

THE AUTOMOBILE AND THE FUTURE:
SOME ISSUES

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ABSTRACT: *The automobile has been central to debates on the future of oil-based societies in which economic progress is believed to be heavily dependent on a healthy industrial base, with the state of the auto industry an indicator of the overall condition of this sector. The effect of the OPEC cartel and the successful implant of Japanese cars in the domestic markets of North America, Europe, Britain and Australasia, has transformed a highly predictable transport sector into one of both great uncertainties and potential.*

Nine years have elapsed since the initial OPEC price rises; sufficient time to begin to assess the influence of energy and other factors on the auto industry and on the demands by households and businesses for types of vehicles and the use thereof. This paper discusses the future of the automobile in the light of the special emphasis being directed to the auto industry, fuel options, and consumer energy conservation.

INTRODUCTION

It is often argued that the future of the car is predominantly conditioned by the availability of oil. As a consequence for the car, the oil 'crisis' is an energy 'crisis' threatening its role as an unique form of transport in industrial countries.

A common prescription is that households will have to make a number of lifestyle changes: less use of cars, more use of public transport, more centralisation of activities, less discretionary travel, and more car pooling. The prescription also asks for urban renewal and increased residential densities.

The functional advantages of the car in the formation and maintenance of particular (preferred) lifestyles, and the importance of the automobile industry have in recent years been exposed to significant pressures. The initial source of this pressure, the international oil 'crisis', is now understood more clearly to be a political and financial crisis rather than a global shortage of crude oil per se:

'There is an energy crisis because government has decreed that there shall be one.....Of course, government has not done so openly.' (Friedman, 1979)

An extensive literature focusses on the levels of oil reserves which will be recoverable at various prices (e.g. Stobaugh and Yergin 1979, Saunders 1981, Australian Senate Standing Committee on National Resources, 1980). Its main position is a diminishing supply of oil reserves, a position used by governments in the pronouncement of an 'energy crisis'. The situation was further exacerbated in the U.S. during the 70's by the unwillingness of government to permit market forces to determine a price structure that not only reflects the true cost of the supply of petrol, but which also provides the requisite incentives for exploration and research into all forms of energy sources for transport. The countries that currently price crude oil at world parity claim to have demonstrated its impact on exploration for more oil reserves while at the same time encouraging investment in research into alternative technologies.

An oil 'crisis' (if it exists) does not necessitate an energy 'crisis' unless suitable government policies are not introduced. A major concern is not the amount of global oil but the need for imported oil. Some countries, especially in the developing nations, import 100% of their oil and oil products. The debate is mainly in the political arena: '...the energy crisis is a crisis of our political system' (Stobaugh and Yergin 1979, 13). In particular, if all controls on the prices of crude oil and other petroleum

products were eliminated, leaving a competitive pricing structure to operate as the arbiter, then in any situation of shortage of oil the shortage should substantially disappear. Consumers would be able to obtain all the oil they were willing to pay for, the condition which governs all other product markets. A competitive pricing structure would assist the introduction of new technologies and alternative fuels. Importantly, given the higher level of technological competence and economic development of today's society, the outcome could be a less expensive (in real terms) and more abundant supply of energy (in various forms). The oil companies have a vested interest in the outcome (as do governments who obtain considerable revenue from the output of such giants), their reticence in responding to pressures for research into alternative fuel sources reflecting the non-viability of alternatives at current prices.

To discuss the future of the car an appreciation is required of many factors. The growth in car ownership in the 60s and 70s was not solely (or even primarily) the result of low-priced oil. While relatively low retail petrol prices may have influenced the size of vehicles purchased and the pattern of vehicle usage, other factors influenced the total stock of vehicles: the capital cost of a car relative to the benefits; rising incomes, the influence of suburbanisation, encouraged by relatively lower land prices in the suburbs, and the absence of suitable public transport in many areas. The role of these other influences has been reinforced by (1) the increase in the participation of married women in the workforce, (1) increased variability in work hours (staggered workhours and compressed workweek policies), and spatial dispersion of the family. The combination of petrol prices and engine efficiency is of particular concern to the motorist, yet the fuel cost per kilometre is such a small percentage of both the overall and transport money-budget that it has had only a marginal impact on car ownership.

The motor-vehicle manufacturers have reacted to the expectations of higher retail petrol prices (so as to preserve a growing car market) with the provision of more fuel-efficient vehicles. The new generation of vehicles have also been influenced significantly by the safety and pollution regulations of most countries.

1. In Australia, participation rates for married women rose from 6.5% of all wives in 1947 to 32.8% at the 1971 census, and 41.5% in the November 1977 Labour Force Survey. In the U.S., the participation rates for married women (husband present) were 14% (1940), 22% (1950), 31% (1960), and 40% (1970) (Eyland et al. forthcoming).

The following sections discuss the future of the automobile in the light of the special emphasis being directed to the auto industry, alternative fuels and energy conservation. The orientation is that of industrialised nations. To some extent it presents a personal interpretation of the automobile and the future.

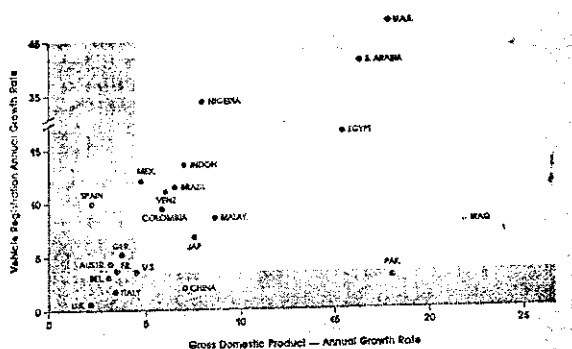
THE AUTOMOBILE INDUSTRY

Many of the problems in the automobile industry are associated with adjustments in the distribution of market power rather than in any global decline in the total industry.⁽²⁾ However, since an industrialised nation's automobile industry has been viewed as 'the single most potent economic lever' (Leach 1973: i) any tremors in its performance are serious. While part of the short-term recession in specific national auto industries, especially that of the U.S., will be remedied in the long-term⁽³⁾ as a consequence of investment in plant and equipment to produce more competitive automobiles, there is likely to be a more permanent reshaping of national manufacturers to reflect the trend to a globalised auto industry. This has exacerbated the debate on import curbs, especially in the U.S., for example, Ford (U.S.) is calling for tough new curbs on imports while at the same time enlisting a Japanese auto firm (Toyo Kogyo,

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2. Australia, 1980, illustrates the general health of the industry. 450,235 passenger cars were sold, 1.6% less than the strong sales in year 1979 in which new models were brought out by GM Holden and Ford Australia. The big shift in the market was not so much in brands as in engine sizes. The 4-cylinder market advanced from a 57% share to 67%, a record increase. V8 sales slumped from 52,000 in 1979 to 22,000 in 1980. 6-cylinder sales in 1980 were 128,000 and 4-cylinder sales were 300,000. The last 3 months of 1980 saw a swing back to 6-cylinder models; dealers suggesting that some buyers rediscovered that small cars are cramped during the vacation season. Import sales increased from 89,000 in 1979 to 112,000 in 1980, a 25% market share, despite the 57.5% tariff on landed cost and a quota system designed to limit imports to a maximum of 20% of the new car market (Automotive News, 1981).
 3. Lead times are typically 4 to 5 years for new power-train components and 3 years for other vehicle parts. This in part explains the heavy (current) import of vehicle parts, especially for the smaller vehicles.

of which Ford has 25% equity interest)⁽⁴⁾ to help develop small, fuel-efficient vehicles for the American market in the mid-80s, which will be fully imported. In Australia Ford imports Mazda parts for its Laser. One explanation is the cash shortage due to heavy commitments in South America and Third World countries (for example, the \$120 million paint plant in Argentina) and the need to have a high efficiency front-wheel drive mini-compact for 1985 to compete with similar planned offerings of GM (S-car, 40-50 mpg or 14-18 kpl), Chrysler and several non-U.S. firms.

Globalising the industry means producing vehicles and associated components in that part of the world in which the return on investment is the greatest, and has the potential effect of reducing nation-loyalties in anticipation of increased global market shares rather than domestic market shares. It does not mean standardising a total vehicle design across all market nations (i.e. a world car, a concept that has not succeeded). The real future growth markets for autos and the sources of less expensive labour are the developing countries which include the OPEC nations (Figure 1) (See also Mogridge 1981). In the 80s the Third World



Source: Automotive News, 1981

Figure 1. Vehicle Registration Growth vs Gross Domestic Product Growth, 1976-1980

4. GM (U.S.) owns 34% of Isuzu and has recently acquired Chrysler's operations in Columbia and Venezuela. Renault owns 22.5% of American Motors and 20% of Volvo cars.

is experiencing population booms, particularly in the under-30 age category, along with massive migration to metropolitan areas and high under-employment (exceeding 50% in countries like Mexico). The appropriate vehicles when acquisition is possible are those in the small-medium size categories. This market will be open to the U.S.-based giants as a result of downsizing. The new auto markets and multi-manufacturer participation will require auto companies to develop a high degree of political sophistication.

A major reason for the current problems in the U.S. auto industry is the abrupt shift in consumer demand towards small cars caused by the 1979 OPEC price rise. The '79 rise appears to have been the final proof that consumers needed to confirm that prices were going to remain high. Consumer illusions had been fostered by the government's previous policy of holding fuel prices below world levels, initially discouraging the market's demand for fuel economy. Interestingly, although Australia and the U.S. premium petrol is currently priced at almost the same level (\$A0.34 per litre and \$A0.33 per litre respectively as of 1 April 1981), the Australian consumer appears to have acknowledged, much before 1979, regular price increases with the market size mix historically more geared up to accommodate down-sizing demand. During early 1981 the U.S. fleet of new registrations had greater efficiency over the Australian flow, given the help of imports; and is rapidly catching up with the efficiency of the Australian stock. At the current rate of change, it is estimated that the small car percentage of the U.S. auto fleet will be 70% in the 1990's and level off at 80% in the late 1990's (Automotive News 1981).

The low-price petrol policy in the U.S. which followed the loss of Iranian oil in 1979, together with shortages and petrol lines, magnified the shock of a transition that precipitated a significant shift in car-type demand from one end of the market to the other. This gave the Japanese a windfall. (5) Few other countries (such as Denmark and Holland) experienced that degree of shock despite a greater dependence on imported oil. This partially reinforced the policy of globalising the industry which in the long-term may be in the interests of the international industry as well as consumers.

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5. The quality control of Japanese autos showed the U.S. manufacturers that quality control must become a prime objective, and is now a key factor in the U.S. industries plan to reclaim its earlier market share.

It is argued that a free market will enrich the competitive base of the U.S. auto industry and make it more efficient. However, the real issue is equality of access to markets in other countries. That is, since U.S. consumers are free to take advantage of the lowest prices any importer can provide, then arguably U.S. producers should be free to export to anywhere in the world. Globalising of the automobile industry may aid this equalisation but only in the long-term; in the short-term cost differences between the U.S. and Japan, for example, must be dealt with to ensure that the transformation to a world product occurs. Globalising may also have the effect of rationalisation of the number of mass-market manufacturers to a level the world economy can support.

New directions are emerging in the automobile industries. These adjustments, while causing economic problems, appear to be taking the automobile into a new era. Particular nations may well obtain net gains or net losses for their producers, but the consumer appears to be benefitting.

IMPACT OF PETROL PRICES AND AUTO EFFICIENCY ON CAR OWNERSHIP AND USAGE

It is generally argued that the price of petrol and the fuel efficiency of vehicles influence the types of automobiles owned and their usage. This section reviews the evidence.

Petrol prices in 1973 and 1979 for six countries are given in Table 1 together with average kilometres per vehicle. In the U.S. petrol prices increased 102% from 47 cents/gallon in 1973 to \$0.95/gallon in 1979; average U.S. kilometres per vehicle increased 12% during this period. In Europe, where petrol prices have traditionally been higher because of taxes and the absence of price control, average kilometres per vehicle increased between '73 and '79 in France, remained unchanged in Germany and declined marginally in England and significantly in Italy. The real price of petrol dropped by 8.5 per cent in Australia, with average kilometres per car decreasing by 2.7 per cent. The only conclusive (although temporary) reduction in average vehicle kilometres between '73 and '79 occurred when there was a petrol shortage due in 1974 to an oil embargo, and spot shortages in 1979 following the Iranian revolt (Figure 2). It is very risky to use such aggregate data in Table 1 to infer any causality between petrol price changes and vehicle kilometre changes, without accounting for other changes in the economy and in household auto stock.

Table 1 Real petrol prices and kilometres per vehicle, 1973 and 1979

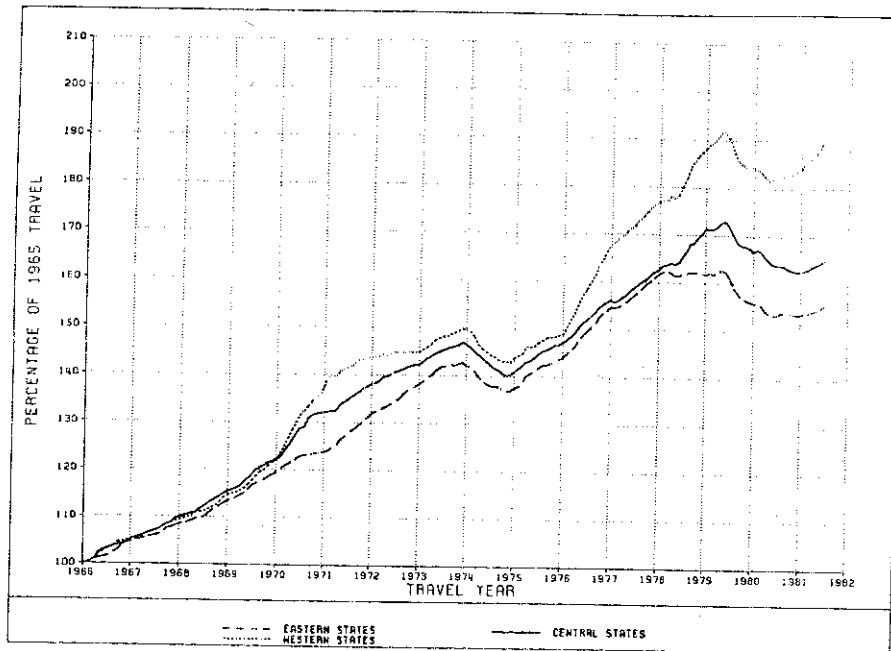
(in constant U.S. dollars, 1978 = base)

	Petrol Price (\$US) per U.S. gallon		Per Cent Change '73-'79	Average kms per Vehicle		Per Cent Change '73-'79
	'73	'79		'73	'79	
U.S.	.47	.95	102	15984	17902	12.0
United Kingdom	1.12	1.30	16	14400	14300	-0.7
France	1.35	1.67	24	12480	13440	7.7
Germany	1.63	1.80	10	16160	16160	0.0
Italy	1.38	1.35	-2	12000	9600	-20.0
Australia ⁺	.82	.75	-8.5	15400	15000	-2.7

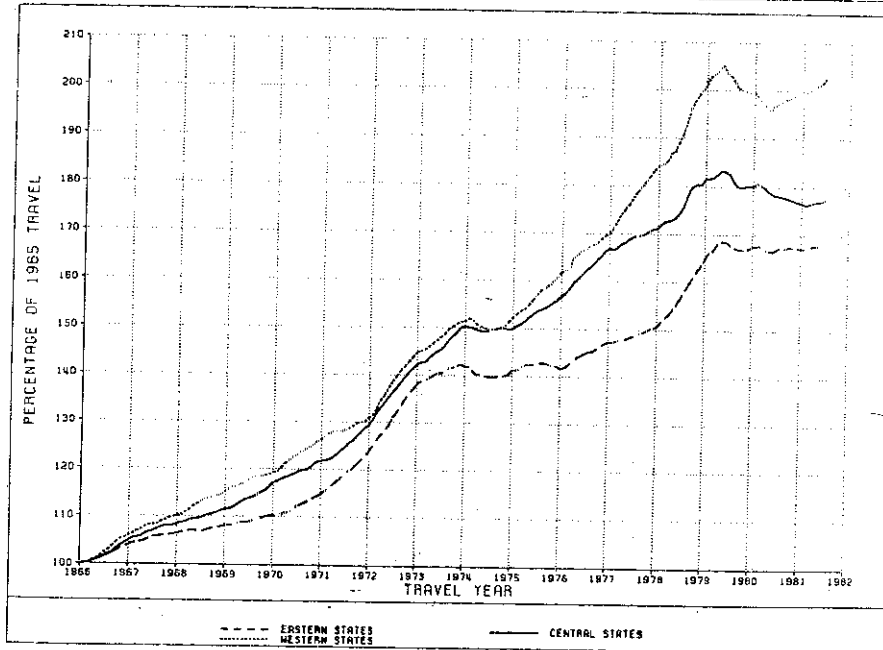
+ cars and station wagons only

Sources: CPI's from OECD, Main Economic Indicators 1960-1979 (OECD, Paris 1980)
 Actual Petrol Prices, Kulp et al., 1980 (Tables 5.4, 2.34)
 Oil and Australia 1980 (Australian Institute of Petroleum Ltd)
 ABS Survey of Motor Vehicle Usage (including extrapolations)
 Report in Automotive News March 9, 1981 on Goodyear Tyre and Rubber Co. analysis.
 Tanner (1981)

(a)



(b)



Source: U.S. Department of Transportation, 1981, April.

Figure 2 (a) Annual travel on main rural roads as percentage of year 1965
(b) Travel on urban roads and streets as percentage of year 1965

The empirical evidence up to the mid '70s on the own price elasticity of transport demand for petrol in the Western World suggests it is relatively inelastic (Burright and Enns 1975, Bendtsen 1980). The predicted short-run own price elasticity of demand in the U.S. varies from -0.15 to -0.36, with -0.21 selected by the Federal Energy Agency (Charles River Associates, 1977) and Lea (1981) and Wheaton (1980) both proposing -0.38. The estimated long-run elasticity varies between -0.17 and -0.92, with a Federal Energy Agency figure of -0.76. These figures are almost identical to Sweeney's (1974) results of -.22 (short run) and -.78 (long run). The estimated short-run elasticity in Australia for 1955-76 is -0.08 (Schou and Johnson, 1979); and the figure for the United Kingdom, 1973-74 is -0.1 (Mogridge, 1977). The values will vary according to trip purpose, household income, and time-of-day of travel. Such low short-run responsiveness to petrol price increases makes this an ineffective policy tool by itself for meeting short-run crises.

Since only a small percentage of the generalised cost of travel is petrol and oil, with the value attached to time savings making time costs predominant (Hensher, 1977; Hensher and Dalvi, 1978; Lave, 1980), petrol costs would have to increase substantially (at least 300%) for its cost to be a significant factor (in the set of economic indicators) influencing behaviour.

The elasticities reported above are post hoc analyses of past data (and not forecasts of the future), relating to long-term trends which end in the mid-'70s. Recent (up to '78) work by Pindyck and Griffin (as reported in Harris and Davies 1981) analysing data from 12 countries suggests (over a 15 year period) a higher long-run price elasticity of energy demand in transport of -1.06. A fundamental concern about all these price elasticities is the extent to which the effects of a general economic recession, changes in the structure of final demand, technical innovation and good housekeeping conservation have been accounted for. The very recent (1980 onwards) evidence on the relationship between petrol price increases and demand for petrol suggests that these other effects are poorly represented in econometric models used to obtain price elasticities of demand.

The evidence indicates that the price of petrol has a greater impact on car size than on car usage. Mogridge (1977, 1981) shows that the fuel price increase is taken up in a long-run adjustment in car size. This result is based on a study of annual car prices (by age and size) from 1957 to 1973 and monthly prices from 1973.

Efficient resource utilisation requires that the fuel efficiency of the car be optimised within the constraints of current technology and expectations of future fuel prices. Lea (1981)

indicates, for the U.S., car efficiency direct point elasticities with respect to fuel price of -0.25 (long run) and -0.12 (short run), significantly lower than the U.S. petrol consumption elasticities with respect to petrol price as selected by the FEA. However, when compared with the actual fuel efficiency of the total auto fleet in the U.S. from 1972 to 1979, the observed 8% improvement (Lea 1981) is much greater than the predicted 2.3% short run improvement or 4.8% long run improvement. Events in the last 3 years have placed doubt on the use of elasticities derived from highly aggregate trend-oriented models of the mid-'70s. (6)

There are many factors contributing to fuel efficiency: vehicle characteristics, maintenance, driving habits, and operating conditions. The most influential vehicle characteristic influencing fuel consumption is vehicle weight. (7) An estimated 1977 relationship between weight (W) and fuel consumption (C) for passenger vehicles in Australia is (Lane, 1977)

$$C = 31 + 58 W \text{ litres/1000 km, where } W \text{ is weight in tonnes.}$$

Thus, a 20% petrol saving can be achieved by switching from a car weighing 1.5 tonne to 1.1 tonne. The average weight of all cars and station wagons in Australia in 1977 was 1.3 tonne (with 57% of the vehicles in excess of 1.1 tonne). In contrast the U.S. GM fleet's average test weight for 1977 was 1.896 tonne (4180 pounds), with a projected 1984 weight of just under 1.36 tonnes (3000 pounds). This 1984 projection for a major U.S. manufacturer's autos is similar to Australia's 1977 position; however with imports, the overall U.S. figure will be much lower. The use of lighter weight materials (aluminium and plastic composites) is expected to reduce weight (Agnew, 1981). The average U.S. made 1981 model car contains a record 130 pounds of aluminium, equal to 4% of its weight (compared to 2% in 1970). Accessories also influence engine output power. The range of energy consumption per vehicle-kilometre contributed by automatic transmission and air conditioning are respectively 0-5% and 10-15%. The constant speed accessory drive is one means of

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6. This is one area where short-run elasticities in particular require carefully conducted, highly disaggregated empirical studies, preferably using longitudinal panel data. 'Analysis of household level data... could lead to significant improvements in the understanding of the vehicle market at modest cost' (Mellman 1981, 30).
7. A study by Essenhigh et al. (1979) shows that increased fuel consumption due to larger engine size can be partially offset by a specific engine efficiency that improves linearly with increasing engine size. GM proposes to decrease engine sizes only slightly faster than vehicle weights so that power-to-weight ratio, related to vehicle acceleration performance, will not show a large loss (Agnew, 1981, 5).

improving the air-conditioner consumption level, reducing it to 6-11%⁽⁸⁾
Other add-on modifications such as thermostatically controlled cooling fans can reduce fuel requirements by up to 5-10%.

Maintenance⁽⁹⁾ and driving habits are primarily under the control of the user, despite the ability of government to undertake programs on driver education and advertising campaigns. The orientation must include a direct pecuniary saving to the individual, rather than only a contribution to societies energy conservation (see below). Lack of maintenance unnecessarily increases fuel consumption - the major contributions relating to air-cleaners, air-fuel mixture, ignition timing, tyre pressure, wheel alignment and brake settings. Driving more slowly, changing gears at the correct moment, and avoiding sudden stops and rapid acceleration can save up to 20% of fuel consumption. However, for many individuals the cost of tuning usually exceeds any perceived benefits.

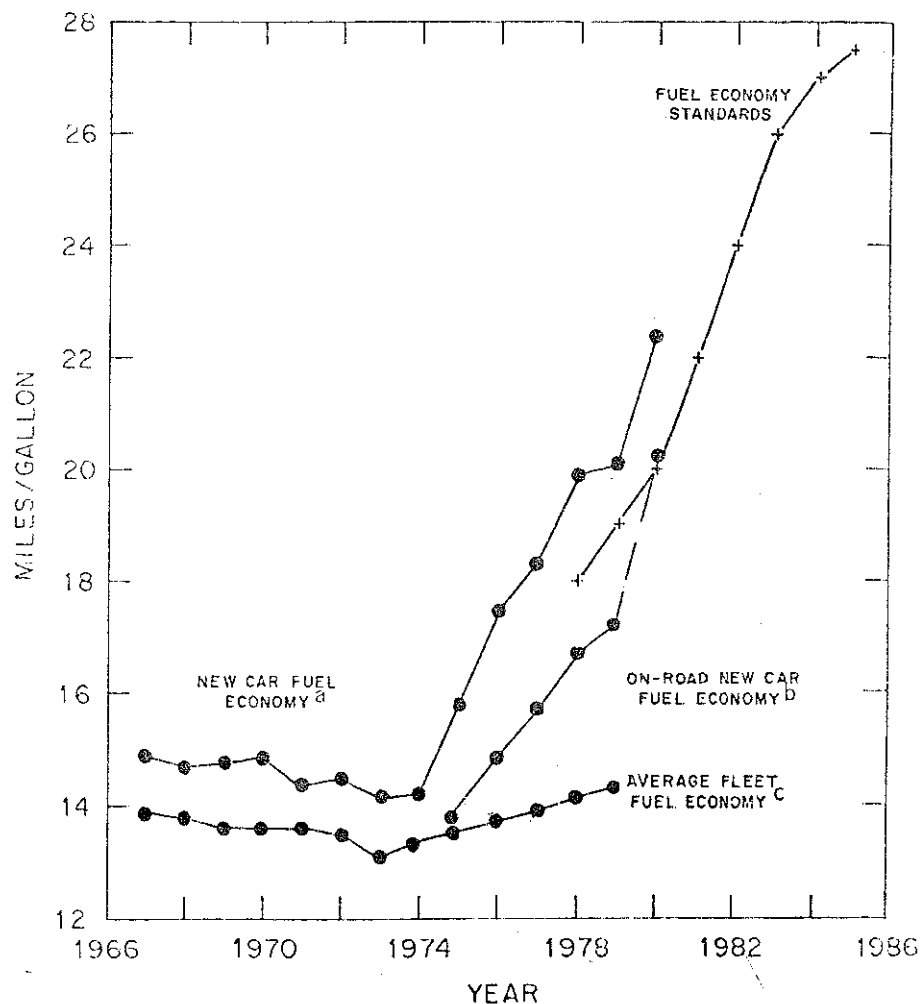
The area given most consideration (of those outlined above) is the vehicle characteristics (e.g. Erlbaum et al., 1977). It is commonly assumed that vehicles with greater engine capacity are less efficient and thus should be taxed at a differential (higher) rate. This is usually achieved by varying car registration fees. However, age is a major factor, especially now that manufacturers are more conscious of the need to improve fuel efficiency. In the U.S. the federal laws mandate steadily increasing average new car efficiency from 7.8 kpi in 1978 to 11.9 kpi in 1985 (with the effects spread over the entire fleet by 1995). A study by Erlbaum et al. (1977)

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- 8. A report in the (New South Wales) National Roads and Motorists Association (NRMA) magazine, Open Road, claimed a net 2% fuel saving from air conditioning. With the windows up, wind resistance is reduced.
 - 9. There is (unsubstantiated) evidence in Australia that the current range of smaller vehicles are most costly in maintenance, especially for high-kilometre vehicles, since the parts are of lower quality. The reduction in average vehicle kilometres travelled per vehicle, however, must offset (partly, at least) this cost penalty. Time will identify a consumer group who may find smaller vehicles more costly. However, the small vehicle of the future is projected to be of higher quality than current large vehicles. This reinforces the fuel efficiency benefits. In the U.S., however, some observers argue that larger cars are perceived to be losing quality while smaller cars are perceived to be improving in quality (Mellman 1981, 26).

developed energy forecasts in terms of the price, availability and efficiency of vehicle types and concluded that the achievement of significant petrol conservation (i.e. the whole fleet at an average of 11.9 kpl by 1985) in New York State would require, with reasonable petrol prices and continued mobility growth, the full vehicle stock turnover by 1985, a ten year period.

Even though such levels of fuel efficiency will be achieved, having already exceeded the 1981 U.S. mandated level (Figure 3), this does not necessarily mean a reduction in petrol consumption per household. The reasoning is not clear. The important parameters are the growth in multi-car households, the increased fuel efficiency of new vehicles, and the relatively greater kilometres of new vehicles. The causal relationships are however unclear. The position adopted here is that the growth in multi-car households⁽¹⁰⁾ is mainly associated with other issues such as suburbanisation, growth of the company car sector (in part response to wage freezes or indexation), and changes in patterns of family lifestyle (especially the increase in working wives). Given the increase in multi-vehicle households, the kilometres per vehicle per household have declined in recent years; however given the evidence that newer vehicles tend to have greater annual kilometres (Lane, 1977)⁽¹¹⁾ (this always being relative to the stock, implying some annual growth in VKT), then since the new annual registrations are overall more fuel efficient, we would expect them to be associated with the greatest kilometres per vehicle. This does not imply that there is a positive causal relationship between fuel efficiency and kilometres travelled. The price elasticity of vehicle kilometres travelled (VKT) is small either because fuel costs are only a fraction of total costs and/or are not very large in absolute terms. In the U.S., total VKT has not declined much since 1979 even though petrol prices have quadrupled, hence lowering effective petrol prices via more kilometres per litre is unlikely to lead to greatly increased travel (Weiner 1981). The real reasons appear to lie elsewhere.

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10. A very recent, and as yet uninfluential, effect is the availability of 'clone' cars, such as twin-cab light commercials and family car vans. Such options may slow down the growth of multi-car households if the main reason for multiple-ownership is in flexibility of an auto type in meeting household needs.
 11. Lane (1977) shows for Australia that 50% of the kilometres are by vehicles of no more than 4 years vintage. This evidence does not suggest that a fleet of all-new cars would be driven more; it must be interpreted as historical data and used cautiously in projections. The income effect clearly plays an important role.



^aJ. D. Murrell, J. A. Foster, and D. M. Bristor, Environmental Protection Agency, Passenger Car and Light Truck Fuel Economy Trends through 1980, SAE Paper 800853.

^bCalculated using EPA fuel economy values. It should be noted that EPA new car fuel economy values are calculated using manufacturers' sales projections, while the on-road new car fuel economy is based on actual sales data. The source for on-road fuel economy is: Energy and Environmental Analysis, Inc., The Highway Fuel Consumption Model- Fourth Quarterly Report, prepared for the U.S. Department of Energy, Washington, D.C., July 1981.

^cU.S. Department of Transportation, Federal Highway Administration, Highway Statistics, Washington, D.C., annual.

Source: Correspondence with Dr Phil Patterson, U.S. DOE. This supersedes the Table in Chen et al. (1981)

Figure 3 Automotive fuel economy standards for U.S., 1967 to 1985

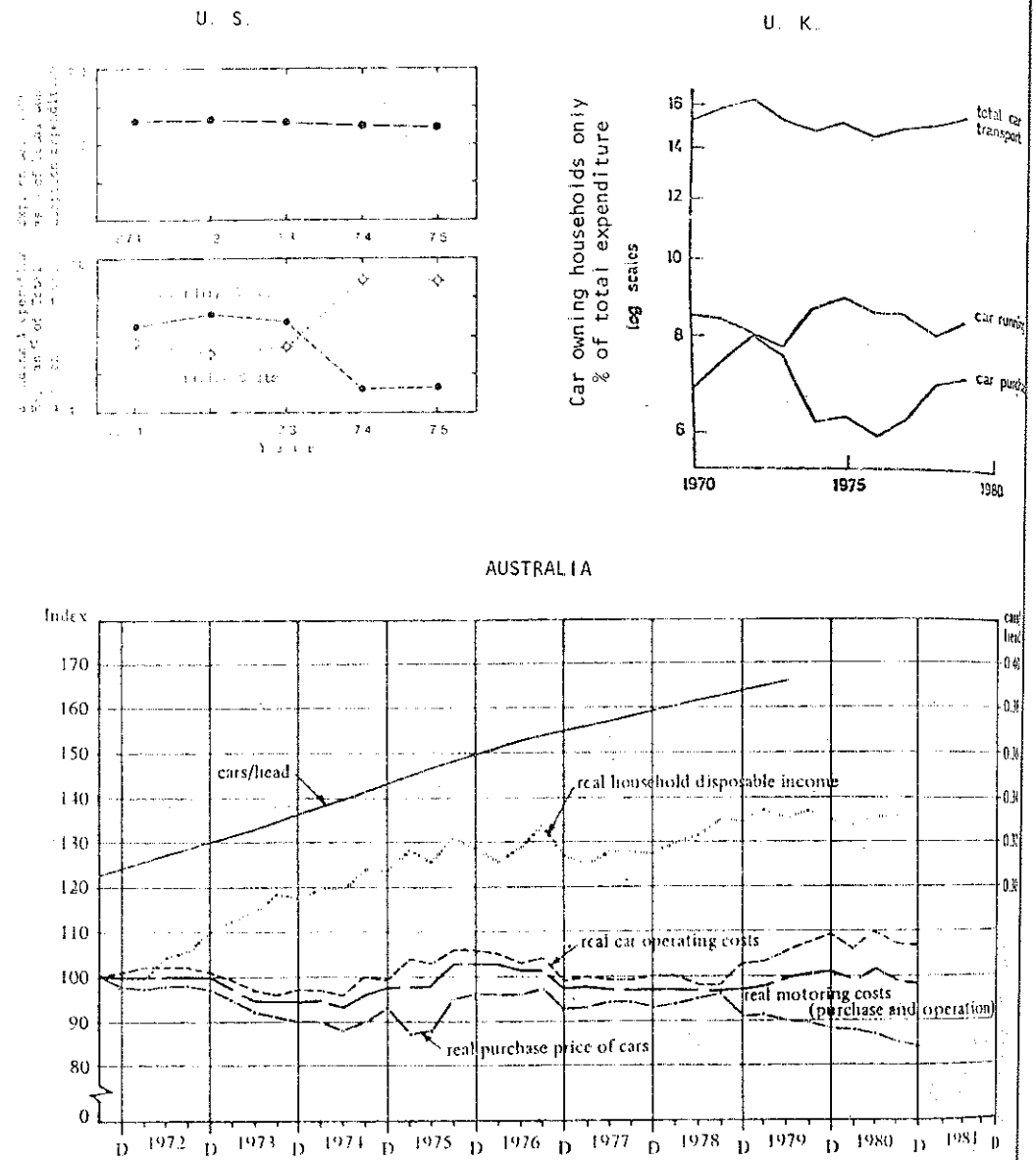
On the evidence above, a fuel efficient car is not in itself an inducement to cut petrol consumption. The discussion above on petrol consumption is in terms of a vehicle. A more meaningful energy consumption unit might be kilometres travelled per household (HKT). Given the evidence in Australia by the Bureau of Transport Economics (1981) and U.K. by Dix et al. (1981) on an increase in multiple-car ownership by households and a reduction in annual kilometres per car, then we are observing an increase in HKT's even though kilometres travelled per car are falling. A decline since 1979 in per vehicle kilometres is also occurring in the U.S. (Subcommittee on Trade 1980, 10, U.S. Department of Transportation 1981, Figure 3)), although the reasoning behind it is not yet clear. It is clear that correct definition of the analysis unit is essential in identifying the final implications of policy on the role of the car. Petrol consumption per car may decline, but per household is likely to increase.

Mogridge (1977, 1981) shows that a constant 15.5% (+ 0.5%) of U.K. disposable income is allocated to car travel in car-owning households (Figure 4). This result is similar to that for the U.S. (Zahavi and Cheslow 1980). Consequently the increase in U.K. petrol prices in 1973 (from 35 p per gallon to 70-80 p per gallon) resulted in a greater proportion of available resources being spent on car usage and correspondingly less on car purchase. In the period 1-72/74-75, the percentage of the budget devoted to car purchase decreased from 7.68% to 6.22% and for car usage increased from 0.05% to 0.87% (an overall reduction from 15.73% to 14.99%). In the long term despite a move towards smaller more fuel-efficient cars there may be an older (less fuel efficient) stock of vehicles as less of the household's disposable income is available for replacement purchases. This trend is evidenced in the U.S., where the average age of passenger cars in 1979 was 6.4 years compared to 5.5 in 1969 (12) (Subcommittee on Trade, 1980, 16). Furthermore, in some countries (e.g. Germany, Italy, Netherlands, Australia) the growth in multi-car households, (13) has reduced kilometres travelled per vehicle (Bureau of Transport Economics, 1981, Bates and Roberts 1981), contributing to the extended life of a vehicle in a household. Mogridge (1981) indicates that households in the U.K. tend to keep cars longer when petrol prices rise. To what extent this adds to or partly offsets the fuel efficiency effect on replacement is unknown. Bates and Roberts (1981a, 1981b) argue from household expenditure data that the purchase/usage substitution effect used in Mogridge's studies up to 1975 is secondary during the period '75-'79 to the growth of

The Australian age trend is 6.4 (1962), 6.1 (1971), 6.6 (1976); the comparable U.S. figures are respectively 6.0, 5.7 and 6.2.

For Australian capital cities the number of households with two or more cars increased during the period 1966 and 1976 by between 8 and 14 per cent (Bureau of Transport Economics 1981).

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Sources: USA: Zahavi and Cheslow 1980, 80. U.K.: Mogridge 1981, 14.
Australia: Transport Australia 1980, 25.

Figure 4. Trends in travel expenditures - U.S., U.K., Australia.

company registered 'household' vehicles in the U.K. as the important influence in maintaining the relative constancy of expenditure on travel and transport. The strong increases in new car registrations between 1975 and 1978 occurred during a period of significant price increases for new cars and no increase in mean gross household income. The neglected company car sector is discussed in a later section

The Australian Household Expenditure Survey 1974-75 (Australian Bureau of Statistics 1976 a,b) shows similar results, although classifications are slightly different (see Morris and Wigan 1979). 17.7% of expenditure is on transport and travel, with transport excluding holiday travel being 15.5%. Car purchase is 25.42% of 17.7%, (the comparative Australian figure to the U.K. 6.22% of budget devoted to car purchase is 4.50%) although since the Australian figures relate to all transport, this percentage is likely to be lower than the U.K. cars-only percentage. The proportion of expenditure spent on cars by all households in Australia, using the same expenditure categories as Mogridge (1979a) is 13.4% (ABS 1976a,b), which varies from 15.3% for Canberra and Adelaide through to 15% for Perth, 14.3% for Brisbane, and 12.8% for Sydney and Melbourne.

FUEL OPTIONS

The literature on alternative fuels is expansive and generally lacking any consensus on the timing of and commercial viability of particular options. As a consequence the real futures of many of the proposed 'alternatives' to petrol is unclear. It is clear, however, that the timing of the commercial viability of fuel options is related to (a) the responsiveness of the automobile industry to consumer demand for more fuel efficient vehicles (as consumers' expectations of higher petrol prices are demonstrated in the market place) and (b) to uncertainty at the political level as to the availability of crude oil.

The uncertainty is given as sufficient reason to actively investigate alternative fuel options; the economic and social risks of starting too late far outweigh the economic and social costs of starting too soon. A major concern is the lead times in bringing alternative fuels into the market. Nicklin (1981) argues that 'projects whose objective is to shorten the lead time for commercialisation in the event of a crisis are a good insurance'. Has the Reagan Administration done the right thing by reducing expenditure, and slowing the implementation of the program to develop synthetic

fuels?⁽¹⁴⁾ President Reagan's position on many auto-related issues is that 'if it's worth doing the private sector will do it'. The recent reduction of the federally funded electric and hybrid vehicle program and the scrapping of the federally funded demonstration program is another illustration of this philosophy.

What are the futures for automobiles propelled by alternative fuels? The comments (and some evidence) below are limited to fuel options which are being seriously evaluated for introduction on a significant production scale before the year 2000. Improvements in fuel efficiency of the internal combustion (spark ignition) engine are assumed to continue to influence the commercial viability of alternative-fuelled automobiles.

Light Duty Diesel

With the exception of some European manufacturers, diesel engines have to date not been given a serious role in the list of automobile options. A 14% diesel car penetration is predicted in the U.S. by 1990 (Johnson and La Belle, 1981, Figure 2.3); it is currently less than 2%; 12.4% of all car sales in Italy in January '81 were diesel vehicles, aided by the price of diesel being 40% of the price of petrol. Recent Volkswagen Formula E Golf diesels recorded 39.2 (13.8 kpl) for the urban cycle and 52.3 mpg (18.4 kpl) at 90 kph; making it 17% more fuel efficient than the standard model. However, there are a number of hurdles to overcome before we could see a strong move to diesel engines, especially the 14% penetration predicted for the U.S. and Australia where the emission standards are particularly severe. Currently in the U.S. there is a 0.62 grams per kilometer (gpk) oxides of nitrogen (NO_x) level requirement; for Australia it is 1.9 gpk (Table 2).^x By 1985 the requirement will be 0.2 gpk in the U.S. and even more stringent

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14. For short-lead time fuels such as gasohol this action does not appear to be calamitous, especially since its potential volume in the U.S. is not significant. Gasohol in January 1981 for 31 U.S. states was 39,148,000 gallons equivalent to .45% of petrol for all 50 states. The January '81 figure, however, is a 34.6% increase since January 1980. (U.S. Department of Transportation Monthly Motor Gasoline Reported by States January February 1981). This original program was designed to encourage alcohol capacity for blending into gasohol, projecting 700 million gallons in 1982. One Senator believes the projection may not even reach 350 million gallons now.

Table 2 Exhaust emission standards in Australia,
New South Wales and the U.S.

		Emissions in grams per kilometer (gpk)		
		Carbon Monoxide (CO)	Hydro- carbons (HC)	Oxides of Nitrogen (NO _x)
<u>Australia</u>				
1976	ADR27 A Stage 1	24.2	2.1	1.9
1978	ADR27 A Stage 2	22.0	1.91	1.73
1976	NSW Reg 22(1)(f)	24.2	2.1	1.9
1981	NSW Reg 22(1)(f)	18.6	1.75	1.9
1985	NSW Reg 22(1)(f)	9.3	0.9	1.9
<u>United States of America</u>				
1975/76		9.32	0.93	1.93
1977/78/79		9.32	0.93	1.24
1980		4.25	0.25	1.24
1981/82/83		2.11	0.25	0.62
1985				0.20

Note: reducing HC is more practical and cost effective than reducing NO_x
Source: Motor Trades Association, March 1981, 28.

requirements for New South Wales. (15) These requirements will be especially difficult to meet for large diesel cars. (16) While a number

15. Care must be taken in comparing standards between nations since the driving cycle varies. The U.S. 1983 figures compatible with the driving cycle proposed for NSW 1985 standards would be 12.88 (CO), 1.05 (HC) and 1.9 (NO_x). In the U.S., given the current administration's path of deregulation, the 0.2 NO_x figures for 1985 is doubted to apply.
16. In March this year the U.S. National Commission on Air Quality recommended diesel vehicles be allowed to meet .94 gpk instead of 0.62 gpk of NO_x standard through to 1984, when technology should be available to permit the larger diesels to meet 0.62 gpk level and small diesels to meet the 0.259 gpk level (Automotive News, March 9, 1981).

of proposals are being considered to meet the 0.62 gpk standard (for example, Lucas CAV propose more precise injection and exhaust gas recirculation), the only feasible options for accommodating 0.2 gpk are downsizing vehicles and engines, electronic control systems for diesel fuel injection, continuing research into how particulate levels relate to the pattern of total emissions, and turbocharging. The current prechamber diesel may be widely replaced by a direct-injection diesel, the most efficient internal combustion option available; however, it will be expensive to perfect.

In recent years, however, the gap in economy between petrol and diesel engines has been considerably narrowed by petrol engine improvements, according to Joseph Lucas Ltd (Automotive News, March 16, 1981, E-14); Agnew (1981, 5) of General Motors however suggests a 25% kilometres per litre advantage for a diesel engine than a comparably-powered petrol engine up to 1985. Petrol designs on the drawing boards of other manufacturers and their lower particulate emissions level and production costs may threaten the diesel's future. It appears that the real future for diesel in automobiles will be wide cut (very degraded) and more variable fuels, for use in an engine independent of both octane and cetane number, the latter a measure of delay period after diesel fuel is injected into a cylinder and its ignition.

The Senate Standing Committee on National Resources in Australia (SCA) (1980) suggest 'two reasons for avoiding any large scale switch to diesel vehicles': (a) emissions of carcinogens¹⁷; and other emissions which increase susceptibility to bronchitis, asthma, pneumonia and emphysema; and that smog created by diesel exhaust may be a greater problem than cancer; (b) the yield of middle distillates (e.g. diesel) from a barrel of Australian crude oil is lower than that of petrol. Since diesel fuel is already a premium fuel in other uses it is not considered advisable to develop a significant additional market for diesel until refining strategies have been resolved.

Refining strategy is a key parameter in the fuel options debate - fuel quality could begin to deteriorate significantly in the mid 80s (Heywood and Wilkes 1981); the liquid hydrocarbons from which future petrol and diesel fuel will be made (whether petroleum in the short-term or oil from shale, coal or tar sands in the long-term) are likely to contain increased quantities of impurities such

17. For a detailed analysis of the potential environmental consequences of the light duty diesel see Johnson et al., 1979.

as sulphur and nitrogen. This might work in favour of the predominating fuel, petrol. However, pressure to reduce octane rating of petrol to increase the yield from crude oil (and hence reduce energy used in refining) could shift the emphasis to engines with less demanding fuel requirements, such as the direct-injection stratified-charge, the gas turbine and the Stirling engine. Gasohol is a less technologically ambitious route to multiple-fuel capability engines.

Gasohol

Gasohol is a mix of 90 per cent unleaded gasoline and 10 per cent ethylalcohol (National Geographic 1981, 23, Bevilacqua et al., 1980). It has been used to describe the petrol-alcohol blends successfully used in a growing number of countries, in particular Brazil and France. In 1980 the Brazilian industry manufactured about 200,000 gasohol-fuelled passenger cars, with a goal of 400,000 by end of 1981 and a total switch to alcohol fuels by the year 2000. Whereas Brazil's additive is ethanol (derived from its abundance of sugar cane), France is going the methanol route because of its resource advantage. By 1985 France plans the nationwide availability of carburol, a synthetic fuel ingredient as a maximum 10% additive to petrol. The government has budgeted \$A350 million for methanol conversion of coal, producing 0.5 million tonnes of methanol, one-third of the estimated 1985 requirements. A fleet of 500 cars will be mobilised in 1981 to test the gasoline/carburol mixes of all types under a variety of real life conditions. The California Energy Commission has recently decided to develop methanol as their alternative fuel for many uses. Ethanol, produced from renewable resources (fermented crops), requires expansive agricultural land and has effluent producing distilleries. Methanol, more favoured by the oil companies, can be derived from coal or natural gas. While Australia is well suited to both blends, the coal-route is likely to be surrounded by the environmental controversy embedded in the future of coal.⁽¹⁸⁾ In spite of this, the State of Victoria (Australia) is to construct a coal-to-oil plant with an annual production of 3 million tonnes of petrol diesel fuel and chemical feedstock. The SCA (1980) recommends a 'comprehensive research project covering all aspects of the actual use of alcohol blends under Australian conditions', including the issue of optimum use of agricultural land and the appropriateness of

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18. For example, in the U.S., the coal industry has traditionally been a backward industry, which must suddenly be transformed into a modern, technologically advanced one. Potential users are unwilling to commit themselves to coal especially because of the uncertainty about meeting environmental requirements (Stobaugh and Yergin 1979).

various tax-cum-subsidy schemes. The SCA believes that there is no evidence to suggest that methanol or ethanol production will have a significant price advantage over petrol in the foreseeable future. Many sources argue that if alcohol is to have a future role, it is via the alcohol-to-petrol route (avoiding the distribution and driveability problems) than the alcohol fuel adaptation route.

Electric and hybrid battery-sourced cars

The arguments that the future of the electric car is conditional on the successful development of an improved light weight advanced battery are well documented (e.g. Hamilton, 1980; Singh et al., 1980). However, despite the known technological challenges, current travel patterns make even the currently available battery-driven cars a feasible option for the majority of urban trips. Barriers to overcome before the electric car (EC) or hybrid car (HC) can demonstrate their potential competitiveness as city cars include range limitation, production scale (which affects the price per car) and inadequate consumer exposure to the product. The proposed vehicle designs are as stylish as current petrol-fuelled vehicles (Dance 1981). The price of ECs in the U.S. is not competitive; the Jet Industries' EC costs \$US11,500. In the U.K., a 1524 kg payload is £8160, 50% above current petrol car price. However, the ECs running costs are 50% lower (Dance 1981, 16). In mid-'81 in the U.S. there are 61 organisations using 628 U.S. DOE demonstration project ECs or 1003 including orders and contract funds, supplied by 10 manufacturers. These are mainly light commercial vehicles; however, attention has recently been turned to the household car market, with firms agreeing to sell or lease ECs to households (and small businesses). Potential EC manufacturers and risk capital investors are monitoring the 'project' although the scrapping of U.S. DOE demonstration project has placed an air of uncertainty over the future direction of such incentive schemes. Detroit Edison plan to lease 15 ECs to employees as part of its participation in the U.S. Department of Energy's electric and hybrid vehicle demonstration program. In the U.K. the Department of the Environment has given a matching grant to Lucas-Chloride of up to \$US2.3 million per year over the period '81-'86. Most major Japanese manufacturers are also developing electric-drive versions of existing cars, with government blessing and support.

Service leasing, whereby new cars are supplied to business clients and charges applied only for their use rather than for the cars themselves is one way of promoting the EC at relatively little cost to the consumer. A Los Angeles Rent-a-car firm provides an opportunity for the potential owner to evaluate the EC. The first round of ECs, however, are unlikely to have similar characteristics (e.g. speed, luxury) to conventional company cars. Any demonstration

program should be directed initially towards the population who use small/medium size cars. Electric cars are not more energy efficient than conventional cars, but they may save petroleum if their electric recharge power is generated from power plants that do not burn oil (Singh et al., 1980, Appendix C). In countries such as Australia and the U.S., the resources to produce electricity are mainly non-oil. In the U.S. (19) in 1980 - Coal = 48.8%, Oil = 12.0%, Gas = 15.3%, Hydro = 12.5% and Nuclear = 10.9%. In Australia for '79-'80 (Australian Department of National Development and Energy, 1980, 49) coal = 84.6%, oil = 2.9%, gas = 7.3% and hydro = 5.2%.

Hamilton (1980a) predicts that future ECs can reduce petroleum consumption 75% or more for each unit of conventional vehicular travel they displace if recharged from non-oil burning power plants. Significant total petroleum savings will require large-scale use of ECs. Studies on the potential market share penetration (20) for ECs (Morton et al., 1978; Dickson and Walton, 1977; Marfisi et al., 1978; Bevilacqua et al., 1979; Singh and Bernard, 1979; Kulp et al., 1981) summarising SRI A. D. Little, Mathtec and Argonne National Laboratory suggest a range of consensus of 0.3% - 16.5% by the late 1990's. The range is based on varying assumptions on EC range (80-200 kms), petrol price (18 ¢/l - 66 ¢/l in '78 prices), petrol availability (low - high), EC purchase price (\$US5200-\$8400 in '78 prices) and ECs role as only the second or third household car or as the first car. From the 'evidence', the effect of the introduction of ECs on the reduction in petrol consumption could be marginal or significant. One of the key influences on the likely impact is the complete dependence on a single (non-petrol) source. A preferred (partially battery-sourced) vehicle is the hybrid car.

19. Importantly, in the U.S., if ECs require additional electricity utilities, then the oil-fired facilities will be restarted. These are the first to shut down in periods of low demand, the period when battery recharge is likely to occur. The Electric Power Research Institute claims that as many as 13 million ECs could be regularly charged by American electric utilities by the year 2000 without increasing the need for electricity generating output. These cars are predicted to save 100 million barrels of oil per year. To ensure recharging late at night, appropriate incentives will be required otherwise early evening recharging is foreseen.
20. Not to be confused with studies which identify the EC market, (Gunde (1981), Booz Allen, GRC and Brookhaven National Laboratory 'Applicability models' as reported in Kulp et al., 1980, 2-59 to 2-61) that segment of the automobile market for which ECs could potentially replace ICE vehicles given current and/or predicted driving and trip-making patterns.

A major limitation for the EC as currently promoted, is that its driving range limits it to local trips. To alleviate this restriction (which in the future might be eliminated by advanced battery technology), the hybrid car (HC) has been proposed.⁽²¹⁾ An HC has both an electric motor and a small petrol engine, offering the full mobility of a conventional petrol powered car but with reduced fuel consumption. If HCs are price-competitive with the conventional car then the HC's unlimited range will probably capture a larger share of the auto market than ECs. The petroleum conservation potential is much greater than ECs, given the greater market potential.⁽²²⁾

The hybrid car program is likely to progress swiftly in Europe and Japan; however its future is less certain in the U.S., where President Reagan has proposed scrapping Federal budget support for the EC and HC demonstration programs (along with the Stirling and Brayton engine programs). The U.S. DOT has asked Congress to eliminate funding for the cooperative automotive research program for a total savings of \$US87 million. This is based on the premise that automobile companies know best what kind of research to undertake and that given other demands on Federal resources it is inappropriate for the Government to finance long-term research to benefit a particular industry (Transportation Consumer 1981). There appears, however to be a good case for government subsidy in a program characterised by information costs, political and environmental externalities and an oligopolistic market. The immediate future in the U.S. for the HC appears to be in the hands of the auto manufacturers, who currently are reappraising their position in relation to all automobiles. With the globalising of the auto industry, it might be predicted that HCs, on currently predicted support, will be imported into the U.S. when the market seems ready.

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- 21 Two classes of HCs are possible, a series HC which employs a petrol engine to drive a generator which charges the battery system, and a parallel HC in which the petrol engine and the electric system are both coupled directly to drive the wheels (see Singh et al, 1980, 14).
 - 22. This is more likely for the HC than the EC since size and cost of propulsion battery may be reduced because very long electric range is not required, offsetting the cost of an ICE (Hamilton and Curtis, 1979). Dance (1981) quotes for U.K., approximately 40% of EC purchase cost is in batteries, excluding charger. Singh et al. (1980) argue that HCs will not be price-competitive with the ICE.

Weiner (1981) argues that through the '80s increased fuel economy combined with rising petrol prices and other out-of-pocket costs will result in reduced operating costs. However in the 1990s petrol prices are predicted to overtake fuel economy improvements with operating costs again rising (Weiner 1981, Figure 9). It is at this time that the HC may be a serious alternative. Singh et al., (1980) however are somewhat pessimistic about the future of ECs and HCs up to the year 2000. In a major study for the U.S. DOE they conclude that such cars will not compete on lifecycle cost, given consideration of all battery technologies likely to be commercialised. The high cost of battery replacement (every 2-3 years), less performance than the ICE car (especially in hilly urban areas and cold climates), and range limitations, suggests little likelihood of one-car families acquiring them, and limited likelihood of multi-car families purchasing a relatively expensive second car.

CONSERVATION ENERGY - THE UNGLAMOROUS FUEL OPTION

Energy conservation is a largely untapped 'source' of energy, with many immediate opportunities, and may well be the least expensive, safest and most productive energy readily available in large quantities. It entails behaviour modification in contrast to the 'technical solution approach'. Stobaugh and Yergin (1979, 11-12) suggest that conservation could perhaps 'supply' up to 40 per cent of America's current energy usage, although they do not predict that it will. Such an achievement would require a consistent set of signals, higher energy prices in particular, incentives, regulations and information. Clearly the barriers to conservation are great, rarely technological, often economic but in most instances institutional, political and social (Johnson and La Belle 1981).

As a quality energy source conservation does not undermine international monetary systems, does not pollute, and stimulates innovation, employment and economic growth (Yergin 1979; Harris and Davies 1981).⁽²³⁾ Conservation lacks glamour because of the small scale, decentralised nature of most of the projects. And it also lacks the appearance of dramatic impact: its effects are spread out over the whole economy, and difficult to observe; the drama and appeal of a giant fuel plant are absent.

23. For some years it was argued that there is a strong positive (one-to-one) relationship between energy use and GDP. Recent studies of industrialised nations have disputed this claim, suggesting that although energy use and GDP are certainly not independent, the relationship is more variable than commonly assumed (Myers, 1975)

Lave (1980) illustrates the potential of decentralised conservation schemes for saving energy. Rather than imposing an 89 kph speed limit on all drivers - which has only produced a 2% energy saving in the U.S. (see Bates and Roberts 1981b for European evidence) - he proposes a differential speed limit: big cars are limited to 89 kph but fuel efficient cars are permitted to travel 104 kph, traffic permitting. The idea is to create an incentive for people to switch to fuel efficient cars. Since two decades of mode split research have led to the conclusion that, 'the fastest mode gets all the people', Lave argues that the behavioural incentives to switch cars would be very powerful. (24)

Lave also examines the benefits of small cars versus giant rail systems in the context of Los Angeles travel patterns. He shows that the money intended to build a rail transit system in Los Angeles would be sufficient to give away free fuel-efficient commuter cars to all freeway travellers in Los Angeles. (Actually, it would only require about 20% of the amount required for the rail system). And the end result of using these cars would be a vastly greater savings of energy, as well as a reduction in smog and congestion. He calculates yearly savings of 347 million gallons of fuel, and \$300 million of reduced travel time. These applications of Lave's Law of large proportions, 'the biggest components matter the most', while somewhat unglamorous, compared to, say, extensive electrification of the rail network (25) are good economics and have good potential for conservation of energy.

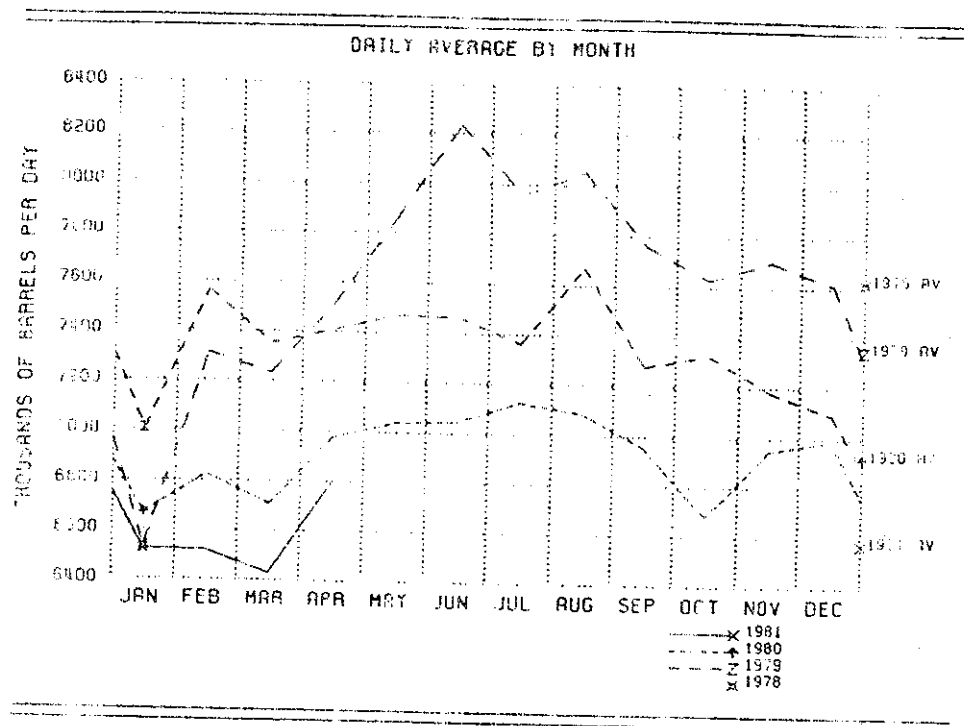
Conservation usually takes time; it is a long-range initiative to alter energy use behaviour. It contrasts with contingency planning/strategies which are short-term coping strategies or stop-gap responses to energy shortages (such as petrol rationing) (Transportation Research Board 1980).

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- 24. Energy Undersecretary Sawhill, in the Carter administration, was supporting this scheme as well as one that would have permitted intercity buses to travel at 112 kph (70 mph) on the interstate highway system: by giving the buses a travel time advantage over cars, a significant proportion of car trips would be diverted to buses.
 - 25. The Sydney-Melbourne electrification proposal has been described as 'an excellent example of the pursuit of 'dramatic' solutions to this country's energy problems at the expense of less glamorous but more productive approaches' (Australian Senate Standing Committee on National Resources, 1980, 21).

Initial attempts at behaviour modification began in 1973 after the OPEC oil price increases. It has taken nearly a decade for some real effects to be observed; (26) however, the evidence on the contribution of behaviour modification vis-a-vis technology modification is not yet fully documented. Chen et al, (1981) have recently analysed the change in fuel economy from 1979 to 1980 model year vehicles in the U.S. They conclude that 65% of the fuel economy improvement is due to technological change and 35% to sales shift; with 60% of the sales shift improvement due to within size-class shifts. 20 per cent of total fuel economy improvement is attributed to consumer selection of more efficient models within the same size class. In the U.S., where large and luxury vehicles were the rule rather than the exception, we note (using EPA automobile classification):

- (1) an 8% decrease in petrol consumption between 1979 and 1980; in February 1981 a decrease of 7.4 per cent in comparison to February 1980.
- (2) an annual reduction in 1980 in daily barrels of oil consumed, by 475,000 (or 6.4%) (Figure 4). Patterson (1981) has produced some evidence that from a nationally representative sample 30% indicated they had reduced their motor fuel use, and 20% had increased their use over the last 12 months (since Spring 1980); the most important method used to accomplish this being 'fewer trips' (41%) followed distantly by increased fuel efficiency (14%). When this evidence is combined with the conclusions above by Chen et al. (1981), it is tempting to conclude that behaviour modification is having a significant influence on energy conservation. However, even if this were a correct interpretation of the 'fact', there is still enormous unrealised energy savings from further behaviour modification.
- (3) The subcompact (e.g. Toyota Corolla, Honda Accord) share increased by 33% between September 1979 (30%) and September 1980 (39.9%) with a high of 41.2% in August 1980; although since then it has dropped back to 31.6% of the market share at April 1981 (with a period high of 36.5% at February 1981) (Chen et al. 1981) This decline in market share, was taken

6. Up to late 1970s this period was technologically constrained. An example of how market forces can work against technological modifications conserving energy is the recent introduction in the U.S. of premium octane lead-free fuel (96 RON) and the increase in standard grade to 92.5 RON as a consequence of engine knocks, due to lead-free petrol with a low octane rating. This has a detrimental effect on crude oil consumption, increasing the demand for more OPEC oil. The average lead-free petrol quality is now 93.5 RON (compared in the 1975 agreement).



Source: U.S. Department of Transportation (1981a)

Figure 4. U.S. Sales of Motor Gasoline

up by compact (e.g. Ford Granada, Peugeot 504) and midsize (e.g. Ford Fairmont, Dodge Charger), each capturing approximately 50% of this subcompact reduction. The compact, however, has gained significantly since September 1980, a 121% market share increase (from 7.2% to 15.9% in April 1981). This is accompanied

by an 8.64 kpg fuel economy improvement, a 19% increase from the previous model year. (27)

- (4) The combined fuel economy of domestic and domestic-sponsored cars in August 1980 showed a 4.32 kilometres per gallon improvement over the end-of-year 1979 level. The eight months up to April 1981 showed an improvement in model year 1981 autos fleet fuel economy of 3.36 kilometres per gallon; due mainly to domestic autos which increased by 8.7% (3.36 kpg) in fuel efficiency, while imports improved by 5.4% (2.56 kpg). Although large cars made only marginal improvements in fuel efficiency (31 kpg to 33.4 kpg) their market share dropped by 45% up to March 1981.
 - (5) Table 3 shows the downsizing effect for domestically-produced and total automobiles; and the implied fuel savings concomitant with such a downsizing. (28) New car registrations in 1980 were down 12.0% on 1978. This is the lowest since 1975. For new imported cars, registrations in 1980 were at an all-time high.
 - (6) by the end of 1980 'vehicle kilometres travelled' (VKT) had declined 6 per cent from its high in mid-1979 (Weiner 1981).
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27. During late summer 1979, winter 1980 and the early months of 1981 (up to end of April), rebates were offered in the U.S. to purchasers of new domestic vehicles. For example, the GM rebate between March 20 and April 4 to customers was \$500 - \$700 on particular models with dealers contributing \$300 of the \$700 and \$200 of the \$500. The previous rebate had yielded car sales 20% higher for GM than expected, and demonstrated that 'price concessions move cars'. Sales leaped 30.3% both on a year-to-year daily rate basis, although for GM it was costly - \$50 million on rebates and \$35 million for GM dealers. The rebates helped to shift the less than optimal (60-day is viewed as optimal) inventory, which reached a high of 78½ days in February 1981 (Automotive News, February 16). A study by Crafton and Hoffer (1980) shows that while new car dealers do pass manufacturer rebates forward, they only pass, on average, 25% of it forward to consumers (Automotive News, February 16).
 28. Mellman (1981) suggests that the changing demographic structure of households in the U.S. is a contributing influence on downsizing. The increase in households with one or two persons tends to reduce the constraint on their vehicle choice by functional needs. This flexibility allows their purchase patterns to be quite volatile in response to changes in influences such as fuel prices. This implies in the U.S. that subcompact's market share may already be approaching saturation point. Cheslow (1980), however, concludes that when changing demographic trends are taken up to the year 2000 (using the projections of the number of households and families up to 1995 of U.S. Bureau of Census and extrapolation to 2000 from 1990 to 1995 trend), the mix of cars by size class after 1979 remains nearly unchanged. Further research is required to disentangle the complex causal relationships.

TABLE 3

NEW CAR REGISTRATIONS BY PERCENTAGE^c OF EPA SIZE CLASSIFICATION,
MODEL YEARS 1965-1981^a - U.S.

T = domestic and imported autos
D = domestic autos only

Model Year	Minicompact		Subcompact		Compact		Midsize		Large		Two-seater		Fleet ^b	Import penetration (%) ^d
	T	D	T	D	T	D	T	D	T	D	T	D		
1965	4.5		9.4		11.3		21.0		53.1		0.7		9,332,612	
1966	4.5		9.2		9.5		23.6		52.3		0.7		9,035,116	
1967	4.8		10.6		8.5		23.4		51.8		0.7		8,348,463	
1968	5.6		10.8		8.1		24.1		50.7		0.7		9,404,039	
1969	5.4		11.1		8.3		24.2		50.0		0.8		9,450,142	
1970	5.5		11.6		9.8		23.3		48.9		0.9		8,395,896	
1971	5.6		12.7		11.0		21.9		47.7		1.0		10,239,462	
1972	5.2		14.2		11.8		21.4		46.2		1.1		10,937,698	
1973	5.4		14.7		11.3		22.6		44.9		1.1		11,384,576	
1974	5.9		14.7		11.3		23.7		43.3		1.1		8,740,893	
1975	7.5		17.0		24.3		23.5		25.7		1.8		8,627,883	
1976	8.6		18.9		24.1		21.5		25.0		2.0		10,099,168	
1977	7.2		16.2		25.7		21.7		27.4		1.7		11,175,087	
1978	10.0	5.6	21.8	12.3	14.4	16.5	30.8	39.1	20.5	26.0	2.5	0.4	11,308,078	
1979	6.0	3.6	29.9	22.7	8.3	8.2	34.2	41.3	19.6	23.7	2.1	0.4	10,813,527	17.6
1980	4.5	3.3	37.4	26.2	6.6	6.4	34.2	44.1	15.0	19.4	2.4	0.5	9,833,404	22.9
1981	3.6	1.1	32.4	20.1	13.3	14.8	36.3	47.5	12.2	16.0	2.2	0.5	5,272,584	23.6

- a. 1981 data are from October through April.
- b. Fleet figures are obtained from Ward's Automotive reports except for 1980, 1981, which are from Chen et al. (1981). These figures are higher, in comparable years, than figures reported in Chen et al. (1981, Table 2), the latter represents only sales that could be mapped to correspond to EPA fuel economy values. 1978 is a disturbing year, with Ward's Automotive figures significantly different from Chen et al. by 3,122,215 automobiles.
- c. The percentage market shares for 1978 to date relate to the EPA compatible sales; given in Chen et al. (June 1981, Table 2).
- d. These figures, based on Chen et al. (1981) are lower than Automotive News figures (e.g. '79 = 24.52%, '80 = 26.41%). A further set of percentages are given in the Subcommittee on Trade report which indicate 21.9% for '79. Much of the differences can be explained by the exclusion in Chen et al. of sales which do not map into EPA fuel economy values.

Sources: U.S. Department of Transportation National Highway Traffic Safety Administration, *Automotive Characteristic Historical Data base*, and Chen et al. (June 1981, 4) or *Automotive News* (various issues)

A preferred unit of analysis, however, in the context of household energy conservation is household kilometres travelled (HKT) (as also discussed earlier). This defines the true conservation effect rather than any possible structural changes to the population/economy as a whole. The Michigan Survey Sample analysed by Mellman (1981) reported an increase of 166 HKT between '77 and '80, whereas the VKTs declined by 1923 km

Conserving energy is desirable if it assists 'the necessary transition to an economy based on renewable sources of energy (which) will or would be much smoother and less troublesome than if we carried on rapidly using up the non-renewable sources of oil' (Mogridge, 1981, 3).

COMPANY CARS - A MAJOR GROWTH SECTOR

Until recently the company car sector was not seriously viewed as different from the household car sector in terms of energy consumption. An extensive search of the literature found no substantive evidence of an interest in the company car sector prior to 1978 (Cooke 1978) except by national executive societies wishing to establish guidelines for organisations in setting the 'perk' structure for employees. (29)

In Australia the company car represents only 9% of all cars registered in New South Wales (1978/79); however it represents 44% of all new cars registered in 1979 (or 35% of the new car market for Australia). The company car share of new car registrations in the U.K. varies from a high of 70% (British Institute of Management Foundation 1979) to a low of 44%, the latter from 1979 application forms for new vehicle registrations (where self-employed company cars tend to go undetected). According to a survey of Schou (1981a, 1981b), 70% of the company cars in New South Wales are large cars (weight above 1200 kg, engine size greater than 2.5 litres, 6 or more cylinders, and fuel economy less than 8 kpl) while only 8% are small cars (weight less than 1000 kg, engine size 1.8 litres, 4 cylinders and fuel economy

- 29 After pensioner life insurance scheme contributions by a firm, provision of a company car and coverage of all company car expenses rank second (Hensher 1977, 48-57), accounting in 1973 in Australia for 51% of all income-related benefits. 43.1% of senior management were supplied with a company car (currently 80% in the U.K. (Whitelegg 1981) and 50% in 1977 (Cooke 1978)) with 33% receiving payment for all car expenses. A recent survey of vehicle fleet management in Europe (reported in Whitelegg 1981) gave the following percentages of senior management with company cars: U.K. (80%), Belgium (50%), Netherlands (50%), France (40-45%), Italy (30-35%), West Germany (30-35%), Switzerland (30%) and Spain (30%).

greater than 10 kpl). The average fuel economy is 7.1 kpl, 15% less than the average for all cars. Company cars accumulate more annual kilometres compared to the national average (Schou 1981). The average engine size of company cars in the U.K. in 1979 was 1650 cc compared to 1390cc for all other cars (Potter and Reikie 1980). Studies by Dix and others (1980, 1981) show that the company car is an addition in households owning at least one car, the latter retained after the addition. Although the mean annual kilometres per vehicle is declining in Australia due to increased multi-car ownership per household, the company car appears to partly explain why HKTs are increasing (see previous section).

In the short-term this sector provides significant potential for fuel savings because of the current fleet mix; (30) and the evidence in Australia (Schou 1981) that the average replacement cycle is just over three years. (31)

The increasing visibility of the company car market means that the government must think carefully about any major tax disincentive schemes which could have further serious implications for output, employment and import penetration of foreign-made cars in countries which currently have faltering automobile industries. The suggestion by Mogridge (1981, 17) of reducing the societal subsidy to company car beneficiaries in the U.K. by placing an upper limit on tax relief, was introduced in Australia in 1979 (with a \$19,500 upper limit on the value of a 1981 model vehicle claimable as a tax deduction). The indication to date is that the domestic auto industry has not gained, there being a growth in demand for 1 year old luxury-imported vehicles and extended leases on the imported upmarket cars beyond the normal lease renewal period. (32) This result may be short-term; its long run effect

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- 30. One organisation in Australia, with 350 cars has already succeeded in reducing fuel consumption by 10%, a saving in 1980 of \$150,000, by moving from a situation where less than 1% of its car and light utility fleet had 4 cylinder engines to a position where only 3.5% of the fleet is composed of 6 cylinder and small V8 engines. At the most senior executive levels, engine capacity has been limited to 3.5 litres and fuel economy targetted at 14 litres per 100 km (20 mpg). A 30 per cent fuel consumption reduction is projected up to 1985 by the company. An important outcome of this 'experiment' is that senior executives did not move to other organisations which predominantly supply the more luxurious V8 vehicles.
 - 31. The national average in the U.K. is 3 years, comparable to the company car average in Australia. Is the company car mean in the U.K. less than 3 years? We do not know.
 - 32. Personal communication with George Alto Monte, Vice President Motor Traders Association of New South Wales.

on fuel conservation is unknown. Dix et al., (1981) have calculated the subsidy to the British company car beneficiaries; the figure of £2,000 million per annum being considerably greater than the subsidy to public transport.

Empirical work by Schou (1981a, b) surveying 216 companies in New South Wales suggests that petrol rationing, petrol price increases, an inefficiency tax, and reductions in tax deductibility (where cars do not meet the fuel economy standard of 10 kpl) are all unlikely to impact on the overall demand for company cars, but will influence substantially its fleet composition.

The movement to vehicle leasing, especially service leasing appears to be a response to the costs of acquiring and using a car, in a sense legitimising the tax deductible nature of this asset and flow of consumption services. This is one possible indication of the price responsiveness of society to the increased cost of owning and operating automobiles, and is a mechanism for ensuring that the tax burden is spread across the general population rather than solely the beneficiaries of such a major 'perk'. The company car market could respond very differently to price and policy incentives than the household auto market. There is necessity for research on this topic.

THE AUTOMOBILE, URBAN FORM AND ENERGY

It is often suggested that the automobile has been a prime stimulant to suburbanisation of residential location and decentralisation of activities. This argument claims that some urban forms are more energy intensive than others, especially forms which reinforce the predominance of the automobile, because traffic densities are too low to justify high-capacity public transport facilities. A number of carefully conducted studies have pieced together the empirical evidence to dispute this stance. A most thorough study is that by Small (1981) using the U.S. national travel data and supplementary sources. (33)

Small looked at determinants of intrametropolitan location patterns to identify the possible impact of energy scarcity on urban development patterns in the next 20 years or so. Two scenarios were considered: (a) a high cost situation; tripling of 1977 petrol prices but a stable supply of energy and (b) a severe shortage scenario :

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33. There have been innumerable simulation studies of the transportation energy effects on urban growth (e.g. Romanos et al., 1980); however, the preferred focus is on adjustments from the existing urban form and patterns of use.

unstable supply, intermittent recurring disruptions (34) The results are reported for both work and non-work travel.

For work trips and the high cost scenario, the average household choosing between a city and suburban residence must add an extra \$160 per annum to the cost of commuting if it locates in the city and \$210 if it locates in the suburbs. The differential provides a measure of strength of the net incentive toward centralisation. Alternative adjustments such as smaller cars could reduce this differential even more. For non-work travel the equivalent net incentive is \$113. This is an extremely small effect. For the severe shortage scenario, a land use control which resulted in densities of 15 units per acre compared to the current mean of 5 units/acre would reduce automobile use for work trips by only 1.4% after 6 years.

Thus energy shortage on this evidence is not likely to affect urban development patterns; behaviour modification and technological change in the auto industry are more likely to yield significant reductions in energy consumption. Even without such adaptations, Small concludes that 'the differences in energy consumption between cities and suburbs are relatively modest, and would provide individuals or firms only small incentives to alter their location decisions'.

In reality, the trend in urban development is decentralisation (Button and Pearman 1981, Weiner 1981, Sydney Morning Herald 1981, Bates and Roberts 1981b). In the U.S., 3 million people left the cities for rural and semi-rural areas during the past 10 years, which more than reversed the drift to the cities that occurred in the 1960s. Demographers expect the pattern to accelerate, particularly as more industries are being established outside of metropolitan areas. Inner London lost 16% of its population in the decade up to 1976. These occurrences serve to encourage the further growth of automobile demand. Button and Pearman (1981) provide an excellent overview of this trend. While transport could be used as a planning tool to reshape the destiny of the cities, the urban areas and society, it appears unlikely in the foreseeable future that existing and planned public transport will increase its market share significantly. In the U.S. the automobile accommodates approximately 92% of all person kilometres of travel (Gorman 1978, 137, Table 3); in Australia it is 90% (Department of Transport 1981, 9).

34. Small assumed technological and behavioural patterns determining energy use as those prevailing in the 70s, but used the 1980 mandated average fuel consumption level of 7 kpl (20 mpg).

CONCLUDING COMMENTS

This paper has attempted to identify the directions of change occurring in the production and consumption of automobiles. While the topic is complex, the evidence suggests that individuals without abandoning their traditional dependence on the car, are shifting to smaller, more fuel-efficient cars. They have adjusted to higher energy prices by switching to energy-efficient cars rather than by reducing auto travel. The automobile industry is globalising itself to take advantage of the economies of expertise and the high growth markets in the Third World.

A number of new directions are emerging which serve to enhance the future role of the car. These directions encompass technological change, both in vehicle design and fuel efficiency; industrial restructuring, in particular globalising the auto industry; significant new growth markets for car sales, especially in South America and the OPEC nations; location adjustment of households, such as out-migration from cities; participation adjustments, especially the percentage increase in women entering the workforce and increased licensed women drivers; ownership restructuring of consumption markets in the Western World, especially the growth in company registered cars; and promising substitutes for fossil fuels. While many studies have investigated conservation of energy through behaviour modification, a most obvious source of societal benefit, it is an area of far greater potential than shown to date.

However, while we can be somewhat confident as to the direction of change, we are much less confident about the timing of such change. The wheels are in motion, but the speed of adaptation is uncertain. The timing uncertainty is, more than anything, the cause of much of the concern about the future of the automobile.

NEW CAR REGISTRATIONS BY SIZE OF VEHICLE FOR AUSTRALIA 1966-81

SIZE CATEGORIES ^a						
	SMALL		MEDIUM		LUXURY	
	number	%	number	%	number	%
1966	97746	31.87	198142	64.61	10800	3.52
1967	119631	35.65	205736	61.32	10174	3.03
1968	141914	38.48	217425	58.95	9497	2.57
1969	156752	39.10	235058	58.64	9069	2.26
1970	173829	42.08	230235	55.74	8997	2.18
1971	172173	41.27	236394	56.66	8657	2.07
1972	177965	43.85	218514	53.84	9373	2.31
1973	214001	46.53	235365	51.17	10559	2.30
1974	239173	50.25	223319	46.92	13504	2.83
1975	264699	56.22	192851	40.96	13264	2.82
1976	261196	55.72	194938	41.58	12663	2.70
1977	246903	57.08	165702	38.79	14554	3.41
1978	275744	61.20	160324	35.58	14495	3.22
1979	258547	56.20	188294	40.93	13203	2.87
1980	293592	64.79	148504	32.77	11082	2.44
1981 ^b	70399	65.97	33621	31.51	2694	2.52

Notes: a. These size categories are those of the Industries Assistance Commission, and are adaptations of the ADAPS categories modified as follows: small autos are the ADAPS small plus medium categories plus Cortina 6; medium autos are ADAPS upper medium and luxury categories minus Cortina 6 plus Peugeot 604 plus Datsun 280ZX; luxury autos are ADAPS luxury category.

b. 1st quarter 1981.

Source Industries Assistance Commission, Canberra.

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