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EC3382 – Term Report

10b: What are the factors affecting car ownership? Is it possible to reduce the rate of growth of car ownership?

Group Details

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1. Introduction

1.1 Overview

Car ownership is a double edged sword. In many countries, the increase in car ownership signals a certain form of wealth. China's recent uptake in the number of cars households own has been lauded as an increase in domestic consumption, symbolic of the increase in household incomes. Yet, in more developed countries where car ownership is a norm, car ownership has presented a wealth of problems from positive considerations such as the loss of time value to normative ones that argue for social considerations. Other social costs like pollution have been continual thorns that have plagued automobile dependent countries. Yet, the drive to reduce car ownership has been long and arduous with many economic policies not bearing their expected fruits.

1.2 Thesis

We firmly believe that the rate of car ownership can be reduced. This can only be done if all solutions deployed are unique to the level of development of the specific area. Secondly, solutions cannot be offered on a standalone basis. A basket of solutions must be carried out to ensure success in reducing the rate of car ownership.

1.3 Scope & Structure

It is on the platform that this paper begins studying factors that affect car ownership (Part 2). Ingram and Liu's Determination of Motorization and Road Provision (1999) provides a good starting point for our analysis and throughout this paper we will be assessing and evaluating more recent literature specific to the above mentioned categories.

With these factors in mind, this paper will propose all possible measures to reduce the growth of car ownership (Part 3). These include reducing the benefits of car travel, increasing the viability of substitutes, the importance of land use methods and the role of technology.

This is not a new field of study and many papers have covered this topic in detail. However, we recognize that the value of an economic analysis is specific and unique to the area it was performed at. It is with this belief that we will propose solutions unique to the level of development based on the factors covered in Part 2.

In the level of development, we look first at more developed countries followed by why and how less developed countries should adopt car ownership reduction measures. Less developed countries have been late to the table in reducing car ownership on the whole. This is due to the assumption in LDCs that automobile orientated transport systems are 'desirable and inevitable'. (VTPI, 2010) Nevertheless the process has been started and is slowly gaining clout in LDCs. The many solutions that MDCs have adopted in varying levels of success can be replicated in LDCs, especially the more fundamental ones that need a complete developmental and planning focus to limit and reduce car ownership.

Due to the limited literature available on LDCs and the disparity in reducing car ownership between developed countries and less developed ones, this paper will focus on the various methodologies that have been adopted by MDCs. The few less developed countries that have taken control measures will also be highlighted as case studies.

2. Factors Affecting Car Ownership

2.1 Income

Income is the primary determinant of auto ownership, which, in turn, is the main determinant of modal choice. Increased income obviously makes cars more affordable. In the US, auto ownership increases most rapidly over incomes ranging from $20,000 to $39,999 (Pucher and Renne 2003). While 26.5% of households with incomes less than $20,000 have no motor vehicle at all, only 5.0% of households in the next highest income category ($20,000 to $39,999) have no motor vehicle. Only 1.2% of households with incomes over $75,000 have no motor vehicle. Thus, by far the largest jump in auto ownership comes at the low end of the income scale. A car is obviously one of the first purchases households make as soon as they can, even if it strains their already limited budgets. Indeed, it is probably unique to the United States that three-fourths of even its poorest households own a car. That reflects the extent to which the car has become a virtual necessity for even the most basic transportation needs in most American metropolitan areas.

Similarly, the rate of multiple car ownership increases with income. Thus, the percentage of households with two or more cars increases from 25.2% in the under $20,000 category to 50.9% in the $20,000 to $39,999 category and 87.8% in the $100,000 and over category. The percentage of households with three or more cars increases from 7.7% in the under $20,000 category to 15.3% in the $20,000 to $39,999 category and 38.5% in the $100,000 and over category. The sharp increase in multiple car ownership with increased income is fully expected, and is also consistent with all earlier NPTS surveys.

Studies like Ingram and Liu (1999) have found that income elasticities of car ownership ranged from 1.02 to 1.21, meaning that for every 10% increase in income, car ownership increased by as much as 12%. This is in line with many other studies that show that income elasticities of cars are generally above unity. The income elasticities of car ownership differ in the short-run and long-run, as long-run behavior is generally more responsive to income changes. Goodwin, Dargay and Hanly (2003) conclude that if real income goes up by 10%, the number of vehicles, and the total amount of fuel they consume, will both go up by nearly 4% within about a year, and by over 10% in the longer run.

However, Kopits and Cropper (2003) find that vehicle ownership nearly levels off at about $16,000 (2003 dollars) per capita annual income, and some researchers suggest that above a certain level (estimated at $21,000 U.S. by Talukdar), automobile ownership levels may even decline slightly (Newman and Kenworthy, 1998). Karlaftis and Golias (2002) find that the purchase of a household's first vehicle is primarily dependent on socioeconomic factors (as income increases, so does the ownership of a vehicle), but the purchase of second and third vehicles is primarily dependent on the quality of travel alternatives in their community.

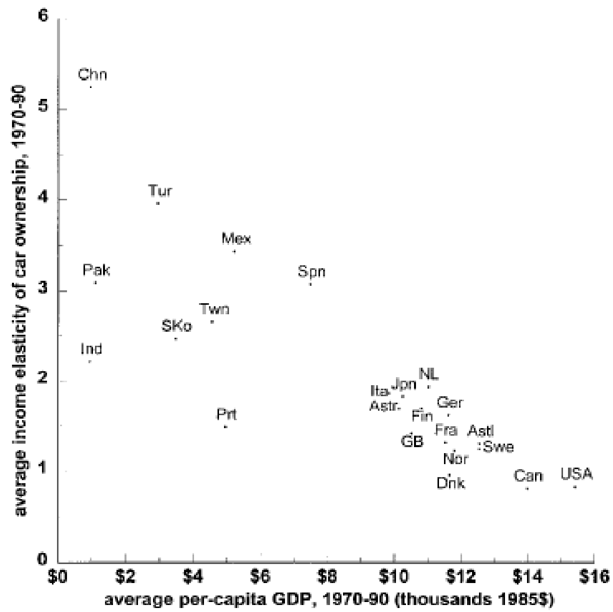


Fig 1: Income Elasticity of Car Ownership vs. Average Income, 1970 - 1990

In line with the level of income mentioned above, the level of development, which can be seen as per-capita income in the economy, also determines how income elastic car ownership is. Fig. 1 (Dargay and Gately 1999) shows that car and vehicle ownership has grown at least twice as fast as income for lower-income countries. That is, the income elasticity of ownership has been much higher than 2.0 for the lowest-income countries.

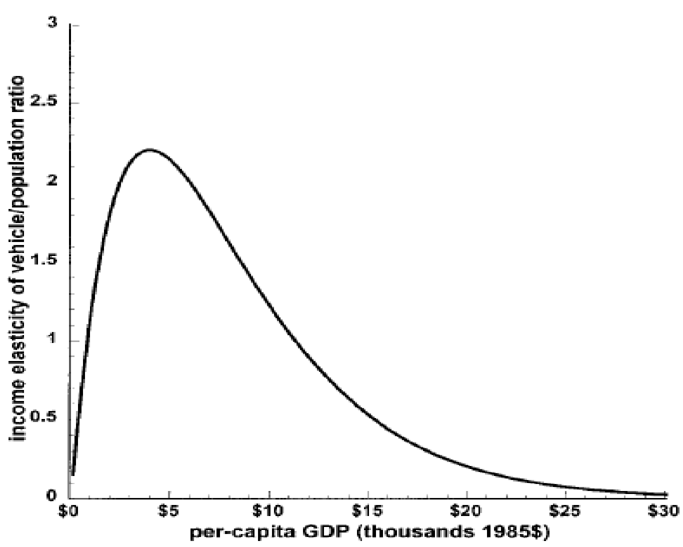


Figure 2: Implied Income Elasticity (Dargay & Gately, 1999)

In addition, Fig 2 also shows that the higher a country's income level the lower is its ratio of ownership growth to income growth. At even higher levels of per-capita income than shown on this graph (at about $30 000), ownership growth (and the income elasticity of ownership) would approach zero, as ownership saturation is reached, which is similar to the trend for household income.

2.2 Prices

The price of a car is more than just the purchase price of the car alone. Usage prices, parking prices and fuel prices all come into consideration when purchasing a car and must be taken into consideration when evaluating the impact on car ownership. In addition, the extremely wide variety of cars makes it hard to construct an average price index, which is why there are few empirical studies which include vehicle prices as an explanatory variable for vehicle ownership.

Based on various studies, the elasticity of vehicle ownership with respect to price is estimated to be -0.4 to -1.0, meaning that a 10% increase in total vehicle costs reduces vehicle ownership by 4-10% (Litman 2010). McCarthy (1996) estimates the price elasticity of vehicle purchases at –0.6 to –0.87. As gasoline prices are more readily available than vehicle prices, the price of fuel is often used as a gauge for the price of a car. Glaister and Graham (2000) conclude that the long-run elasticity of vehicle fuel consumption with respect to income is 1.1 to 1.3, and the long-run elasticity of vehicle travel with respect to income is 1.1 to 1.8, with lower short-run values.

As mentioned by Ingram and Liu, the inelasticity of car ownership with respect to cars has an important policy implication because prices are often suggested or used as an instrument to control motor vehicle ownership and use. Since it is lower than income elasticity, prices will have to be raised faster than income to keep ownership levels stable.

2.3 Taxes & Regulations

Taxes and regulations decide the price of a car in a particular city, state or country and thus play a key role in deciding car ownership. Car ownership taxes like road taxes and license fees, plus usage taxes like fuel, congestion and parking charges are determined by government and city policy. The impacts on these taxes and regulations on car ownership and usage will be discussed more in detail in the later part of the paper (Part 3.2)

2.4 Land Use

Land use is a significant factor to car ownership. As land use is a key area of the second part of our paper, we would discuss land use and its multiple sub factors in relation to land use methods at a later stage due to the flow of our argument (Part 3.4.1).

2.5 Density

Ingram and Liu found that low densities increases motorization, high densities decreases it. The elasticity of motor vehicle ownership with regards to population density is greater at urban level compared to national level. This problem is turned into a vicious cycle when they found that motorization causes decentralization. There are basically 2 arguments about vehicle ownership in urban areas vs. rural areas.

- Urbanization negatively associated with vehicle ownership since vehicle ownership is more attractive in rural compared to urban areas
- But, urbanization is positively associated with per capita income (of which is higher in urban areas)

Thus this demonstrates the conflicting effects of density and income with regards to urbanization. While this may point to ambiguity, the congestion rates of urban cities have pointed that the second effect is larger than the former.

2.6 Desire for Comfort

Economists have often viewed transportation from the point of efficiency. Multiple studies show that public transit are often 20-30 times more efficient at transporting people as compared to cars. For a normal car that often carries between 1 to 2 passengers, buses offer 20 passengers in the same car length.

However, the pursuit of efficiency often ignores the desire of human beings for comfort and space. This of course moves out of the territory of economics but must be considered as a key factor. In varies articles to Singapore's national paper - The Straits Times, citizens complained that local rail transit provider SMRT failed to see how passengers cannot be treated like freight and space and comfort must be key considerations as well.

With increased incomes there is an increase in the desire for comfort this is because comfort is considered a luxury good. Thus, we see a dual effect that increases car ownership with the increase in income coupled with a greater desire for comfort.

As such, we believe that while this factor is immeasurable economically, it is a key factor of car ownership as the desire for comfort has been a strong reason for the continued ownership of cars.

2.7 Social Status

The car has become more than a tool for transport. David Bannister (2005) argues that the car has become 'an icon of the twentieth century'. He continues that it is seen as a security where this form of transport is always ready and an available unlike that of public transit.

Urry (2001) continues the argument that that car has become a symbol of social status. We extract the most ways that car ownership has fulfilled such roles:

- The car is a manufactured product produced by iconic firms that sprout from capitalism and industry.
- The car has also been the main item of individual consumption directly after housing needs are met. The ability to own a secondary item apart from housing provides the owner with alleviated income status
- Car ownership has provided individual mobility. This is exclusive to the user and is a highly viable and prestigious mode of transport compared to private transit.

As many countries have used a system of quotas and taxes to reduce car ownership, they indirectly raise the value of the car. In certain countries like Singapore, owning a car becomes a symbol of high income as it substantial financial strength is required to afford one.

Whitelegg (1997) adds that the car offered its owners the means to individually 'escape' from real world environmental constraints.

The key reason for bringing in this factor is that perception is often the key instrument in demand. Economic theory is based on the assumption that individuals are rational even allowing for bounded rationality. It is in this area that perceptions are akin to bounded rationality and if owning a car is seen as a prestige or a necessity like housing, priority placed in this product by consumers would make it very hard for car ownership patterns to change.

Banister adds that drivers have been 'extremely resourceful in finding ways to avoid doing something they do not support'. This lends weight to the problem of many policies aimed at reducing car use and ownership. Thus, the key factor of perception in the economic definition of bounded rationality must be addressed.

2.8 Substitutes & Complements

Reduced automobile use due to increased vehicle operating cost causes drivers to switch to alternative modes, depending on the length and purpose of the trip. Litman (2010) finds that a disincentive to driving (say, higher parking fees or a road toll in urban areas) generally causes 20-60% of automobile trips to shift to transit, while other trips will shift to nonmotorized modes, ridesharing, or be avoided altogether when travelers consolidate errands or shift destinations. However, the change in small, as the elasticity of transit travel with respect to automobile costs is only about 0.05 to 0.15 in the short run (first year) and increases to about 0.2 to 0.4 over the long run (five to ten years) (Litman 2010). Other modes include car sharing, bicycle and walking.

Litman uses the example of the TravelSmart program in the city of Perth, Australia to evaluate the viability of substituting the car using marketing and a variety of incentives to encourage residents to use alternative travel modes. The goal of the program is to encourage residents to increase the portion of total trips made by environmentally friendly modes (walking, cycling and public transit) from 10% to 25% of trips by 2029. This goal is considered feasible, based on detailed market research and transportation surveys. Before-and-after surveys of pilot projects found the following results (Transport WA, 2001):

Trips By Change	
Car-as-driver	Down 14%
Public Transit	Up 17%
Cycling	Up 61%
Walking	Up 35%
Car Mileage	Down 17%

Table 1: Survey Results

The results show that alternatives to the car are viable if the cost-benefit ratio of the car to its substitutes is tipped in the latter's favor. The second part of the paper attempts to find ways to do this through an analysis of case studies and papers on reducing car ownership and expands on the elasticties involved (Part. 3.3).

3. Reducing the Rate of Car Ownership

3.1 Overview

We now adopt methods to curb car ownership, sensitive to the factors that we have just discussed. As we mentioned in Part 1, factors and solutions are unique to each specific area and for this paper, we will divide areas into two main groups - less developed countries (LDCs) and more developed countries (MDCs).

There is no official definition to what separates a less developed country from a more developed one. International organizations have characterized the divide via GDP, human development index and other measures each with their own set of criticisms. However, as we noted earlier that the specific nature of an area is important in determining car ownership, our definition of LDCs and MDCs are as follows:

A LDC is one that exhibits low urban development. It constitutes at most a semi urban development process with little high value infrastructure. This definition is important as it allows for more flexibility of policies without having vested interests and infrastructure already in place.

MDCs, in our point of view, are cities that have significant urban infrastructure in place. These include paved roads and an intermediate level of transport system networks. This points to the fact that fundamental changes are harder to be made to the transport system and smaller piece-meal like approaches will be more appropriate to stem the growth in car ownership.

Planning to reduce the rate of car ownership is daunting and most developed countries have often found it a near impossible task. Numerous examples show the use of varying methods but not a package of policies to attack the problem in a holistic manner. In this section we advocate the use of not just one but four approaches to the car ownership problem. This is divided into two sets.

- The first set involves the twin effects of pushing the consumer away from buying cars and pulling them towards substitute forms of transport. This set applies to both MDCs and LDCs.
- The second set looks at the management of both land and traffic systems, focusing more on the role played by the government and the relevant land planning authorities. This section also allows us to introduce the role of technology into the transport sector. Land use methods are driven mostly at LDCs due to their flexibility. The general financial weakness of LDCs mean that they may not be able to sustainably adopt high technology methods. However, there are low cost technological solutions available to them as well.

We believe that even though LDCs have not been quick to adopt such car ownership reduction measures, most fundamental measures fit them best and will return higher levels of success as compared to MDCs. MDCs continually experiment with a plethora of solutions to car ownership. We will study them and show how LDCs can adopt them and reap better rewards because they are still at the early stage of nation planning and have the flexibility that MDCs do not enjoy.

3.2 Reducing the Benefits of Car Ownership

Generally, car owners regard the cost of buying a car as a sunk cost, and this tends to reduce the impact of the variable costs of using the car with it as owners seek to recover the investment by increasing usage and thus utility of the car. However, the true costs of a car, including the external costs, are often not included in the price mechanisms and in the formation of transport policies. A complete cost-benefit analysis of car ownership and usage has to be undertaken for cars to be priced more efficiently.

3.2.1 Real Costs

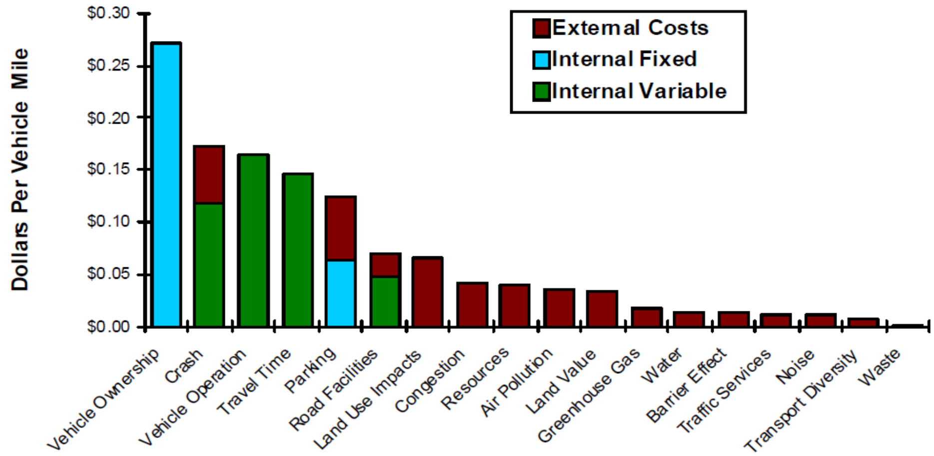
Small (1993) explores the real cost of transportation by breaking it several components, including not just the internal costs, but the marginal costs as well. The running and vehicle costs made up the largest component, perhaps $0.15/km. Infrastructure costs, in the form of user taxes like fuel tax, and parking costs took up relatively small amounts at $0.06/km and $0.08/km respectively. This was because the latter 2 were subsidized by the government in the case of infrastructure and employers in the case of parking, and were not true reflections of the costs involved.

3.2.2 External Costs

External costs like congestion and air emissions took up a more significant and understated portion of transportation costs. Congestion costs are highly varied and depend on many factors like income, trip purpose etc. Suppose an urban arterial with a normal speed of 50 km/hr is slowed by congestion to 25 km/hr. At average U.S. wage rates, Small estimates that this delay of 1.2 minutes per kilometer costs the driver about $0.11/km (Small, 1993). This is only the average time cost of drivers, and does not include the much larger marginal cost, which causes total cost to rise non-linearly with the number of peak users. Hence, this a source of market failure as an individual’s decision to travel only takes into account the average cost and not the real cost to all users of the road.

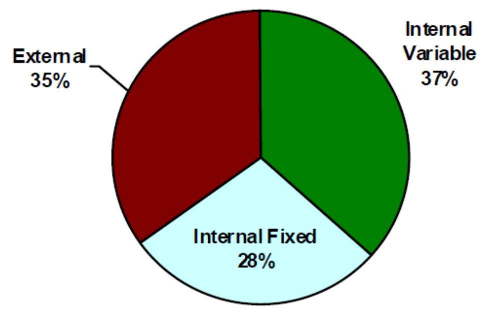
The cost of air emissions is not easy to determine as the true cost to health, environmental and ethical costs to society transcends economic calculations. A few plausible attempts have been made to quantify at least some of the relevant scenarios. For the United States, estimates of aggregate costs from the pollution caused by automobiles are on the order of $20-40 billion per year. This translates into about $1000-$2000 over the life of each car (Small, 1993).

This is in line with Litman’s analysis of average automobile costs (2009). Though smaller than internal costs, external costs are numerous and can make up as much as one-third of costs when taken together, as can be seen from Figure 3 and 4.



This figure shows Average Car costs per vehicle mile, ranked by magnitude. External costs tend to be small but are numerous.

Fig 3: Average Automobile Costs



This figure illustrates the aggregate distribution of costs for an average car. About 60% of total vehicle costs are either External or Internal-Fixed.

Fig 4: Average Car Cost Distribution

External and fixed costs represent under pricing of a car. On average, each dollar spent on vehicle operating expenses imposes about $2.55 in total costs to society (Litman 2009). Failure to consider these costs can lead to decisions that result in negative net benefits to society. For example, society is overall worse off if a roadway expansion saves motorists 5¢ per mile in average travel time costs but imposes 10¢ per mile on average in additional economic and environmental costs.

Currently, pricing structures are inefficient and cars are underpriced in relation to the costs they impose on society. As the demand for cars is price inelastic, the effectiveness of price measures like fuel and road taxes alone are limited in reducing car ownership. Prices of cars have to be raised substantially from current prices such that they reflect more of their external costs.

3.2.3 Case Study - Singapore

Singapore is one of the expensive countries to own a car due to a mix of quota, road and import taxes that the government uses to regulate the car population. The most effective of these is the Certificate of Entitlement (COE) quota scheme that entitles holders to own a car for 10 years. A quota N* is set, and car buyers go through a bidding process that allows them to decide the price based on their willingness to pay ie. their marginal benefit. By setting the number of certificates sold each round at N*, the government is able to directly and effectively control the car population in Singapore and allow the market to decide the prices (P*) where Marginal Benefit= Marginal Social Cost, thus achieving an efficient outcome. Through the use of this measure, the car population growth rate in Singapore has been kept steady at 3% per year since implementation, with the Land Transport Authority (LTA) planning to reduce it to 0% in the future in light of limited roads and parking.

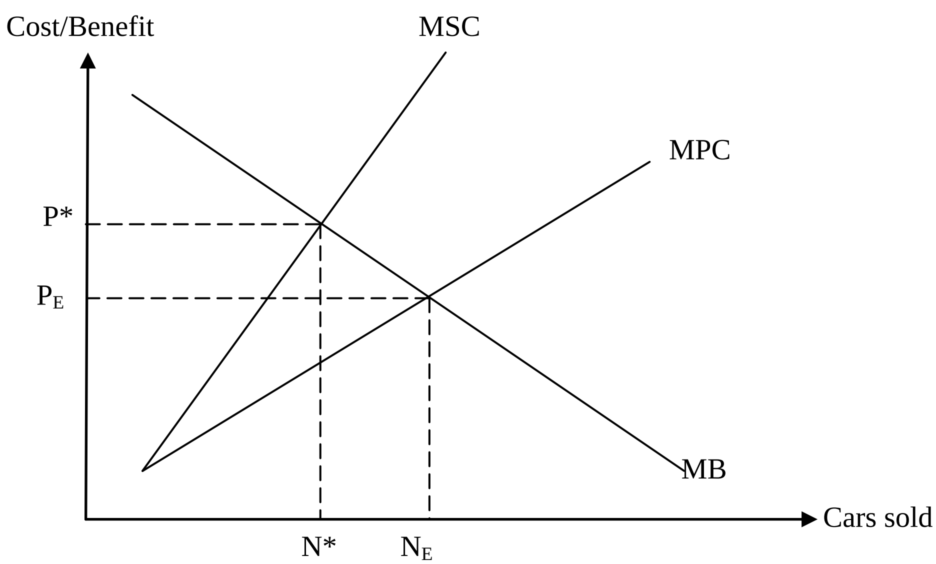


Fig 5: Quota System in Singapore

Though more effective than controlling ownership, ownership taxes like the COE are not as efficient at internalizing external costs of the cars as usage tax. Chia *et al.* (2001) constructed a general equilibrium model to show that ownership taxes are not as welfare-maximizing to society as usage taxes. Their model calculates that total welfare gain under ownership taxes yields only 1.8% of total income compared to 6.37% under usage tax. This is because ownership tax does not impact the price of trips, which is the source of congestion and pollution externalities. However, in terms of revenue productivity, ownership taxes are strongly preferred to usage taxes if revenues raised are able to be used to improve society’s welfare. While ownership taxes might fall short as externality-correcting tax, it is superior as a revenue-raising tool around the initial equilibrium as it is largely non-distorting.

3.2.4 Combinations with Other Taxes

Combining ownership taxes with usage taxes might be a more equitable and acceptable way for reducing ownership. Rather than increasing the fixed cost by one large amount, increasing the variable costs over several measures might be more politically acceptable to the public. While car ownership is often argued to be price inelastic, a combination of measures such as increase of road pricing, parking pricing and fuel taxes can result in substantial variable costs that can reduce the utility of the car such that drivers might have to reconsider their options when buying a car.

3.2.4.1 Road Pricing

Road pricing is the most common measure for transport demand management (TDM). Congestion pricing in particular has become increasingly popular. Following the success of the ERP in Singapore in reducing congestion, many other urban cities like London and Stockholm have emulated this form of road pricing. Following the initial period after implementation in London, automobile traffic declined about 20% (a reduction of about 20,000 vehicles per day), resulting in a 10% automobile mode share. Bus ridership increased 14% and subway ridership about 1% (Litman, 2006). Similarly, Stockholm's congestion pricing reduced traffic volumes by about 25%, removing 100,000 vehicles from the roads during peak business hours and increasing public transit ridership by 40,000 users per day.

3.2.4.2 Parking Pricing

Parking pricing, an often under-utilized measure, is one of the most effective ways to reduce motor vehicle traffic. It typically reduces automobile trips by 10-30%, or even more if implemented as part of a comprehensive TDM program. As mentioned by Small earlier, parking prices are heavily subsidized by employers and the city authorities. Parking prices should be raised to justify the development and opportunity costs of the parking lots. Furthermore, since parking lots are often under-utilized during off-peak periods, the 2004 San Francisco Countywide Transportation Plan suggested demand-responsive parking prices to increase or decrease prices in accordance to occupancy rates. Redwood City in California has implemented this in 2005 (TDM Encyclopedia 2010). At least annually and not more frequently than quarterly, a Parking Manager shall survey the average occupancy for each parking area in the Downtown Meter Zone that has parking meters. Based on the survey results, the Parking Manager shall adjust the rates up or down in twenty-five cent ($0.25) intervals to seek to achieve the target occupancy rate of 85%. This is very relevant for high-density cities where land is valued at a premium. Regulations to limit parking spaces will make parking pricing even more effective.

3.2.4.3 Fuel Pricing

Fuel prices are also another component of a car's costs.

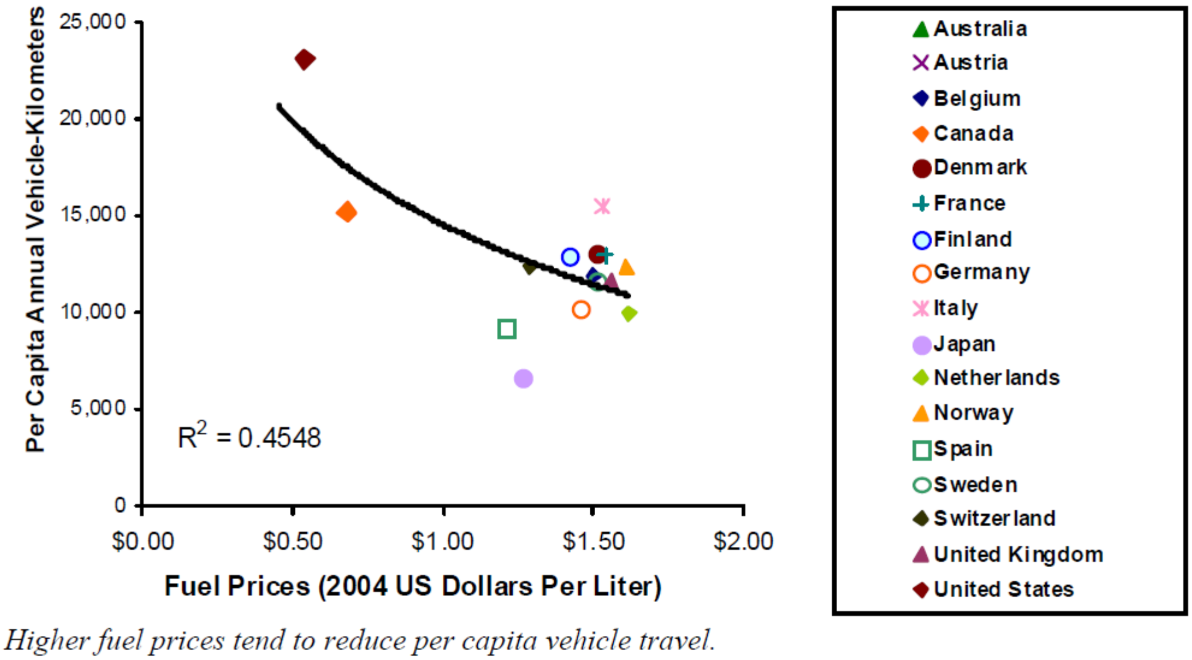


Fig 6: Fuel Price vs. Per Capita Vehicle Travel

Figure 6 (Litman 2010) shows that the US has one of the lowest fuel prices among developing countries, which is why it has the highest automobile use. To discourage automobile as a mode of transport and to internalize the pollution costs, fuel prices have to be raised further. Analysis by Goodwin, Dargay and Hanly (2003) show that a 10% increase in fuel prices reduces vehicle ownership 1% in the short-run and 2.5% over the long-run, and fuel represents about 25% of total vehicle costs.

Though the effect is low, the figure proves that fuel prices do have a discernible effect on vehicle use.

3.2.4.4 Others

Other possible solutions that can be considered include pegging increases in road taxes to GDP growth and increasing cost of ownership for more than one car. As income elasticities of ownership are the highest, pegging road taxes to the income growth of the population can be one of the ways to make sure prices of cars keep pace with the growing demand. Also, since the rate of multiple car ownership increases with income, it is also possible to increase the cost of owning 2nd or 3rd cars so that taxes will be more progressive than the former, where it might not be fair to impose an increase in ownership taxes on all owners.

3.2.5 Applications to Less Developing Countries

A major obstacle to TDM planning in developing countries is the assumption that automobile-oriented transportation systems are desirable and inevitable. However, the above solutions are not just limited to MDCs, as LDCs can avoid future problems by implementing such reforms before they become highly automobile dependent.

3.2.5.1 Case Study India

An example is India's National Action Plan on Climate Change, which has recommended a mix of measures based on the understanding that all-round costs of using personal vehicles need to be raised even as public transport is strengthened to reduce the alarming growth rate of private vehicles and their emissions. Among the mission document's recommendations are making ownership of parking space compulsory for those wishing to buy new private vehicles, limiting the availability of parking space in city centres, banning parking on arterial roads, charging higher parking rates at peak hours, make street parking steep and imposing a congestion charge besides other measures. There's also a proposal for a dedicated urban transport fund to pump money into running public transport better in urban areas.

Currently, there is little incentive to limit driving to trips where benefit exceeds cost, due to the difficulty of implementing such draconian polices. Whether car prices are regressive depends on how revenues are used, through the form of subsidies to public transport operators or improving the existing public transport facilities. Options and benefits for non-drivers should be increased to ensure that cars remain an option only for those who can afford to pay for its full costs, internal and external.

3.3 Increase the Viability of Substitutes

Public transport, particularly transit, can help solve many of the problems facing transportation today in modern cities. Litman (August 2010) lists these problems in Table 2.

• Traffic congestion	• Automobile costs to consumers
• Parking congestion	• Inadequate mobility for non-drivers
• Traffic accidents	• Excessive energy consumption
• Road and parking infrastructure costs	• Pollution emissions

Table 2: Transportation Problems Transit Helps Solve

In addition, public transit's role in a modern transportation system is increasingly growing as the costs of cars increase and commuters seek more modes of transport to fulfil their transport needs. Reasons like increasing congestion, urbanization, rising roadway expansion suggest that public transit will become a more attractive choice in the future. To reduce car ownership and convince drivers to switch to public transport, the benefits of public transit has to increase in relation to the increasing costs of the car.

3.3.1 Difficulties in Converting

Mode of Transportation	**Total Number of Vehicles in Household**				
	0	**1**	**2**	**3 or more**	**All**
Total Auto	34.1	81.9	88.8	90.5	85.9
Single occupancy vehicles	5.2	36.8	36.6	42.5	37.3
High occupancy vehicles	28.9	45.1	52.2	48.0	48.6
Total Transit	19.1	2.7	0.6	0.5	1.7
Bus and Light Rail	14.1	1.9	0.4	0.3	1.2
Metro/Subway/Heavy Rail	4.8	0.7	0.1	0.1	0.4
Commuter Rail	0.2	0.2	0.1	0.1	0.1
Total Nonmotorized	43.5	13.2	8.8	7.1	10.4
Walk	41.1	12.5	7.8	6.3	9.5
Bicycle	2.4	0.7	0.9	0.8	0.9
School Bus	1.5	1.7	1.4	1.4	1.5
Taxicab	1.0	0.2	0.1	0.1	0.1
Other	0.9	0.3	0.4	0.3	0.4
All	100	100	100	100	100

Table 3: Impact of Auto Ownership on Mode Choice (NHTS, 2001)

The bad news for transit is that most households abandon public transportation as soon as they own their first car. As shown in Table 3, the ownership of even one car dramatically transforms travel behavior. Thus, transit use drops from 19.1% of trips by households with no car to only 2.7% of trips by households with one car. The doubling of auto ownership per capita since 1960 is surely one of the most important reasons for the steady decline in transit's modal share. The already high and still rising level of auto ownership in the United States will remain a strong deterrent to transit use in the coming years.

Conventional transport evaluation models tend to undervalue public transit because they overlook many benefits, as summarized in Table 4.

Usually Considered	Often Overlooked
• Financial costs to government	• Downstream congestion impacts
• Vehicle operating costs (fuel, tolls, tire wear)	• Impacts on non motorized travel
• Travel speed (reduced congestion delay)	• Parking costs
• Per-mile crash risk	• Vehicle ownership and mileage-based depreciation costs
• Project construction environmental impacts	• Project construction traffic delays
	• Generated traffic impacts
	• Indirect environmental impacts
	• Strategic land use impacts
	• Transportation diversity value (e.g. mobility for non drivers
	• Equity impacts
	• Per-capita crash risks
	• Impacts on physical activity and public health
	• Some travelers' preference for transit (lower travel time costs)

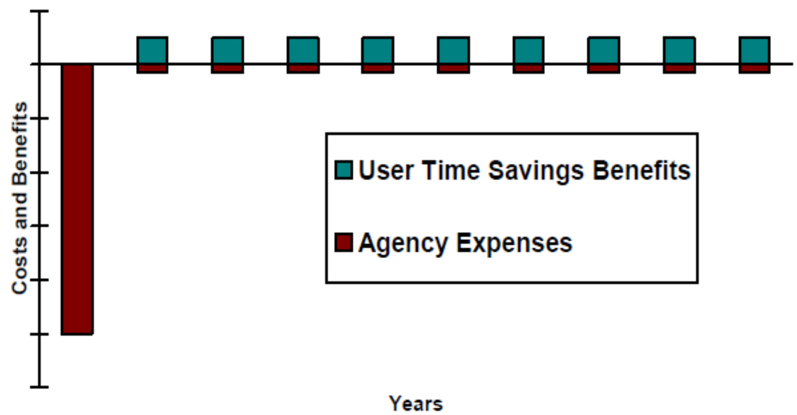
Table 4: Conventional Scope of Analysis (VPTI, 2004)

Transport planners have to take into account the often overlooked benefits of public transit such that it becomes an attractive enough option for drivers to make the switch. Transit system costs tend to be relatively easy to determine, since most show up in government agency budgets. The main challenge is therefore to identify all incremental benefits, including those that are difficult to monetize.

3.3.2 Cost Benefit Analysis

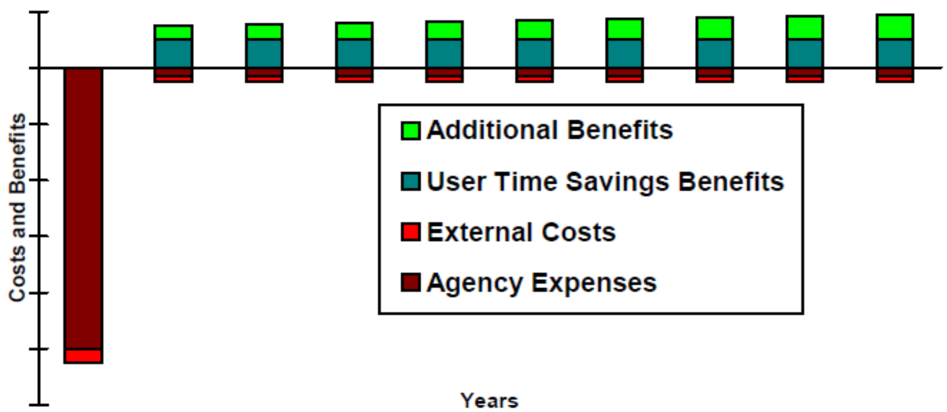
The benefits of a transit service can be divided into 3 main benefits, namely the user, mobility and efficiency benefits (Litman, 2010).

- User benefits are the improved travelling time, cost and comfort the user derives from the service. It comes in the form of low fares, more frequent and faster services and more pleasurable travelling experience.
- Mobility benefits result from the additional mobility provided by a transportation service, particularly to people who are physically, economically or socially disadvantaged. Basic mobility, such as access to essential services like work, medical care and grocery shopping, is considered to be the most beneficial compared to trips for recreational and luxury purposes.
- Efficiency benefits can be derived when transit reduces the costs of traffic congestion, road and parking facilities, accidents and pollution emissions. This is the main benefit that public transit can bring to society and is the component that planners should aim to maximize.



Conventional analysis only considers direct financial public agency expenditures as costs, and congestion reduction (primarily user travel time savings) as benefits. This tends to make highway investments appear most cost effective.

Fig 7: Conventional Transit Investment Analysis



Comprehensive analysis incorporates the impacts of generated traffic, external costs, and mobility benefits provided by transit. This indicates greater costs for highway investments and greater benefits for transit investments.

Fig 8: Comprehensive Transit Investment Analysis

Figures 7 and 8 compare a conventional Cost-Benefit Analysis (CBA) with a comprehensive one. A comprehensive CBA takes into account additional benefits like increased travel options for non-drivers and more efficient land use and the reduction of external costs from automobiles like parking demand, surface street congestion, accidents and pollution.

3.3.3 Case Study - Vancouver

Transit has been shown to work in reducing car ownership in certain countries and cities, particularly those that have high rates of urbanization and high population densities. Despite strong population and economic growth, the city of Vancouver recorded a small decline in the number of registered automobiles, and a reduction in downtown automobile trips in 2004. Small reductions in growth rates were also recorded in nearby suburbs. Experts conclude that this resulted from increased transit services and a growing preference for urban living. Transit ridership rose 9.5% compared to last year, and was 24.6% higher than 2002. A customer survey found that 42% of SkyTrain riders, 49% of West Coast Express riders, 35% on the 99B bus route and 25% on the 98B route previously commuted by car (Litman August 2010). Vancouver shows that when public transit is able to serve the needs of the community, demand for it can grow.

3.3.4 Case Study - Hong Kong

Hong Kong is one of the most successful countries that has managed to reduce car ownership with public transport. Despite having a fairly high per capita GDP that is comparable to the UK, car ownership and usage is extremely low, with around 90% of all vehicular trips made by public transport. Car ownership per thousand population stands at only 49, compared to 325 in Japan and 120 in Singapore (Cullinane 2002). It has achieved this without restrictive measures like Singapore.

In Hong Kong, the major public transport companies are all privately-owned. For this reason, nearly all of them are profitable, one of the few countries in the world to achieve this. The MTR Corporation, Hong Kong's railway operator, merged with the KCR in 2007 and is now a major property developer and landlord in Hong Kong. It owns and runs the MTR metro system in Hong Kong and also invests and builds railways in different parts in the world, and has won contracts to operate rapid-transit systems in major cities like London and Melbourne around the world.

Through privatization, operators are forced to be technically and allocatively efficient, pushing them to allocate resources more efficiently, increase productivity and maximize profits. By having more incentive to be efficient, private operators are more likely to increase frequency and speed of services. Culliane found that public transport frequencies are generally very high in Hong Kong. Trains run approximately every 4 minutes for 18 hours a day, whilst underground trains run approximately every 2 minutes. Buses too are very frequent. Apart from overcrowding during peak hours, a problem that afflicts all transport operators, all public transport is very comfortable. A survey carried out by the same paper found that almost 39% agreed that public transport is so good that they didn't need a car. The same percentage remained neutral. Therefore, only a minority think that a car is needed for transport in Hong Kong, given the efficiency of public transport.

However, not all operators are able to do this as demand might not be sizeable enough for them to recover their cost. Government might have to provide subsidies in order for transit services to stay in operation. Revenue collected from taxes on car ownership and usage can be invested in transport infrastructure to increase user benefits. In this way, the taxes used to internalize the external costs of cars can be used to offset the costs to society, particularly the non-drivers.

Using the Figure 9, a subsidy for public transport will have dual effects. For car trips, there will be a shift in the demand curve to D_2, and the number of car trips will be reduced by Q_2-Q_1. The reduction in the number of car trips can lead to a reduction of car ownership since the utility of the car is reduced for owners. For public transport, the drop in the costs due to the subsidy will lead to more commuters Q_2-Q_1 for operators. However, the switch of mode of transport to public transit from cars will not be easy given the low cross-elasticity between the modes.

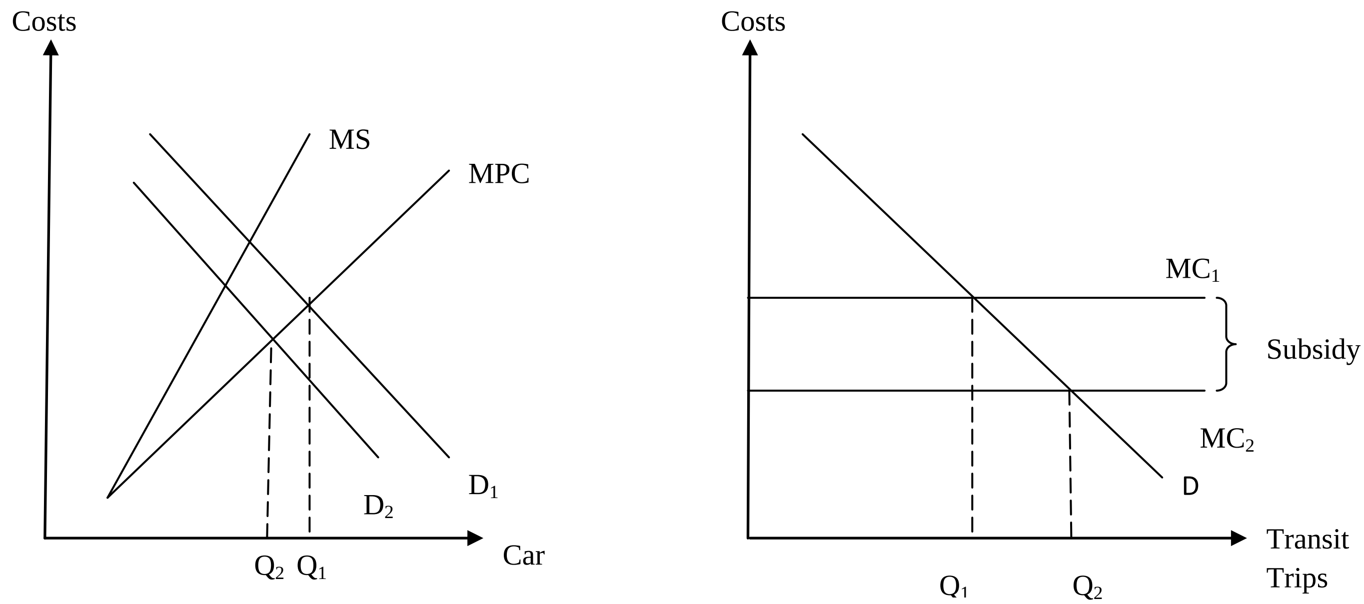


Fig 9:Impacts of Subsidies for Public Transport

3.3.5 Transit Elasticities

	Market Segment	Short Term	Long Term
Transit ridership WRT transit fares	Overall	-0.2 to -.05	-0.6 to -0.9
Transit ridership WRT transit fares	Peak	-0.15 to -0.3	-0.4 to -0.6
Transit ridership WRT transit fares	Off-peak	-0.3 to -0.6	-0.8 to -1.0
Transit ridership WRT transit fares	Suburban Commuters	-0.3 to -0.6	-0.8 to -1.0
Transit ridership WRT transit fares	Overall	0.5 to 0.7	0.7 to 1.1
Transit ridership WRT auto operating costs	Overall	0.05 to 0.15	0.2 to 0.4
Automobile travel WRT transit costs	Overall	0.03 to 0.1	0.15 to 0.3

Table 5: Transit Elasticity Values

Litman (2010) summarizes the transit elasticities form various studies into the table above.

Some key findings from Litman's study:

- Transit price elasticities are relatively high for efforts to shift automobile travel to transit as a demand management strategy (i.e., a relatively large fare reduction is needed to attract motorists), although improved transit services or increased automobile operating costs through road or parking pricing are likely to increase the impacts of fare reductions.

- Discretionary ridership is often more responsive to service quality (speed, frequency and comfort) than fares.

- Packages of incentives that include fare reduction or discounted passes, increased service and improved marketing can be particularly effective at increasing ridership.

- Cross-elasticities between transit and automobile travel are relatively low in the short run (0.05), but increase over the long run (probably to 0.3 and perhaps as high as 0.4).

Salon's study (2009) on New York also concurs, as she found that New Yorkers are more sensitive to travel time than travel cost due to the higher value of the cost of time to them. The largest elasticities and marginal effects of car use for commuting are with respect to Non-Car Commute Time, and the largest portion of this effect is from waiting time and riding time. The elasticity of car use with respect to Non-Car Commute Time amounts to a substantial 1. Her study also found that adding an additional subway link will reduce commute mode share of cars by 2.4% and increase non-car households by 2.7%.

The policy implications from these findings mean that transit benefits must be improved significantly for car ownership growth to slow down. As services quality or user benefits are more responsive, operators can focus on this area to improve ridership. Therefore, the most effective way to reduce ownership is to make transit faster and auto slower, perhaps by allowing congestion.

3.4 Land Use Methods

There has been much debate between land use and transport. The debate centers around the idea in influencing. Does land use influence transport or vice versa? Differing authors of recent literature will give substantial differing views. What they all agree on is that land use and transport are inherently intertwined. We believe the discussion of which affects more is not relevant as most countries already have certain land use patterns and transport systems in place. Thus, the focus should be placed on ensuring that both components work together to reduce car ownership in the long run.

Like the above solutions, land use methods can be applied to both MDCs and LDCs. What is key is the degree of changes made to adopt friendly land use policies that discourages car ownership. We believe that LDCs have greater flexibility in land planning and thus will be able to adopt a more extensive set of land use changes. For the MDCs, taking more minor changes and refining them to be acceptable to current consumer preferences would be key.

The first solution - Transit Orientated Development (TOD) is targeted mainly at LDCs but its application to MDCs is also possible as shown in multiple case studies. The second solution - Land Efficient Development (LEM) serves mainly the MDCs as a consumer orientated nudge towards adopting the minor changes made in TOD that are harder to accept in MDCs.

Before going into detail on two complete packages of land use strategies, we will evaluate the general land use factors that affect car ownership.

3.4.1 Land Use Factors

3.4.1.1 Density

The foundational factor in land use is density. The core reason for such emphasis is due to its overarching effects on other factors. A common argument is that high densities are preferred to make consumers change from car usage to transit usage. We begin by analyzing density before moving to other equally important factors that find themselves occupied with a similar concept to density.

Density is measured an various methods and compares the numbers of the subject in question over land area. This subject can be people, residential apartments, employment buildings / opportunities. The result on travel behavior has been studied by nearly every economist modeling transit strategies and policies. (VTPI, 2008) summarizes the effects below:

- Fall in overall transportation demand: An increase in population and employment densities greatly reduces automobile travel as it reduces travel distances. This is because the number of destinations within the specified area has increased. This is dependent on mixed land use (covered later).
- Fall in specific car usage: Traffic speeds are adversely affected by an increase in densities as there is very likely more cross junctions and higher pedestrian traffic. Such increases the travel times which directly reduces the benefits of car usage. Manville and Shoup (2005) collaborated such observations as they found that a 1% increase in population density is matched by a 0.58% reduction in vehicle miles of travel (VMT). FHWA (2005) provides the following measurements:

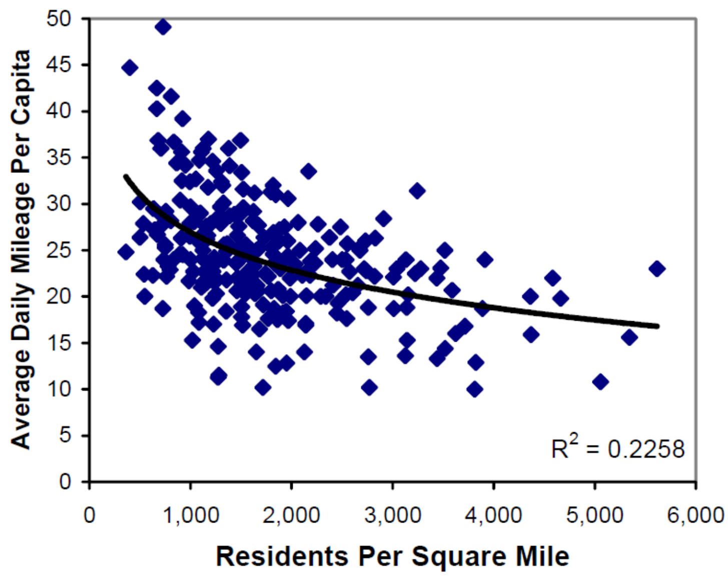


Fig 10:Density - Mileage Relationship

It is clear via the regression line plotted that and increase in residential density reduces VMT per capita.

- Greater travel options: An increase in densities encourage the use of more travel methods including non motorized transit such as walking and cycling. This is dependent on the connectivity of the specified area (covered later).
- Favoring Transit: Barnes (2003) argued that in comparing densities, densities in employment is more important than residential density in pushing the population to use transit over cars.

Density is a general concept and factor, it is the basis of which other factors are built upon. As a recent study by Ewing and Cervero (2010) concluded, density in itself is useless unless it is coupled with other factors that we will discuss below.

3.4.1.2 Land Use Mix

Land use mix is a fundamental idea of New Urbanism (VTPI 2008). It is built on high densities and advocates that different land uses should not be segregated but blended together to provide residents easy access to various functions such as offices (employment), public services (schools, medical facilities) and amenities (retail stores, etc).

The clustering of different services increases the density even further in terms of usage and not just general numbers that the section above explained. This represents a practical form of density increase which is more effective in producing a reduction in car usage and ownership in the long run.

The following impacts were studied by Kuzmyak and Pratt (2003) and highlight the impacts of land use mix:

- Balancing Land Use Mix: They argued that there must be a 1:1 ratio of residents to jobs in the area. Such a balance would reduce average travel distance of both transit and automobiles. However, we conjecture that this effect while pleasant cannot be sustained due to the changing nature of employment making it hard to keep to a 1:1 ratio.
- Promoting Non Motorized Transit: The same authors found that walking and cycling are the preferred modes of transit for commuters who live in estates developed with land use mix in mind. This depicts a significant leap from car travel to non motorized travel bypassing default transit options such as bus and cars. We believe that the reason for this leap is due to the general negativity that transit have incurred in the perception of travelers and when given a choice, commuters will choose to avoid motorized transit if they have to forgo car travel as long as the situation permits. Our argument on perception is based on the following grounds by Cambridge Systematic (1994). In the table below, consumers react better to visual and perception based characteristics instead of actual empirical changes. Thus, working with perceptions and design is key to move consumers away from car usage and ownership.

Characteristic	Without	With	Difference
Accessibility to services	72.1	70.5	-1.6
Safety considerations	73.2	70.6	-2.6
Perception of increased ease of access to convenient services	72.4	69.6	-2.8
Aesthetic urban design	72.3	66.6	-5.7

Table 6: Consumer Reaction to Characteristic Changes

Therefore while land use mix is an important factor of producing more transit friendly environments, the execution and delivery of such measures must be mete out in a manner perceived to be beneficial by consumers.

3.4.1.3 Centeredness

Centeredness is an extension of the Land Use Mix factor. Instead of looking at how well multi faceted services are clustered in the region, it focuses on clusters at the city centre. This is highly tied to employment as city centers are often central business districts, that we will call 'cores'. Like land use mix, centeredness hold similar benefits as explained above.

However, Ewing, Pendall and Chen (2002) have argued that centeredness has a knock on effect on the region as a whole. They brought the examples of Los Angeles and Chicago. The later possesses strong cores unlike the former. Highly centered cores are plagued with intense congestion on roads and competition for parking spaces. This has caused people coming into the city center to take public transport from the onset. This is how the periphery areas see lesser car usage and a larger shift to transit (Litman, 2004).

In VTPI (2010), the authors propose that urban planners believe in having 1 strong highly centered core in the city center followed by smaller cores spread out radially from the city. This miniature cores will contain offices and retail areas leaving the central core free for only the 'highest level business activities'. Their argument is to reduce transit times in the central core.

We believe that a balance between having a strong central core and supporting miniature cores must be struck. Part of the reason why centeredness works is because the central core is flooded with car traffic automatically causing users to swap to transit. If the peripheral cores become too strong, activity will be again spread out and that destroys the factor of centeredness. Thus, this presents a continually adjustment for urban authorities to handle to ensure the right level of centeredness is maintained to keep transit as a more attractive form of transport as compared to car usage.

3.4.1.4 Connectivity

While mixed land use has taken a detailed look at the density of the placement of different services, connectivity points to how direct travel between destinations is achieved (VTPI 2008).

The main idea is to make all areas of the specified area easily accessible and this is usually achieved in a grid like placement of all buildings, allowing all 4 sides of a typical building exposed and open to travel paths bordering its perimeter. The figure below is taken from Kulash, Anglin and Marks (1990) and illustrates how connectivity based road systems provide a more transit friendly estate as compared to hierarchical road systems

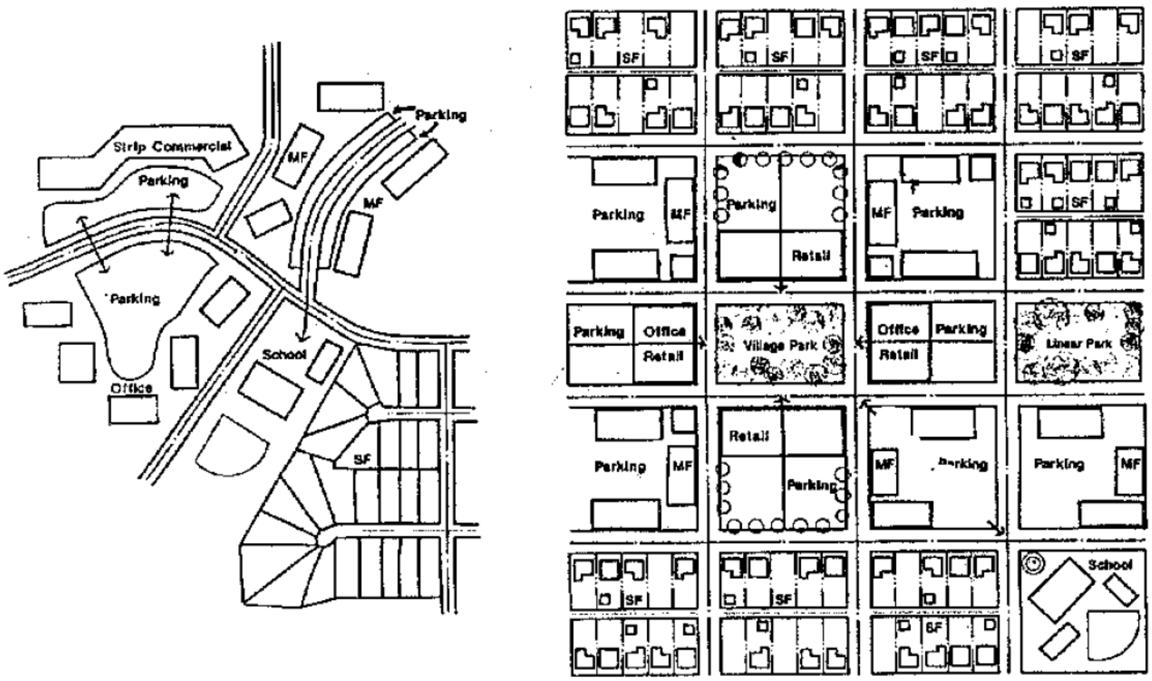


Fig 11:Low Connectivity vs. High Connectivity

The system on the left (hierarchical) is transit unfriendly. To get to specific locations, one must go through via a number of roads in order to finally reach his destination. As bus systems generally do not provide such directness in travel it means that the consumer might have to transfer buses and walk to and from collection and distribution points just to reach his destination. This heavily favors the use of cars. However, should the estate be organized in a grid layout as shown on the right, consumers will be able to reach any building easily due to a higher number of ways to directly access the destination of their choice, hence higher connectivity.

A number of studies support connectivity:

- Reduction in VMT: Ewing and Cervero (2010) found empirical evidence of the theory explained above. They found that increased street intersection is negatively related to increases in VMT.
- Increased Non Motorized Transit: Both Ewing and Cervero together with Larco (2010) found that walking and cycling in particular was heavily encouraged and taken up

relatively well in areas that implemented increased connectivity. Larco found in his survey that 70-87% of his respondents began walking and biking to amenities after road connectivity changes were made. This was mainly attributed to increased safety of using such measures since roads were now more pedestrian friendly.

To further improve the idea of connectivity and make it a tool to combat the rise of car ownership, Frank and Hawkins (2007) advocated blocking car access at critical points of the grid system. This will directly push consumers to utilize cycling and or walking methods to reach their destination. They estimate and increase in walking by 26% and a decrease in VMT by 23%. While such a hard handed approach will certainly force consumers to comply, policy makers may face backlash for impeding car usage in such a blunt manner.

We believe that such policies will not be popular even though it has a good end in mind and more subtle but effective policies would better serve to nudge consumers away from car usage and ownership in the long run.

3.4.1.5 Roadway Design

Roadway design is a supporting factor to connectivity. It looks at specific elements of a road design such as the following suggested by VPTI (2010):

- Traffic Calming & Management of Lanes for Vehicles: Narrower drive ways for motorized vehicles will reduce traffic speeds and thus the benefits of cars. However, this will also affect motorized transit.
- Condition and quality of sidewalks: Well maintained wide sidewalks welcome pedestrians to walk or cycle. Allowing greater flow of non motorized traffic with the downsizing of roads will be a very strong push factor for local residents to walk/cycle when travelling about their neighbourhood
- Street furniture and Landscaping: Should the width of sidewalks be expanded, furniture can be added and these includes benches, and even push cart shops. This adds vibrancy to the sidewalks and will greatly encourage usage. Landscaping is yet again important as visual appeasement help draw users as mentioned earlier under land use mix.

Morrison, Thomson and Petticrew (2004) found that while the second and third factor is often immeasurable in terms of improvements to a reduction in car use, traffic calming did reduce total VMT. They state that for every 1 meter increase in street width, traffic speeds increase by 1.6 km/h. This causes an increase in the benefits of car use as reduced time and the greater availability of the lane due to faster speeds will encourage driving. VPTI reinforces their studies by showing that a 20% reduction in traffic speeds will reduce travel by 10% in the short run and 20% in the long run. This is a significant factor in reducing car usage which may render car ownership of less importance in the future.

3.4.1.6 Parking Management

Continuing from road design, reducing where most cars dock in non usage is a key factor to reducing ownership. Most factors and land use designs often work by reducing the viability of car usage. While this may yield encouraging results for the reduction of car ownership, cheap and unmanaged parking will cause consumers to simply keep owning a car while keeping them parked. Parking management is key in reducing the viability of not just using a car but owning one.

Most efforts have been drawn simply to parking prices. Falling back on the economic principle of price as a control, TRACE (1999) provides the following parking price elasticities.

Usage	**Car Driver**	**Car Passenger**	**Public Transport**	**Slow Modes**
Commuting	-0.08	+0.02	+0.02	+0.02
Business	-0.02	+0.01	+0.01	+0.01
Education	-0.10	+0.00	+0.00	+0.00
Other	-0.30	+0.04	+0.04	+0.05
Total	-0.16	+0.03	=.02	+0.03

Table 7: Usage Price Elasticities

It can be clearly seen that the adjustment of parking prices provides very poor elasticities. It is at this juncture that we propose a quota system instead of a pricing system. As mentioned price elasticities earlier in this paper, price is often not an effective control for car ownership due to misperception of costs and benefits by the consumer. Putting a direct quota by limiting open parking spaces and reducing the number of lots in multi storey car parks will put a major dent on the viability of owning a car since there is very limited spots to park it. While we concede that this is a hard handed approach, we believe it will be more effective than pricing controls due to misplaced values on car ownership.

3.4.1.7 Transit Accessibility

This final factor provides a good bridging point between our discussion of land use factors and the more overarching package of Transit Orientated Development. Transit accessibility refers to making a transit service viable through multiple ways. The 2 key methods to improving transit accessibility and thus demand for transit is as follows (VTPI 2010):

- Better quality transit service: This includes having spacious and accessible collection and distribution points to ensure smooth human traffic flow and easy for boarding and alighting. It also looks into the quality of the ride and the service standards of the providers.
- Increase proximity to transit stop: Placing transit stations at central cores and planting nodes at residential convergence areas. Cervero, *et al* (2004) estimated that placing a station at an area with 10 to 20 more additional residential unit density resulted in a mode split of 20.4% to 27.6% due to the ease of walking to the station. This will be illustrated in our case study later.

Due to the popularity of this factor and its lead up to Transit Orientated Development, many diverse effects have been studied. We will be only highlighting key studies that show clear results in reducing car usage and or car ownership.

- It was observed that car ownership was reduced across the population. Fewer trips were made and there was greater reliance on alternative transit options. (Gard, 2007)
- Rail is considered to be more effective than bus services. Bento, *et al* (2003) observed that an increase of 10% in rail reduces driving by 4.2%. Bus transit pales in comparison at only 1%.
- The power of a packaged solution showed network economies when Renne (2005) found that transit oriented regions bucked the trend of declining transit commuting in the metropolitan areas (United States). Transit commuting actually increased from 15.1% in 1970 to 16.7% in 2000. A shining example is Washington D.C., which we will cover in our case study later. While this may not prove a direct link to a reduction in car ownership, the following factor correlates this one.
- Litman, (2005b) found that transit orientated areas saw households that owned fewer automobiles. The 35.3% vehicle ownership rate pales in comparison to 55.3% which was observed in non transit oriented areas. The income factor was not an issue as the former actually had higher incomes

3.4.2 Transit Orientated Development (TOD)

With the above factors in mind, a popular set of land use strategies proposed is that of Transit Oriented Development (TOD). TOD is geared to enable both motorized and non motorized to be viable alternatives to private automobile transport.

3.4.2.1 Pre-Requisites

However, not all areas can be easily fit and molded to be TOD and prerequisites must be met. Renne (2009) advocated the following key prerequisites for an area to adopt TOD.

- Grid street pattern
- Higher densities
- Limited surface parking and efficient parking management
- Pedestrian- and bicycle–oriented design
- Mixed housing types, including multi-family
- Horizontal (side-by-side) and vertical (within the same building) mixed use
- Office and retail, particularly on main streets.

TOD requires an overhaul in infrastructure planning and in some instances a complete change of mindset in planning philosophies. It is harder for developed cities who have sunk high investments in their current infrastructure to make the change. In fact in such situations, it is likely that the costs of adopting TOD may outweigh the benefits. It is here that LDCs are best suited to adopt TOD due to their relatively lower levels of development and flexibility to adopt new planning methods.

MDCs have again been the torch bearers for TOD in most cases but there have been instances of LDCs who have picked up the need for TOD early and have resounding successes with it.

3.4.2.2 Investment & Funding

Transit development hold trickledown effects as well. Adams and VanDrasek (2007) proposes that transport development can 'stimulate local economic development'. This means that land value around areas that have undergone TOD will often rise after the necessary implementations have been put in place. This trickledown effect does not simply benefit the locals who own property but also helps to fund investments to develop the area according to TOD. Hobban (2005) supports this in his assessment where land developers were often financially supportive of government efforts to develop the land that is TOD friendly. This is a major boon for LDCs that often find investment and funding hard. While obscure areas may still face a problem with investment, there is higher hope that funding can be shared between both private and public funds, freeing the LDCs to be able to focus their funds on other necessary areas of development.

3.4.2.3 MDC Case Studies - Washington D.C.

In the case studies that Evans and Pratt (2007) covered, we will look into 2 key examples. The first is in the City Center which concerns Washington D.C.

Traffic around the stadium is far from constant. Unlike the usual roads that often experience congestion during morning and evening peak hours, stadiums have a high traffic intensity when events and sporting activities are held. In most countries, traffic police and assistance often make contingency plans to handle the large jump in automobile numbers when events are held. A common example of this are the English Premier League games held weekly in England.

Due to the seasonality of transport demand in this area, it is difficult to run a transit line as most trains and/or buses will be unoccupied most of the year. The resulting low returns will make it hard to find a private service provider and is economically inefficient for the government to subsidize and support.

Implementation

However, Washington DC has taken a slightly different approach. The sports arena was planned and built in a downturn region rather than suburban areas where most arenas were built. Due to the distance of suburban areas, it was highly likely that most spectators would drive to the venue as transit was not a viable option due to the lack of direct services or even the lack of any transit route to the venue. Building the sports arena in the downtown area thus allowed the land planners to tap on the already dense region.

This area was already served by the Gallery Place Metrorail HRT since 1997. The authorities did not stop buy just placing the arena next to the station. Two key modifications were made to ensure that transit was not just a viable option but also an attractive one.

- An enhanced station entrance was built to ensure smooth flow of human traffic in and out of the station. It was widened with expanded fare systems to reduce possible bottlenecks. Furthermore, distinct markers were put in place to allow a smooth bidirectional flow.
- The authorities also ensured that parking space was limited and the amount of slots for visitors and spectators were nearly nonexistent. In doing so the authorities avoided the tendency to expand car park lots when constraints occur since there were none in the first place. The public was thus immediately conditioned to accept that the sports arena had no plans to cater for private modes of transport and made the switch to public transit without fuss.

This dual push pull effects made public transit and attractive substitute for private transport and met the key objectives of the city planners.

Impacts

Two major impacts were observed by Evans and Pratt:

- Place Specific: Boardings at the HRT station increased by 56% from 6,525 to 10,179.
- System Wide: Ridership increased by nearly 5% and a new station was built due to the increase in ridership.

Evaluation

The case of Washington D.C. demonstrated two key ideas in the field of transport economics:

The need to provide a multi faceted approach is key to ensure the public make an automated switch transit from car use. Should the authorities simply not provide parking spaces and not modify the HRT station, the accessibility of the sports arena would fall and demand for events held there would be negatively affected. Thus, in its expansion of the station, the authorities made public transit an attractive substitute which resulted in its success.

The benefits of TOD must not be contained only in a place specific region. Due to network economies, the enhancement of a particular node within the network can increase demand for the entire network and its respective stations. In the case of Washington D.C. , the improvement and success of the Gallery Place station brought greater consumer awareness to the viability of public transit which resulted in overcoming a significant difficult of public transport - increasing demand. The other knock on effects such as the building of a new station followed due to demand via network economies.

Conclusion

As we ascertained that public transit is a direct substitute to that of automobiles, the proper planning and execution in Washington D.C. that led to ridership increase will very likely reduce the use of cars. In the long run this can result in the fall in car ownership. Due to the elasticities discussed in part two, the time period required to observe a fall in car ownership will be a long one, but such steps, taken in line with TOD, are definitely in the right direction to reduce car ownership.

3.4.2.4 MDC Case Studies - Pleasant Hill, California

Following the theme of the paper, the second key example would be that of Pleasant Hill, California. It is a suburban area built freshly on undeveloped land. While California is in no way any close to a LDC, it satisfy the low urban development quality that we are looking for.

Unlike Washington D.C., this particular area in California was not built from ground up. Modifications were made in 1995 to make the area more transit oriented. The key infrastructure in question here is the Bay Area Rapid Transit of which the Pleasant Hill station was opened in 1973. Before 1995, much land around the station was given to parking spaces for automobiles in conjunction with mixed land use facilities such as office spaces and housing spots. Due to such duality in policies in the area, automobiles continued to be a preferred mode of transport and ridership numbers were not encouraging.

Transformation

It was identified in 1995 that the main hindrance for ridership problems was due to the wealth of parking spaces available in the vicinity. BART then pushed to convert these parking spaces into elements that supported TOD.

The following changes were made:

- Pedestrian friendly connections were built and there was increased street intersection density. This was to make the street more friendly to all forms of non motorized transport including bicycles and walking.
- Mixed land use development was heightened with the provision of more diversified allocations for housing, office and retail areas. Spreading out these facilities in conjunction with the above point decreased the distance between work, home and amenities.
- Reduced parking spaces. As most open parking spaces were converted for other land use, the authorities had to continue provision of some parking lots albeit with a significant reduction as consumers needed time to switch their mode of transport. A six storey parking garage was built together with multistory car parks within certain facilities. However, the key feature was the reduction in parking space ratios. Arrington (2002) provided a comparative table of parking ratios of Pleasant Hill in comparison to its adjacent Contra Costa County.

Type	General Ratio	TOD Ratio	Parking Supply Units of Measure	Required Reduction
Office	5.0	3.3	Spaces per 1000 square feet of interior space	34%
Residential	1.75	1.35	Spaces per housing unit	23%
Retail	5.0	4.0	Spaces per 1000 square feet of interior space	20%

Table 8: Parking Ratios Pleasant Hill vs. Contra Costa County

Impacts & Results

Pleasant Hill was the center of many studies due to its success. The following results were observed:

- 52% lower peak period auto trips for housing areas and 25% lower vehicle trips for office areas. Trips are observed to be shorter as well. (Belzer and Autler, 2002)
- In a survey of residents of Pleasant Hill area, the following results were garnered by Evans and Pratt.

Mode	Pleasant Hill Area	Walnut Creek	San Francisco
Drove Alone	48.9%	73.8%	43.5%
Carpool	4.0%	8.2%	11.3%
Rail Transit	44.3%	13.5%	9.8%
Bus Transit	0.6%	1.0%	22.4%
Walk	2.3%	2.1%	9.8%
Others	0.0%	1.3%	3.2%

Table 9: Survey Results - Pleasant Hill vs. Other Areas

Pleasant Hill and Walnut Creek are suburban areas held in comparison. The third, Sans Francisco provides typical city figures for comparison. It is clear that from a suburban perspective, Pleasant Hill managed to achieve a high rail transit ridership with a significant fall in drivers as shown in the drove alone and carpool categories. Due to the proximity of the rail station, rail transit dominated overall transit figures. In comparison with San Francisco, the proximity in figures for low driving percentages is admirable considering that Pleasant Hill is not as dense as San Francisco is.

- Work transit was the main cause of the increase in transit uptake. Non work transit was largely still automobile based. The following comparison was provided by Lund, Cervero and Willson (2004)

Mode	Work Mode Share	Non Work Mode Share
Drove Alone	48.9%	70.9%
Carpool	4.0%	10.5%
Rail Transit	44.3%	9.3%
Bus Transit	0.6%	5.8%
Others	2.3%	3.5%

Table 10: Work vs. Non Work impact on Modal Share

The non work mode share points to the fact that non work destinations were not clustered near train stations and thus resulted in greater car usage. Also, bus transit rose only slightly in response even though bus linkages were sufficient for most non work destinations.

- Due to the close proximity of Pleasant Hill station to residences, most commuters accessed the station via walking (80%) or by bus transit (16%). There was no real need to drive to the station in most cases.

Evaluation

A few important lessons can be learnt from the Pleasant Hill TOD redevelopment:

- Rail transit is seen to be a closer replacement for cars unlike buses. With proper clustering of work areas, residents made the switch to rail as rail became viable. Even though bus transit was available to non work destinations, cars were still preferred. We believe that the perception lies between the routes taken. Buses and cars share the same area of transportation - the road. Consumers believe (mostly correctly) that cars would result in significant time savings since the routes used were similar. The higher substitutability of rail can be accounted due to the separate track that it uses. Consumers do not expect trains to undergo the same disadvantages of road usage and thus swapped to trains more readily.
- The concentration of origins and destinations around train stations is key. The high uptake of rail transit can be credited to the fact that the station was within walking distance for 80% of the residents. Also the ridership increase was mostly caused by working places being situated near train stations. There are two options to solving the non work mode share issue. The authorities can situated destinations like retail and other amenities near train stations or they can expand the network and increase the number of nodes on it.

Conclusion

The Pleasant Hill study presents the potential that rail transit holds in causing drivers to switch. While buses are not seen as good substitutes, trains with their faster speeds and monopoly of track usage have given consumers the perception that it can come close in matching the speed of travel of using cars. If trains be the future of transit, then collection and distribution points and time periods are key as illustrated above.

Again in this study, the effects of car ownership cannot be seen in such a short time span. It takes time for consumers to switch and then reach a stage where they are willing to let go of the security of owning a car. Nonetheless, rail transit and its proper execution can be a step forward in reducing car ownership in the long run.

3.4.2.5 LDC Case Studies - Bogota, Columbia (TransMilenio)

Most literature have been focused around developed countries and the U.S. is by far one of the most popular country to be studied in the literature that we reviewed. However, there are two cases of TOD in less developed countries that reinforces our belief that TOD is an optimal solution for cities that are in the process of renewing or building new infrastructure. A transit orientated focus from the start could prevent the automobile dependent development models that have occurred in many developed countries which are hard to correct and change.

The two cases is that of Johannesburg, South Africa's Rea Veya and Bogota, Columbia's TransMilenio. As they adopt similar approaches and Bogota's approach is better documented, we will be focusing on TransMilenio.

The TransMilenio is a successful bus rapid system (BRT) developed in Bogota, Columbia as a solution to a fragmented bus system. The following table lists the features of TOD that were adopted by TransMilenio.

TOD Factor	**Bogota's Application**
Roadway Design	Four central lanes in each street is dedicated for BRT. The bus lanes are further divided into express and normal lanes. Express lanes take the middle two lanes while normal lanes are the outliers.
Connectedness	Connectivity is paramount for the entire BRT system. Bus lanes are interconnected at many points to allow buses to reach their destination in the shortest time possible
Centeredness	Stops are located around heavily centered areas where commercial and residential activity are close by.
Transit Accessibility	The BRT is supported by bicycles. Bogota is planned with multiple cycling paths and BRT stations have adequate bicycle parking lots

Table 11: Bogota's Adoption of TOD Factors

The success of TransMilenio is based on two factors, first the successful implementation of key TOD measures and then the effective co-ownership model without requiring subsidization of transportation fares.

Impacts

- Increased relative speed of BRT: Speeds fell across all modes due to the new transportation system. Car speeds fell from 32.18 km/h to 27.03 km/h on average. On the other hand, 6% more users found that they now only took less than an hour to return home from work. The proportion of people who took more than 1 hour fell by 12%. (Juan Carlos Echeverry, Ana María Ibáñez & Luis Carlos Hillón, 2004)
- Positive Consumer Feedback: An increase in utility of consumers was provided by Lleras (2003). It was found that the value of waiting time fell from US$3.08/hr to US$1.14/hr.
- Increased quality of service: A large drop in traffic accidents was attributed to the proper segmentation of lanes for bus transit. The figure below provided by Juan Carlos Echeverry, Ana María Ibáñez & Luis Carlos Hillón (2004) depict the improvement in road safety that led to the increase in quality of service due to better transit times.

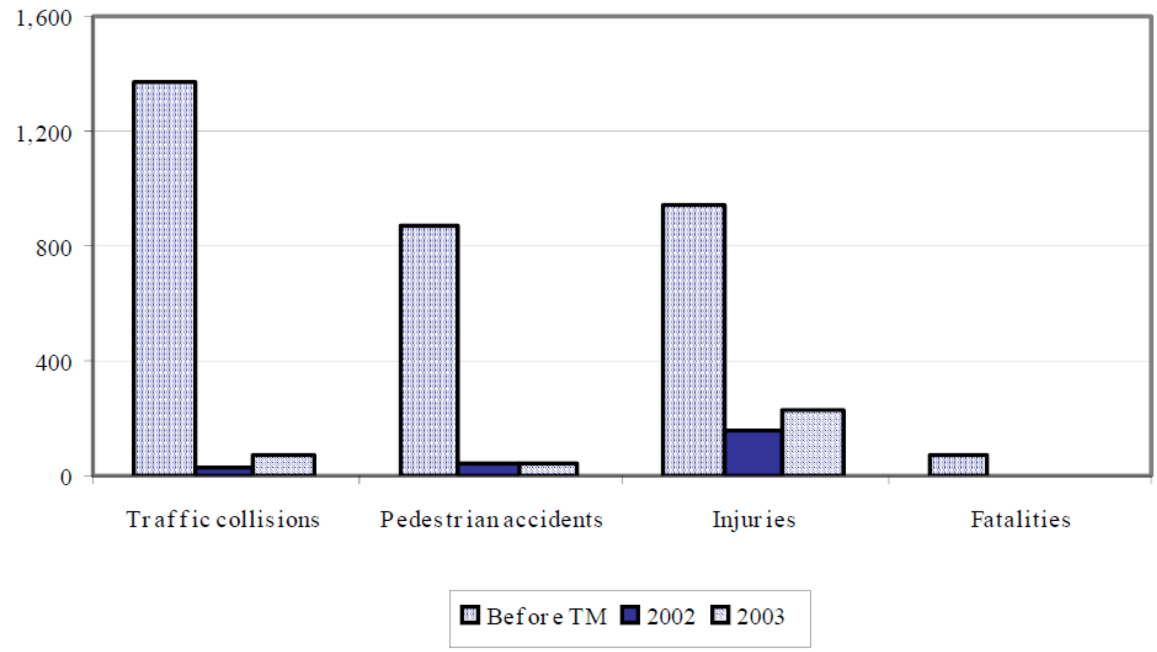


Fig 12:Traffic Accidents Before & After TransMilenio

Conclusion

TransMilenio's BRT in Bogota depicts the embracement of bus over rail in LDCs unlike the opposite seen in U.S. cities. With less developed areas leading to greater land planning flexibility, Bogota was able to open up the 4 lane bus only system and the low cost of buses was suited to its financial and technical capabilities.

Bogota's example also throws up an interesting difference to the usual 'Park & Ride' systems in developed countries. Park & Ride refers to the drive to get private vehicle users to switch to public transit by parking their cars near a station and using transit for the rest of the journey. This has multiple drawbacks such as the need for parking spaces and the automobile congestion near transit stations. Bogota's encouragement for a 'Cycle and Ride' approach depicts a complete move towards complete reliance on non private transport. Thus, we believe this is an effective way to not just lower car usage but also car ownership.

The success of transit came about only with effective TOD combined with an effective rollout of the BRT. Thus, TOD cannot be seen as a be all end all method. It must be supplemented with well designed transit services to take advantage of the TOD infrastructure.

3.4.3 Location Efficient Development

Location efficient development (LED) is an extended arm of TOD. It combines with the latter in two ways. First it looks to develop the area to maximize accessibility to transit options. Second it attempts to increase affordability to entice residents to live in TOD environments with a combination of policies and tools. It is believed that by placing residents and flat buyers in a TOD areas, they will take up transit and swap from automobile transport.

LEDs are aimed mainly at MDCs due to the inertia of moving people who already are entrenched in car based transport. This section will focus on affordability and how financial institutions work with government and private land developers to push for a transit based estate.

3.4.3.1 Relevance

As all economists believe, the first reaction to controlling consumption is price. While we have shown that price elasticities are not ideal, further pushes have been made due to findings by Lipman (2006). The findings suggest that transportation costs are now a significant portion of households. Transportation costs are higher than housing costs in 60% of Metropolitan areas with each average household spending 30% ($10,400) of their incomes on transport and 28% ($9,700) on housing. Lipman continues to advocate reducing both housing and transport cost via the use of LED and the push for public transit.

In this section we echo his proposals as we believe that the reduction of car ownership should not be confined only to direct policies. Packaging the push for public transit under a complete set of cost cutting measures will auger better with residents and consumers. We explore how this has taken place in the following two examples.

3.4.3.2 Affordability

Mortgage lenders such as Fannie Mae adjust their mortgage rates based on project transport cost. The following factors, that are highly related to TOD, are considered:

- Availability and proximity to high quality motorized transit services (Rail & Bus)
- Availability of non motorized friendly support
- Mixed land use. Public amenities must be available in relative close proximity.
- Unbundled parking management to prevent the non vehicle owners from paying for parking fees

If the above mentioned factors are met, mortgage lenders are willing to give home buyers higher mortgages since the amount the buyer needs to spend on transport in future is lower. This means he is likely to be more able to pay higher mortgages. This is also a significant incentive for buyers since they will have greater funds available as the mortgage now covers a larger proportion of their home purchase.

3.4.3.3 Case Study - Fannie May's Location Efficient Mortgage Initiative (VTPI, 2010)

Fannie May is a well known name is the provision of home mortgages. It has been playing a pivotal role in encouraging the take up of TOD estates. The company has identified estates in Seattle and California Bay Area as primary uptake points with Los Angeles, San Francisco and Chicago penned in the future. It introduced the Location Efficient Mortgage Initiative. The mortgage works in the following manner:

- Location efficient values are assigned to each home based on residential density, availability of amenities and public transport access.
- Applicants for the scheme will have to own no more than one car and must live within 0.25 miles of a public transit system.
- Credit will be extended by $17,800 to families who give up one car as it estimates that annual savings will be around $3,200.

The programme has been largely successful with lower income applicants that are finding it hard to buy homes in cities such as Seattle where housing prices have soared. However, because other 'normal' mortgage plans are still available. High income owners may continue to apply for TOD estates without needing to reduce car ownership. Thus, the benefits of TOD might be lost.

3.4.3.3 Case Study - Texas' Transportation User Fee (VTPI, 2010)

Another program that rewards the reduction of car ownership is found in the City of Austin in Taxes. It's utility bills are structured to cater to a Transportation User Fee for each household. This fee is only invoked for households that own private transport. Should the households own automobiles, they will be charged according to the following estimations:

Type	**Estimate**	**Fee**
Single Family Development	40 trips per acre / day	US$30.00 - US$40.00
Condominiums	60 trips per acre / day	
Offices	180 trips per acre / day	Pegged on office size

Table 12: Additional Utility Fees for Car Ownership

While we have shown in part 2 that elasticities on such taxes do not do much to reduce car ownership, residents have taken steps to reduce car usage as city authorities expanded tax exemptions to those who could prove that they did not use their vehicles. This is in conjunction with cost cutting measures a number of households have taken since the recent economic crisis.

We believe this spells two differing results. Firstly, from an optimist view, the relaxation in rules mean that more vehicle owners will reduce the use of their cars and in time find that they do not need to own a car in order to carry out their daily activities. However, one can argue that the relaxation will diminish the efforts that have plagued the push for transit. In the numerous examples above, the best transitions from car ownership to total dependence on transit have been aided by strong pushes that gave little leeway for users to return or fall back on automobiles. Nevertheless, we believe that such additional sources of government revenue can be moved into developing more transit programmes and coupled with the optimist long term effects, will gradually reduce the ownership of cars.

3.4.3.4 Conclusion

LEMs provide further incentives that directly boost TOD and transit, calling for the reductions in car ownership. It shows significant collaboration between the public and private sector to push for reduced car ownership. As we have consistently called for a holistic set of packages, LEM proves that it is not just the policies and strategies that are important. Support from the government, banking sector and also that of private developers is important to push residents and car owners towards a transit based model.

However, LEMs have found less clout in LDCs due to a general weaker structure of the key actors mentioned in this section. As such, we believe that TOD will play the initial significant part in a country's development and LEM should support it after TOD has been executed.

3.5 The Role of Technology

The role of technology has always been a fascination for economies over different fields and this is of no difference to the field of transport economics. In this final part of the paper we will look into two key roles that technology play. A direct impact seen in Traffic Management Systems and a longer run, more indirect impact can be seen in Information Communications Technology.

3.5.1 Traffic Management Systems (TMS)

The highest use of technology in this sector is mainly seen in TMS. Most of these systems are geared for reducing congestion and managing traffic flow. Therefore, from the onset, very few of these relate directly to the reduction in car ownership. In fact we believe that TMS actually increase the viability of car usage and thus ownership due to its optimization of road use. This is echoed by authors such as David Banister (2005). However, we will advocate the use of TMS to benefit and solve the problem that bus transit faces – the right of way on a congested road. We have seen earlier that consumers prefer rail to bus transit mainly due to the monopoly of track usage that buses do not enjoy. In the discussion of Traffic Management Systems (TMS) we find ways to improve the speed and efficiency of bus transit. TMS is split into two key subsections, the first being management centers of TMS and the second, Active Traffic Management.

3.5.1.1 Traffic Management Centers (TMC)

TMCs refer to the nerve center of all TMS. They are located nationwide and manage all facets of the road network (FHWA 2004). With the more active and dynamic controls we are pushing for, it is important that TMCs are efficient at controlling traffic on the fly. They react primarily to the following:

- Traffic increases during peak hours
- Traffic accidents and vehicle malfunctions

They cover a diverse set of roles. Some of them are:

- High occupancy vehicle (HOV) lane management and coordination
- Coordinating dynamic road pricing and other demand alleviating functions
- Road maintenance management
- Performance monitoring and data collection

The high importance of an efficient TMC is problematic to LDCs due to the lesser availability and quality of feedback systems. The key issue is the high cost and complexity of operations for running TMCs. As such, TMCs have been implemented more often in MDCs than that of LDCs.

3.5.1.2 Active Traffic Management

The second arm of TMS is the actual methodologies used to optimize usage. Here are the possible case use scenarios that will benefit bus transit:

Temporary Shoulder Use

Road shoulders are opened for use during peak periods thus expanding the capacity of the road. While this is often used to provide an extra lane for car usage, we believe that this can be implemented for buses to take advantage of. While bus lanes are often used in countries from Brazil to Finland, there is always a competition for road space especially in smaller countries like Singapore that have only 3 lanes to start off with. Temporary shoulder use can be viable if the shoulder is large enough to enable buses to utilize it. In its implementation in the Netherlands, road space was increased by 22% which resulted in an increase in traffic volume of 7%.

Broadcast of Road Conditions / Traveler Information:

Implemented in most countries via national radio stations, traffic updates are important for drivers to avoid highly congested areas and take alternative routes that may be longer in distance but shorter in time spent. We propose that this system be further tweaked to promote the use of transit to consumers. If sufficient effort is made to improve the viability of transit, motorized transit does have a significant chance to be equal or even faster than car usage during peak hours.

What remains to be changed is the perception of consumers and this is where traveler information can make a difference. Information must not be simply limited to the identification of congestion points. It has to be expanded to show what viable transit options are available.

We believe that this must be a long term effort as drivers not only take time to make a switch but will also be less likely to switch if they have to use their vehicles in the later part of the day. Conversely, if they are going home, they would not switch to transit even though transit provides better time savings because they need to bring their car home.

As such, changes can only be observed in the long run when consumers are conditioned after being repeatedly shown that transit is a faster and more viable option during peak hours and periods of congestion. They will then be more likely make an entire switch to public transit.

Case study of Minnesota (FHWA 2005)

The implementation of dynamic shoulder lane use is managed by the Minnesota department of transport. The following traffic management methodologies are used to ensure that only HOVs can use the lane:

- Light emitting diode arrows
- In-pavement markings
- Dynamic message signs

What is important is that if buses are given sole priority in this expansion, the speeds of bus transit will be greatly increased. Again, the problem of space may occur for small countries but this is very viable to larger countries which run a higher number of lanes and have in itself wider lanes. The efficiency of how well temporary shoulder use is dependent on the TMC enforcing it.

There is a significant chance that cars may simply use the inviting open shoulders and a strong enforcement with relevant coercion must be employed. This is important as mismanagement can heavily impede bus transit and further encourage car usage.

3.5.1.3 Complementation

The above measures that TMSs can do to increase the viability of bus transit must be complemented by congestion pricing (FHWA 2005). While the elasticities discussed above show mixed results for the effectiveness of congestion pricing, its complementation with TMS may be just enough to push consumers in making that leap from car usage to transit and in the long run may reduce car ownership

3.5.1.4 Application to LDCs

The use of TMCs has been mainly found in MDCs due to the cost of adopting and putting in place the necessary infrastructure to support the level of technology. TMCs are only as good as the team managing it and this gives rise to training costs and other maintenance issues. As such, LDCs would do well to first adopt less technologically intensive measures such as Singapore's Area Licensing Scheme before moving on to more technologically intensive solutions.

3.5.2 Information & Communication Technologies (ICT)

The second part of our technological focus deals primarily in other ways technology can reduce car ownership without direct impacts on road or vehicle use. Transport is a derived demand and consumers do not necessarily travel for the sake of travelling. They travel to reach destinations where they can meet their needs or get their work and goals accomplished. What ICT offers is reducing the need to travel in order to meet such needs.

3.5.2.1 Reducing Need to Travel for Transactions

We adapt Banister and Stead’s (2004) demonstration on how ICTs can impact transport. It was observed that the rise of the internet and its applications in e-mail, instant messaging and also that of short messaging (SMS) have reduced the need for travel to purchase retail products. Due to digital distribution of software, music, books, information and other products, there is lesser need on the end of the consumer to travel. As we observed in TOD earlier, most consumers continued using the car for non work related travel. It is in this very category that ICT can help reduce the need for car usage.

3.5.2.2 Public Transport Planning

Banister (2005) also observed that the second key area for ICT is that of public transport planning. The role that ICT plays is that it provides an integrated system of information for various public transport timetables that facilitates ease of planning public transport routes. Examples of these can be found in Singapore where Google Maps, Street Directory and Gothere.sg are excellent examples of how train and bus transit timetables are merged and such ICT services help to present public transit information seamlessly to the consumer. Banister continues that this will provide a positive modal shift in favor of public transport as wait times are reduced. Since consumers are now able to correctly estimate when the bus or train will arrive they can adjust their time accordingly. This is important as the benefit of car ownership is that you can start whenever you want to and there is nearly no waiting time involved for your car to be available. While this attribute is not directly available to public transit, reducing waiting time can produce a similar effect and make public transit a more viable option through ICT.

3.5.2.3 Limitations

Putnam (2002) advocated that transport was a need on its own and not derived demand as we have presented above. He believes that travel is instrumental in establishing social networks and for people to meet each other. Thus people will still travel even though transactions are lessened. This is a counter argument in our first point in this section. However, we believe that with greater online social interaction and the changing preferences favoring online interaction, transport will still remain a derived demand and ICTs will play a key role in reducing the overall need for transport, especially in car usage and ownership as expanded in our second point.

3.5.2.3 Application to LDCs

ICTs are general in nature and can be applied across countries of different development stages. What is key is the general adaptability of the people to adopt more technologically based consumer products. Unlike popular perception, LDCs are not starved of consumer based technological products. The high penetration of mobile phone usage in India has given rise to multiple remote mobile based services. As such the divide for LDCs and MDCs as seen in other solutions are not as divisive in ICTs.

4. Conclusion

4.1 Limitations

While LDCs and MDCs are certainly valid ways to make comparisons, there are a multitude of other characteristic differences that separates areas. Rural vs. Urban, Coastal vs. Inland, and many other lines of differences can be used and will affect the analysis of reducing car ownership. However, due the scope of this paper we have limited ourselves to a more general LDC and MDC approach.

4.2 Conclusion

The four solutions we proposed must be adopted as a whole. Leaving one part out will severely undermine the success of reducing car ownership:

- Land use methods are the bedrock of reducing car ownership as it changes the environment and the situation to support transit. This is important as no manner of pricing solutions will be effective if the ground zero situation promotes automobile travel.
- While economics have preached the wonders of pricing, we believe that pricing solutions to reduce cars and increase transit usage is secondary to land use. They provide the push factor only when the situation is ready for it.
- Technology plays more of a gap filling role. It gives behavioral nudges to reinforce pricing solutions. It also gives authorities the power to monitor and adapt - attributes that are key to ensuring that solutions deployed are always customized to the continual changing nature of demand in transport.

This paper concludes that based on existing literature and studies conducted, it remains highly possible to reduce car growth rate in high-density cities like Singapore or New York. Due to the lack of studies on LDCs and the lack of measures taken by them, it remains difficult to predict the effects of these measures on car ownership in these countries. Projections on global car ownership are expected to increase given the inevitable rise in global income due to economic growth, especially in developing countries.

Nevertheless, unexpected external developments like global regulation to decrease fossil-fuel consumption in response to accelerated environmental damage might drastically alter the trend of car ownership in the future. With the current growth rate of cars estimated to be unsustainable in terms of oil demand and emissions, governments around the world, including the LDCs, might be forced to take drastic measures to reduce the growth rate of cars.

For in situations where pricing solutions fail due to intense inertia to change behavioral patterns, major shockwaves and real constraints will make the final decisive push away from car ownership.

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