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The Effect of Land Costs on the Economics of Urban Transportation Systems

Mark Diesendorf[1]

Abstract

Using Sydney, Australia, as a case study, this paper reports on calculations of the costs of automobiles, heavy rail and buses, taking into account the costs of land, infrastructure, rolling stock, operations and maintenance. Land is found to be the principal contributor to the total direct economic cost to society of transportation by automobile. This total cost of automobile transport, measured in dollars per passenger per kilometer traveled, is about 1.5 times the cost of train travel and is about double the cost of bus travel. All three urban transport modes receive public subsidies. The annual subsidy to automobiles is largest in terms of billions of dollars and second largest (after heavy rail) in terms of dollars per passenger per km traveled. These results suggest that, in Sydney and many other cities where land costs and car use are high, the economic optimal mix of transport modes would contain a smaller contribution from automobiles and a larger contribution from trains and buses.

Introduction

Several years ago a consulting report commissioned by the Australian Department of the Environment pointed out that:

> "Unlike other utilities, roads have not so far been treated as a capital asset which should be required to earn a rate of return. This treatment would recognise not only the capital value of bridges and road pavements, but [also] of the land devoted to roads… The theory of land valuation is that all land should be valued at opportunity cost. Applying this to road land would result in its site value being inferred from the adjacent properties." (NIEIR 1996, Section 2.6).

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[1] Sustainability Centre Pty Ltd, PO Box 221, Epping, Sydney NSW 1710, Australia; fax: +61 2 9801 2986; email: mark@sustainabilitycentre.com.au

In this spirit Banfield, Hutabarat and Diesendorf (1999) examined the effect of land costs on the economics of Sydney's urban transport system. They took public land values for cars, buses and trains from the asset values as estimated by the appropriate transport authorities and estimated private land values (e.g. for parking and driveways) from average real estate values in Sydney. Land values were annualized according to discounted cash flow analysis. This paper revises and extends the study by Banfield, Hutabarat and Diesendorf (1999).

Earlier work in other countries that bears upon this issue was published by Lee (1995), James (1998), Cobb (1998) and Litman (1999). However, by taking national perspectives, these authors and also NIER (1996) underestimated the contribution of land to the costs of *urban* transportation systems. In economic terms, land in major cities is the most valuable land.

Method

The raw data collected by Banfield, Hutabarat and Diesendorf (1999) were reanalyzed. These data were originally obtained from a wide range of sources: census surveys, transport providers/operators, a state government department and a motorists' association. In some cases, city data had to be deduced from state data. Data on private buses had to be deduced from data on public buses.

Assumptions have been tested by using more than one method to make estimates and by sensitivity analysis. Although some primary data were originally collected in the early 1990s, all data were normalized to 1996 to coincide with census data. To enable comparisons between different passenger transport modes, costs were calculated in cents per passenger per km traveled.

Capital costs were calculated for land under infrastructure, infrastructure, and rolling stock (fleet) for each of the three urban transport modes considered: cars, trains and buses. Operating costs were obtained for system administration and maintenance and for fleet operation and maintenance, including fuel and labor. However, the costs of traffic policing and security on trains have not yet been included.

Sensitivity analyses were performed for the value of the discount rate and the economic lifetimes of the various assets. The other key assumption, which was also subjected to sensitivity analysis, was on apportioning the costs of construction and maintenance of roads between automobiles and heavy vehicles. The calculation considered three cases:

- *Force*, in which these costs are determined mainly by heavy vehicles;
- *Flow*, in which these costs are determined mainly by the volume of traffic and hence by light vehicles, which make up 80% of traffic; and
- *Flow&force*, an intermediate case between the two extremes of *Force* and *Flow*, in which it is recognized that different roads are built to different strengths. In

this case the costs of major roads were determined mainly by heavy vehicles and the costs of minor roads were determined mainly by light vehicles.

Table 1: Total costs by mode, Sydney 1996

Mode ← / Cost type	Cars $M	Buses $M	Trains $M
Asset values annualized at discount rate = 7% real			
A. Value of land	7857	47	151
B. Value of infrastructure	2531	69	570
C. Value of fleet	2877	25	110
D. Operating cost	6150	534	688
E. Annualized cost ($M) E = A+B+C+D	19415	675	1519
F. Million passenger-km traveled (Mpkt)	31615	2452	3921
G. Annualized cost (c/pkt): G=E/F	61	28	39
Asset values annualized at discount rate = 10% real			
A. Value of land	10088	60	194
B. Value of infrastructure	3250	89	732
C. Value of fleet	3221	31	147
D. Operating cost	6150	534	688
E. Annualized cost E = A+B+C+D	22709	714	1761
F. Million passenger-km traveled (Mpkt)	31615	2452	3921
G. Annualized cost (c/pkt) G=E/F	72	29	45

Note: These results are for the *Flow&force* case. It is assumed that the lifetimes for land, infrastructure, car fleet, bus fleet and train fleet are 25, 25, 8, 20 and 35 years respectively. Results are in Australian dollars: 1 AUD = 0.52 USD in September 2001.

Results

The results for the *Flow&force* case (Table 1) show that the direct economic cost to society of urban transport by automobile, measured in cents per passenger per kilometer traveled, is about 1.5 times the cost of train travel and about double the cost of bus travel.

The result is conservative in the sense that most of the costs that have been omitted so far will fall more heavily on automobiles than on transit: e.g. traffic policing, the uncompensated medical and hospital costs from crashes, and the quantifiable parts of the costs of air and water pollution.

While the *Flow* and *Force* cases (not shown here) give respectively larger/smaller ratios of the cost of automobiles to buses, the qualitative result, that cars are more expensive than the other modes, is the same in each case (1). In the *Flow&force* case the costs of land are about 40 per cent of the total cost of automobiles. In all three cases land is the largest contribution to the cost of cars.

To evaluate the subsidies to each mode, the total costs are disaggregated into those paid publicly and privately. The payments by users to compensate (partially) for public expenditures on their transport modes are evaluated (see Table 2). For cars, the user charges are taken simply to be the registration charges, tolls and licence fees for vehicles, charges for public parking and the excise (tax) on fuel (2). The user charges for transit users are simply the costs of tickets. Table 2 shows that all three modes of urban transport are subsidized. In cents per passenger per km traveled (c/pkt), the largest subsidy goes to trains, followed by automobiles and then buses. But, in absolute terms, by far the largest subsidy goes to automobiles, because of the very large number of passenger-km (pkt) they generate, followed by trains and then buses.

Discussion

In Sydney, Australia, the total direct economic cost of transport by private motor car, measured in cents per passenger per km traveled, is greater than that of train travel which is in turn greater than that of bus travel. This qualitative result in not changed when sensitivity analyses are carried out, varying assumptions about the split in road costs between cars and heavy vehicles, the lifetimes of assets, or the discount rate. Similar results are expected in all cities where land values and automobile usage are high.

The importance of land costs suggests the need for a more efficient use of urban land and hence more emphasis on transport modes that use land efficiently.

It cannot be concluded from the relative subsidies that it is better in economic terms to continue to build infrastructure that will encourage people to drive cars rather than to use trains. This is because the cost of each mode in c/pkt depends on the infrastructure, land, rolling stock and service frequency/quality provided for each mode. This is a non-linear system. If, for example, the railway system were to be improved in an appropriate manner, demand would increase and the cost of train travel in c/pkt would decline. This is supported by data on the geographic distribution of transit use in Sydney, which shows that in local government areas with better-than-average transit infrastructure and service, there are substantially higher levels of transit use (Hutabarat et al., 1999).

Table 2: Calculation of subsidies by mode and discount rate, Sydney 1996.

Mode ← / Cost type	Cars $M	Cars c/pkt	Buses $M	Buses c/pkt	Trains $M	Trains c/pkt
Asset values annualized at discount rate = 7% real						
A. Value of public land	2719		47		151	
B. Value of public infrastructure	1012		69		570	
C. Value of public fleet	0		12		110	
D. Public operating cost	2267		268		688	
E. Public component of annualized cost E = A+B+C+D	5998	19	396	16	1519	39
F. User charge to offset part of public cost	1200	4	295	12	368	9
G. Public subsidy G = E-F	4798	15	101	4	1151	30
Asset values annualized at discount rate = 10% real						
A. Value of public land	3490		60		194	
B. Value of public infrastructure	1300		89		732	
C. Value of public fleet	0		15		147	
D. Public operating cost	2267		268		688	
E. Public component of annualized cost E = A+B+C+D	7057	22	432	18	1761	45
F. User charge to offset part of public cost	1200	4	295	12	368	9
G. Public subsidy G = E-F	5857	18	137	6	1393	36

Note: This table assumes the *Flow&Force* case and that the lifetimes for land, infrastructure, bus fleet and train fleet are 25, 25, 20 and 35 years respectively. Decimals have been rounded to the nearest whole numbers. Results are in AUD: 1 AUD = 0.52 USD in September 2001.

There is an additional a public subsidy to cars that cannot be calculated from the existing data. It arises from part of the privately paid costs. Not all of the privately paid costs of automobiles are paid by motorists -- for instance, free or subsidized off-street car-parking at work locations and shopping centers. The portion of these parking costs that is not paid for directly by users is passed on to all purchasers of the goods and services sold by the workplaces and shopping centers. In particular, shoppers that travel to shopping centers by public transport subsidize shoppers who drive to the mall. This brings out some of the complexity of the system of subsidies that encourages people to drive cars.

Other direct economic costs, that have not been included in this study, are the costs of traffic policing and the uncompensated medical and hospital costs from crashes.

There are also indirect economic costs to be considered. For instance, road building encourages urban sprawl, which in turn leads to higher costs of infrastructure at the fringe (Guhathakurta, 1998).

Environmental and health costs of driving motor cars include the costs of air and water pollution and greenhouse gas emissions. Part of these costs has been calculated by Soerensen (1997, 2000). In the case when the value of human life is taken to be US$3 million globally and is not discounted, Sorensen (1997) calculated that a fair tax level, reflecting such external costs, would be a vehicle tax of US$4000 and a kilometer-driven component of about US$5 per liter of fuel.

While direct evaluation of economic costs shows that the urban transport systems of Sydney and similar cities are not economically optimal, it does not give the actual optimal mix of modes. For this an optimization method has to be utilized.

In conclusion, the tendency of many urban/transport planners to assume that the private motor vehicles will and should be the primary mode of urban passenger transportation may need re-examination. Our results suggest that, in Sydney and many other cities where land costs and car use are high, too much money is being invested in providing for automobiles and too little is being provided for transit. Australian and US cities provide the largest road and parking areas per capita in the world (Newman & Kenworthy, 1989; 2000). An economically optimal urban transport system would reduce these areas while increasing the amount of land and infrastructure available to transit and possibly to walking and cycling.

Further research in other cities is required to calculate optimal allocations of land among transport modes, including light rail, walking and cycling, and between transport and non-transport purposes.

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Endnotes

(1) Specifically, for the *Force* case, total automobile cost is estimated to be 55 c/pkt and total bus cost 33 c/pkt; for the *Flow* case, total automobile cost is estimated to be 66 c/pkt and total bus cost 24 c/pkt. Train cost is the same in all three cases, 39 c/pkt. These results are for a discount rate of 7%.

(2) In Table 2 we have corrected an error made in Banfield, Hutabarat and Diesendorf (1999, Figure 11), which mistakenly includes in the user charges the non-excise component of fuel cost as well as the excise.