight transport) related to this commodity ranged from –0.52 to –0.67.

Other specific price elasticity estimates for the USA are reported in the literature. For aggregate goods, Winston (1985) reported estimates by Levin (1978) of –0.25 to –0.35 (share of road in total freight), for leather rubber and plastic products –2.97 (truck volume), and for machinery –0.4 (truck volume) (Winston 1981). Wilson *et al.* (1988) estimated a price elasticity of demand for US road freight grain (wheat) transport (truck volume) of –0.73.

Table 2. Elasticities of demand for road freight with respect to the freight rate

	Translog	Log-linear	Linear	Logit
Elasticity (all commodities)	–0.692 (46.1)	–1.341 (31.9)	–0.048	–0.928
Elasticity (single commodity)	–0.652 (18.6)	–1.542 (9.0)	–0.381	–0.970

Thus, very different estimates are found across different commodities and for different geographical areas. One consistent area of concern in the freight demand literature has focused on the influence of aggregation and methodology on the magnitude of estimates. Oum (1989) addressed this issue comparing the use of four commonly used aggregate models of transport demand in the context of freight services: the linear demand model, the log-linear demand model, the aggregate logit model and the translog demand system.

He used data on interregional freight flows in Canada in 1979 to investigate the total freight flows of all commodities as well as the flows of one single commodity group: fruits, vegetables and edible foods. The purpose of this comparison is to help to identify the effect of aggregation over commodities on the relative performance of the four alternative models. The estimated price demand (truck volume) elasticities are shown in Table 2.

Oum pointed out that since the linear model excluded all quality of service variables, the price elasticity estimates were likely to be biased. He noted that the log-linear estimates appeared on the high side and that the translog estimates seemed more reasonable. However, crucially, he concluded that the magnitude of the elasticity estimate depended on the functional form being used for estimation. Of the four models compared, he believed that the translog demand system performed best.

Oum *et al.* (1992) returned to this theme providing a review of estimates of the demand elasticity of truck freight. They demonstrated an important point about the elasticity of freight demand put forward in the literature: that estimates can vary as much within the same commodity group as they do across commodities and across estimation methods. Thus, for instance, own price elasticities for aggregate truck freight (all commodities) were –1.43 for the log-linear model, –0.93 for the aggregate tobit and –0.69 for the translog. On the other hand, the translog estimates for the food industry itself ranged from –0.52 to –1.00, and for wood and wood products from –0.56 to –1.55.

The issue of variance in estimates was addressed by Abdelwahab (1998), who presented empirical estimates of market elasticities of demand and elasticities of mode choice probabilities in the intercity freight transport market. The analysis was based on the estimation of a mixed discrete/continuous choice model of mode and shipment size, where the mode choice component of the full model was specified as a binary probit function. The analysis considered two modes (rail and truck) using data describing the transport of individual commodities at the Standard Metropolitan Statistical Area level.

Abdelwahab found that the estimated market own-price elasticity of demand for truck freight transport (truck volume) is greater than unity in all except three market segments out of eight, with a mean of –1.06. He went onto present a comparison of price elasticity estimates for the iron and steel sector based on

Table 3. Comparison of price elasticity estimates for the iron and steel sector

Reference	Model type	Commodity group	Market	Price elasticity
Oum (1980)	Aggregate translog function	steel and iron alloys	Canada	−0.994
Friedlaender and Spady (1980)	Aggregate translog function	iron and steel products	ICC official	−1.091
Chiang *et al.* (1981)	MNL mode and shipment size model	agricultural fertilisers	Chicago–Houston	−1.143
Winston (1981)	MNP mode choice model	primary and fabrication, metal	USA	−0.18–0.775
Kim (1984)	Nested logit and shipment size	primary and fabrication metal	ICC official	−0.101
Kim (1984)	Generalized Cobb–Douglas	primary and fabrication metal	USA	−0.664
Abdelwahab (1998)	Simultaneous equations	primary and fabrication metal	ICC official	−0.797

previous studies by Friedlaender and Spady (1980), Oum (1980), Chaing *et al.* (1981), Winston (1981) and Kim (1984, 1987) (Table 3).

Abdelwahab pointed to the great variation in the magnitude of elasticities estimated by the various studies. However, he regarded this as unsurprising given the differences in model type, data type (e.g. aggregate or disaggregate), grouping and definition of commodity group, market coverage and demand definitions. In conclusion, he argued the comparison served to emphasize the importance of examining the various elasticity measures within a specific economic context (i.e. commodity type, market coverage, type of data, etc.).

Beuthe *et al.* (2001) addressed the theme of variation in estimates across commodity groups and also explored the implications of trip type. They implemented a detailed multimodal geographic information system (GIS) network model of freight transport in Belgium. They assumed that shippers minimize the generalized cost of their transport and optimize an assignment of flows between freight modes, types of vehicles, or their combinations, and routes. Hence, the elasticity estimates obtained were with respect to *generalized cost* rather than to price.

Table 4 shows their aggregate road freight total cost demand elasticities for short- and long-distance trips (> 300 km), and for transport effects (tonnes) as well as traffic effects (tonne-km).

Beuthe *et al.* stated that road transport tonnage demand was inelastic, while it was elastic when computed in tonne-km. This result shows substantially

Table 4. Aggregate demand elasticities of road freight with respect to total cost

	Short distance	Long distance
Tonnes	–0.58	–0.63
Tonne-km	–1.06	–1.31

larger elasticities for freight traffic than for freight transport. They also indicated that the elasticity for long-distance road freight was higher than for short-distance ones.

Disaggregating their analysis for separate commodity groups, Beuthe *et al.* found great variation between commodity type and trip type in the magnitude of total cost elasticity estimates. For some long-distance commodities such as solid fuel and iron products, the elasticity was quoted as zero, while over short-run distances the estimate for petroleum products was –7.92, for metallurgical products was –2.38 an for food products was –0.14.

Commenting on the variation between commodities, the authors warned that the use of more global estimates in forecasting exercises may lead to mistaken assessments when applied to a particular situation. However, similar variation may well exist within their own disaggregation, defined such as it is by only 10 commodities. In fact, Beuthe *et al.* have shown tremendous differences in the magnitude of elasticity estimates depending on the length of trip, even for the same commodity. Thus, it is not clear that estimates disaggregated at the level presented are any more informative than the aggregate figures.

From the material presented above, 143 price elasticity estimates of the demand for road freight have been collected. Summary statistics of these estimates are presented in Table 5.

The price elasticity estimates given in the literature reviewed above range from –7.92 to 1.72. The mean was –1.07.

Figure 1 is a histogram of these estimates. Despite the great range in magnitude of estimates, it shows that the majority of estimates, 66%, fall between –0.5 and –1.3. Forty-two per cent of estimates fall within the range –0.4 to –0.8. Only 13% of estimates are greater than –0.4 and 2% of estimates are positive.

Can it then be concluded on the basis of the elasticity estimates reviewed here (Figure 1) that the order of magnitude of the price demand elasticity of freight traffic falls somewhere between –0.5 and –1.5? Certainly, the studies reviewed herein, spanning a range of different commodities and countries, indicate that the price elasticity of demand for freight is negative and relatively elastic. However, we are also forced to conclude that different elasticities emerge for different

Table 5. Price elasticities of demand for freight services

Number	Mean	Maximum	Minimum	Median	SD
143	–1.07	1.72	–7.92	–1.05	0.84

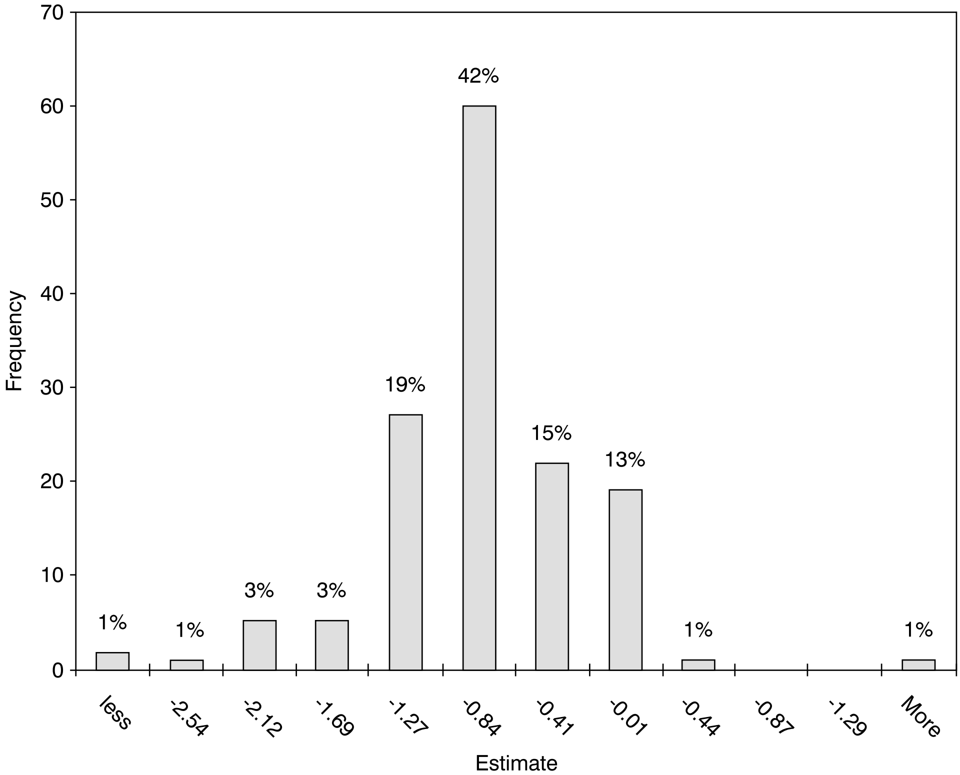

Figure 1. Price elasticity of demand for road freight services.

commodity groups, for different trip types and for different levels of market coverage. Thus, the specifics of any particular context have an important bearing on the magnitude of estimates. However, other issues raised here counsel a cautious approach in the interpretation of the elasticity estimates. Evidence has been found that estimates may be highly sensitive to the modelling approach used and to the level of data aggregation. The treatment of time and the distinction between long- and short-run effects is generally vague. One must also recognize that road freight demand studies are still relatively scarce. For these reasons, we believe that it would be imprudent to offer a firm conclusion about the order of magnitude of the price elasticity of demand for road freight movement.

5. Fuel Demand Elasticities

Graham and Glaister (2002a) surveyed the international fuel demand literature. Their objective was to reach a view about the magnitude of fuel demand elasticities as reported in that literature. Using material from this study and some more recent articles, Graham and Glaister (2002b) gathered a literature survey of 113 studies published between 1966 and 2000, and collected 1083 fuel demand-related elasticity estimates. These included 387 short-run price elasticities, 213 long-run price elasticities, 333 short-run income elasticities and 150 long-run income elasticities.

Table 6. Summary statistics of price elasticity estimates from the literature survey

	Number	Maximum	Minimum	Mean	Median	SD
Short run price	387	0.59	–2.13	–0.25	–0.21	0.24
Long run price	213	0.85	–22.00	–0.77	–0.55	1.65

Table 6 shows summary descriptive statistics on the price elasticity estimates collected from the literature review. The elasticities were estimated principally with respect to all traffic, but in some cases were specific to the private car.

The mean of the 387 short-run price elasticities was –0.25, and although the range was large, from 0.59 to –2.13, the median was very close to the mean. For the long-run estimates, the mean of our estimates was –0.77, with a maximum of 0.85 and minimum of –22.0. The existence of positive price elasticities was surprising. However, only very few short- and long-run estimates were positive, approximately 2% in each case.

Table 7 shows the summary statistics describing the income demand elasticity estimates.

The literature survey collected 333 short-run and 150 long-run income elasticities for demand for fuel. The actual measure of income varied across studies. Aggregate analysis tends to use data on GDP, while household studies are often based on measures of personal or disposable income. The mean short-run was 0.47 ranging from zero to 1.7, and the mean long-run was 0.93, ranging from zero to 2.68.

Looking in more detail at the distribution of fuel demand elasticity estimates reviewed here, the findings can be summarized in the following points:

- Weight of evidence in the literature suggests that the long-run price elasticity of demand for fuel falls between –0.6 and –0.8, and the short-run elasticity between –0.2 and –0.3.
- Income elasticity of fuel demand was between 0.3 and 0.5 in the short run and between 0.5 and 1.5 in the long run.

6. Discussion: Determinants of Road Traffic Demand

This section summarizes the information from our literature review regarding the determinants of road traffic demand and discusses some of the main implications.

Table 7. Summary statistics of income elasticity estimates from the literature survey

	Number	Maximum	Minimum	Mean	Median	SD
Short run income	333	1.71	0.0	0.47	0.42	0.29
Long run income	150	2.68	0.0	0.93	0.91	0.49

Table 8. Summary of elasticities from the traffic demand literature

	Short/long run	Elasticity	Comments
Fuel demand with respect to fuel price	SR	−0.25	mean (n = 377)
	LR	−0.77	mean (n = 213)
Fuel demand with respect to income	SR	0.47	mean (n = 333)
	LR	0.93	mean (n = 150)
Traffic (car-km) with respect to fuel price	SR	−0.15	Graham and Glaister (2002a)
	LR	−0.31	Graham and Glaister (2002a)
Traffic (car trips) with respect to fuel price	SR	−0.16	de Jong and Gunn (2001)
	LR	−0.19	de Jong and Gunn (2001)
Traffic (car-km) with respect to car time	SR	−0.20	de Jong and Gunn (2001)
	LR	−0.74	de Jong and Gunn (2001)
Traffic (car trips) with respect to car time	SR	−0.60	de Jong and Gunn (2001)
	LR	−0.29	de Jong and Gunn (2001)
Traffic (car-km) with respect to income	SR	0.30	Hanly *et al.* (2002)
Traffic (car-km) with respect to income	LR	0.73	Hanly *et al.* (2002)
Freight traffic with respect to price	N.A.	−1.07	mean (n = 143)
Car ownership with respect to cost	SR	−0.20	mean (n = 7)
	LR	−0.90	mean (n = 8)
Car ownership with respect to income	SR	0.28	mean (n = 5)
	LR	0.74	mean (n = 5)

The elasticities derived from the survey are summarized in Table 8, which distinguishes short- from long-run elasticities. In fact, the criteria used to make these temporal distinctions differ across studies. As a general rule, anything less than 1 year is usually regarded as short run. Other studies are based not so strictly on time but on the type of change involved. Thus, for instance TRACE (1998) and de Jong and Gunn (2002) allowed only for mode choice changes in the short run, but included all other behavioural changes in the long run (i.e. destination choice, travel frequency choice, land use change, etc.).

Table 8 also presents the means of road traffic-related elasticity estimates either calculated by us for this survey or taken from other review articles. Car ownership mean elasticities are also quoted, although it must be recognized that these values are based on very few estimates and this necessarily tempers the degree of confidence of these values. Throughout, this review has stressed that there is a great deal of variations in estimates, but if for the moment these means are accepted as being indicative of broad orders of magnitude, some interesting themes can be drawn out.

First, the review clearly shows that growth in the standard of living is crucial in explaining increasing road traffic demand. The level of car ownership is heavily dependent upon income as is the demand for car travel and fuel consumption. Table 8 shows that the mean elasticities of car ownership and car-km with respect to income are very similar in both the long and short runs, but the fuel demand elasticities take higher values. Perhaps this supports the hypothesis that as incomes grow, as well as buying more cars and thus creating more traffic, consumers are more likely to purchase larger cars and cars that are less fuel-efficient.

However, income affects road traffic demand in another important way reflected in Table 8. This is through its influence on the value of time and thus on the level of generalized cost of drivers. The mean long-run elasticity of car-km with respect to car time is –0.74. The actual value of time along with road speed determines the value of car time. Income growth has an important influence on the average money value of time, but the exact nature of this relationship is the subject of continuing research (e.g. Wardman, 1998). Assuming that values of time grow roughly in line with disposable income, Graham and Glaister (2002b) have inferred that the value of time per km for the average urban car driver has increased from approximately 50% of the generalized cost of driving a vehicle-km in 1960 to 65% by 2000. Thus, the value of time may be of greater relative importance to the car driver now than in the past because it has grown faster than many other components of generalized cost. Evidence is not available here to say how these changing cost proportions have affected elasticities, but what is indicated is that the elasticity of car-km with respect to car time in the long run is much higher than the elasticity with respect to fuel price, by a factor of almost 2.5.

Regarding price elasticities, our review confirms the well-known result that growth in fuel prices has a much stronger influence on fuel consumption than on the number of kilometres driven. Car trips are also much less responsive to fuel price changes in the long run than car-km, due perhaps to adaptations in mode choice, destination choice and land-use location—people make less trips, but travel much shorter distances. The car ownership elasticities with respect to cost also indicate that in the long run consumers do respond to price changes.

However, what is also interesting in Table 8 is the relative magnitude of road traffic-related price and income effects. Income elasticities of fuel demand are of greater magnitude in both the short and long run than the price effects. This is also true of the elasticities of car-km with respect to fuel price and income. The indication may be that even to stabilize traffic and fuel consumption at present levels prices would have to rise faster than incomes. However, the offsetting factor may be, as mentioned above, the increase in values of time. Further research is required to uncover the exact nature of this effect.

Finally, from Table 8, our review has emphasized elasticities of demand for freight services. It has also been shown that a great deal of variation exists in the magnitude of estimates reported in the literature and that there are a whole range of factors that have a bearing on this, including the level of aggregation, the methodological approach and the specific demand context. Nevertheless, we are confident that from the studies reviewed, which span a variety of different commodities and countries, the price elasticity of demand for freight is negative and relatively elastic.

7. Conclusions

This paper has provided a brief review of road traffic and fuel demand elasticity estimates from the international literature. An indication has been given of the orders of magnitude of these effects and the factors underpinning variation in estimates have been emphasized. A range of different elasticity estimates of relevance to road traffic has also been reported. By collating and comparing these estimates, some important implications have been drawn out and some factors underpinning the determinants of road traffic demand emphasized.

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