Published in "Environmental Science and Policy" Vol 9 (2006) pp 55-66

TRANSPORT COST ANALYSIS: a case study of the total costs of private and public transport in Auckland.

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Abstract

The current level of motorised transportation worldwide is increasingly a social, environmental and economic problem. Transport benefits come alongside injuries and death, unproductive travel time, energy dependence, and environmental damage. One reason for the increasing problem results from externalising various impacts on society. Many of these external – or 'unpaid' - costs have only gradually been recognised and most have either been under-valued or are considered impossible to estimate since they have no value in a market. This research assesses the external (unpaid) and internal (user paid) cost of transport. It focuses on estimating the total cost of both private and public transport, using a case study for Auckland, New Zealand's largest city. The external costs are significant - 2.23% of the GDP produced by the 1.2 million Auckland region residents in 2001. Of this private transport generated 28 times more external cost than public transport. The internal cost assessment showed that total revenues collected did not even cover 50% of total transport cost. The research has shown that not only are the external costs of vehicle transport high, but that contrary to popular belief the total costs of private transport are subsidised by public transport users. This has implications for successful transport policy options.

Keywords: externalities, transport policy, public transport, Auckland

1. INTRODUCTION

The development of motorised transportation has markedly increased the standard of living over the past century. The benefits of improved personal mobility and access to resources, goods and services previously beyond the grasp of individuals have influenced every citizen in developed countries, and many in the developing nations. Today transportation is involved in every good and service produced in the economy (Greene, 1997).

The increasing resource consumption that supports this trend has at the same time degraded forests, soils, air quality and biological diversity. Motor vehicle usage demands high-energy consumption of non-renewable resources in the form of fossil fuels. As the human population and wealth increase, non-renewable resources decrease, making the problem more severe.

At present over 500 million motor vehicles are in use worldwide (Meyer, 1998), however the economic and population increase in developing nations will further increase overall motor vehicle ownership. Since the 1960s, the number of motor vehicles has grown faster than the global population; in many developed countries such as the United States, this trend is mainly due to affordable motor vehicles and low-priced fuel (MacKenzie, 1992).

The marked increase in population, especially urban populations, occurring in many cities worldwide has led to rising pollution and exposure levels. According to Meyer (1998), road transportation causes 75% of carbon emissions, 50% of oxides of nitrogen emissions and 20% of carbon dioxide emissions in OECD countries. Despite large vehicle emission reduction achievements, total emissions are still growing due to increasing vehicle numbers (Maibach, 2000).

New Zealand has the fourth highest number of motor vehicles per population in the world (MoT, 2002b). This figure increased by almost 26% from 1990 to just under 2.5 million vehicles for a population of just under 4 million in 2002 (MoT, 2002a). Passenger vehicles accounted for two-thirds of the total vehicle fleet. A steady increase to over 3.1 million vehicles in 2015 is predicted. A Ministry of Transport survey showed that three out of four trips are by private motor vehicle, with 50% of these trips undertaken as the driver (MoT, 2002a).

While the number and use of private motor vehicle have increased, trips made by other modes have decreased. Cycling activity for example fell 19% from 1990 to 1998, while regular daily per person-trips on public transport decreased from 260 in 1955 to 35 in 1995. Similar trends have occurred in the United States for example, where patronage decreased by 6.5% in 1994, while in Santiago de Chile, bus use fell from 65% of total trips in 1977 to 50% in 1991 (Meyer, 1998).

Mees (2001) showed that the main reason for this trend, especially in the Auckland region, results from conventional transport policies, which mainly support road construction and have limited funding of other modes of transport. To combat the increasing congestion problem in the largest city of New Zealand, current transport policies rely on increased road construction, which has been shown to be ineffective at reducing congestion (Maddison, 1996).

The World Health Organisation claims that sustainable policy can only be a result of the monetary quantification of environmental-related health effects (Seethaler, 2002). Therefore efficient and effective transport policies need to be based on the analysis of the total social cost of various transport options (Seethaler, 2002), which involves taking into account non-market as well as market transport costs and imposing them on the producer. Once motorists bear their share of costs they currently spread across society, transport problems, such as congestion and air pollution, would be reduced (MacKenzie, 1992). Following that, the sustainability of various forms of transport and transport infrastructure could be evaluated.

Thus, a growing number of European and U.S. studies have focused on assessing the true cost and benefit of transport. This involves examining the external benefits and costs of transport, which are not directly paid by car users, but caused by them. External benefits were shown by many studies to be zero[1]. In comparison, international studies have assessed external costs, such as the economic effects of air pollution, as being far from negligible.

External costs of transport among the 17 EU countries including Switzerland and Norway were for example estimated to be $975 billion[2] (Maibach, 2000a) in 1995, whereas MacKenzie (1992) calculated external costs to be $600 billion for the United States of America in 1989. Meyer (1998) assessed worldwide external costs of transport for the late 90s to be $1,280 billion, while Greene (1997) compared studies from Europe, North America, East Asia, and Australia in the context of social cost of transport and their percentage of GNP. The study found that the cost of accidents to be 2%, noise 0.3%, local air pollution 0.4%, congestion 2% and overall pollution 1-10% of the countries GNP. Overall most studies found air pollution, climate change and external cost of accidents to have the highest percentage of the total external cost.

According to Transit NZ (1996), knowledge of the value of external effects in New Zealand is limited. An integrated analysis, which evaluates the full cost of transport, has not yet been carried out. Currently, road funding is based on formal cost/benefit analysis (MoT, 2002a). However, the national transport policy objective is that "*by 2010 New Zealand will have a transport system that is affordable, integrated, responsive and sustainable*" (MoT, 2002b, p.3). Not knowing the full economic effects of transport make this aim difficult to achieve.

Therefore, the objective of this study is to assess the cost of the effects of various forms of transport that individuals use, and compare this with what these individuals pay to support the transport system. In order to compare the external cost of different forms of transport, the cost per passenger kilometre is considered along with the cost per kilometre[3].Road transport has been chosen, as international studies suggest that it contributes up to 92% of the total transport costs (Maibach, 2000).

Auckland is the largest city in New Zealand and has substantial transport problems, which impose high economic costs on society. A vital transport system is therefore not just important to the region, but essential for the whole country. In that context the underlying research tries to answer the

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[1] The only external benefit arising from road transport is to individuals, who enjoy 'car spotting' (Becker, 2001; Maddison, 1996). 'The reader who [...] is [...] not convinced that there are no external benefits from road transport should ask themselves the question: Will I benefit if my neighbours drive more than they do already' (Maddison, 1996, p. 24)?

[2] All monetary values are given in NZ dollars

[3] Cost per kilometre is the cost one vehicle causes per kilometre whereas the cost per passenger kilometre is defined as the cost one passenger/person within the vehicle causes. Naturally the later cost is equal or smaller then the cost per vehicle kilometre.

following question: "*How much does it cost society to move a person one kilometre by private car and by public transport in the Auckland region?*"

2. INTERNAL COST OF TRANSPORT

The internal or direct cost of transport can be seen as 'out of pocket' costs, money which is directly spent by the government to run the transport system. To determine the cost that the government has spent in 2001 to support the transport system, this research looks at the costs from a microeconomic point of view. This means evaluating how much citizens pay directly to the government. Hence, it is assumed that the rates and taxes people pay equals governmental expenditures. Depending on the mode of transport used, different fees or costs apply to individuals in the Auckland region.

Private as well as public transport operational costs are made up of fixed costs as well as running costs, which among other out-going expenses might include: vehicle purchasing costs, registration, Warrant of Fitness, fuel, insurance cost, repair & maintenance (AA, 2002). These costs are variable as they very much depend on the type and age of the vehicle and the current cost of fuel.

However, as the research examines what an individual pays to support the system, only the fixed costs of transport, those which flow into the national, regional, local governments are of interest. Costs that private vehicle users are faced with include: road user charges, levies on fuel, relicensing and motor vehicle registration fees which flow into the National Roads Fund (MoT, 2002a), and transport taxes to local government. People travelling on public transport support the transport system by paying taxes and via public transport fares.

The taxes collected in 2001 were NZ$22.3 million for public transport, NZ$625.5 million for private transport and NZ$39.5 million from local rates (Jakob, 2003). This includes direct taxes of $521, 017, 860 and an additional $166, 264, 140 paid indirectly with land taxes. Thus the total tax obtained from transport in 2001 in the Auckland region was approximately $687.3 million. Direct costs (taxes) paid by private vehicle owners or users to support the transport system in 2001 in the Auckland region were on average $0.07 pp/km (per passenger per kilometre). Taxes paid by public transport users and the bus company were $0.03 pp/km. (Table 1). This has been calculated via the average bus (26.29 passengers) and car (1.3 passengers) occupancy and total annual vehicle kilometres travelled for buses (26 million km) and cars (6,968 million km) in 2001. In addition, others such as cyclists and walkers paid $140 per person per year in rates to local and regional councils for transport related expenses in 2001. These are not included in the above-mentioned statistics.

Table 1 about here

3. EXTERNAL COST OF TRANSPORT

To estimate the total cost of transport, it is necessary to look at indirect or external costs simultaneously. External costs are not born by the public and private transport users - they are paid by others, generally the society as a whole, but also the environment. These mainly comprise: external accident, air pollution, climate change, external parking, congestion costs and others (Becker, 2002; Litman, 2002). Of all transport related external costs evaluated in the literature, external accident, air pollution and climate change are the three largest (Maddison, 1996), comprising 77% of the overall costs (Becker, 2002). Therefore these three costs are considered in this chapter. One has however to keep in mind that the degree of confidence varies between these three costs. Whereas accident costs, like property damage, can be calculated quite precisely, climate change costs are less certain. For this reason a very conservative approach has been applied which is discussed in more detail throughout this section.

The literature suggests several techniques to quantify and monetise external effects of motor vehicle transport such as damage cost method, control or prevention cost method, hedonic compared to contingent valuation method. These methods are described in detail in Bruce (1995), Himmel (1999), Litman (2002). None of these methods can be used to estimate all motor vehicle related external costs without uncertainties. For each impact a different approach according to its nature has therefore been applied and uncertainties stated which has likewise been done in Becker (2001), Litman (2002), Maddison (1996) or Maibach (2002).

3.1 Accident Costs

Estimating the external cost of the overall total costs of accidents, involves three major steps. Firstly the costs caused via motor vehicle accidents must be identified. Secondly whether or not these costs are internalised or externalised must be determined, and thirdly a monetary value must be placed on these effects (Maddison, 1996).

3.1.1 Direct and Indirect costs

The direct and indirect costs comprise medical costs, rehabilitation costs, and legal costs. These include medical treatment, ambulance costs, aftercare, rehabilitation, nursing, financial aid, police and legal costs, insurance costs, new employment costs[4] and property damage (Becker, 2002).

Direct costs such as medical, rehabilitation, and aftercare costs, are covered in New Zealand via the Accident Compensation Corporation (ACC). ACC is funded via the motor vehicle registration fee and levy on petrol sales. With this policy, ACC covers approved costs for no-fault personal injury for all victims involved in a motor vehicle road crash, including passengers, pedestrians, cyclists and car users, regardless of who caused the accident (ACC, 2002). In the case where ACC is fully funded via road user charges, direct costs can be seen as internal costs. This however was not the case in 2001, when ACC did not charge enough for road accidents and experienced a budget shortfall of $30 million (Griffiths, 2002). Costs arising from motor vehicle accidents in Auckland were 21% of the total (ACC, 2002). Hence, external costs for crashes in the Auckland region were $6.3 million.

Indirect costs include: costs to police, legal costs and costs from training new people for jobs, referred to here as 'new employment costs'. Regarding the New Zealand Police, costs can be seen as completely internal as they are met from the National Road Fund which is funded via road user charges, levies on petrol, and motor vehicle registration fees. Legal costs can be seen as fully external as they impose costs on the society as a whole. The LTSA (Land Transport Safety Authority) estimated legal and court costs for different severities in motor vehicle crashes (Table 2). Using causality statistics from the LTSA (LTSA, 2002), external legal and court costs in the Auckland region amounted to $1,974,900 in 2001.

Insert Table 2 about here

New employment costs are totally external, as businesses are usually unable to reclaim expenses from ACC. Estimates of new employment costs for fatal and serious injuries appear unknown for New Zealand. Becker (2002) however, estimated these costs for a federal state in Germany. These results have been adjusted to provide new employment costs for Auckland. The costs for fatalities and serious injuries have been adjusted according to the gross domestic product differences between New Zealand and Germany per capita for 1999, since the costs for the German study were estimated for 1999 (SBD, 2002b; Statistics NZ, 2002b). The resulting value has then been increased according to the gross domestic product increase of New Zealand between 1999 and 2001 (Statistics NZ, 2002b). The results can be seen in Tables 2 & 3.

Insert Table 3 about here

3.1.2 Costs due to loss of production

Costs arising from the loss of production are those relating to the total economic loss of productivity due to fatalities and permanent or temporary work inability. These cause a reduction in the overall gross domestic product of the country (Becker, 2002).

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[4] New employment costs arise, when due to a serious or fatal injury, businesses have to train or hire a new employee (Greene, 1997).

The best method to assess these costs was found to be the net output loss equation as indicated in Becker (2002), Jakob (2003) or Maibach (2002). The net output loss, reflects the economic impact of the fatality on the rest of the society (Maddison, 1996). There is uncertainty relating to the social costs resulting from the death of a disabled person or anyone past retirement age. Hence an overall average has been taken (Maddison, 1996).

To calculate the gross product loss, the average loss of work time has to be multiplied by the average income. The Ministry of Transport (MoT) estimated the average loss of life expectancy due to motor vehicle accidents is 33 years (Fisher, 2002). Multiplying this with the average income received by employees (Statistics NZ, 2002d) gives a gross product loss of $976,404.

To obtain the value for the net product, the overall consumption has to be subtracted from the gross product loss. The gross national expenditure is the sum of private and governmental consumption. New Zealand Statistics only give the value for private consumption up to 2000 (Statistics NZ, 2002a), thus this value has to be adjusted to the yearly consumption increase and then divided by the population. Therefore the consumption per person in 2001 was $16,922.

Two important economic factors still need to be considered: yearly consumption increase and time preferential rate[5]. The research has shown that these factors cancel each other out so interest rates have not been considered (Becker, 2002).

With an average loss of lifetime of 33 years and a per person yearly consumption of $16,922, the average loss of consumption per fatality is $558,426. Subtracting this from the gross product loss of $976,404 gives a net product loss per fatality of $417,978. This value can be seen as the amount of money, which would have been available to future generations in the case of a non-fatal accident (Becker, 2002). This however, is only the loss of production caused by fatalities. The serious and minor injuries have been estimated based on Becker (2002) as these costs have not yet been estimated for New Zealand. The values can be seen in Table 4.

Insert Table 4 about here

3.1.3 Non-Market costs

Non-market costs include monetary values, which arise in the form of housekeeping and undisclosed earnings (Becker, 2002). These costs are not included in the yearly gross domestic product and are thus not covered in the costs caused due to loss of production. The federal agency for transport in Germany (BAST) estimated these costs for 1999 (Becker, 2002), which is again used to estimate the non-market costs for New Zealand. To adjust the values obtained in Germany to New Zealand dollars, the income differences will be compared and adjusted for inflation over the two years (Table 5).

[5] Time preferential rate or time value of money discounts future benefits. Discount rates recognise that money invested today can create future benefits, hence increase benefits (Litman, 2002). This means that current resources are valued more than future resources (Becker, 2002).

Insert Table 5 about here

3.1.4 Humanitarian costs

Humanitarian costs include costs such as: the pain and suffering of relatives, loss of quality of life and psychological impacts among others. Maibach (2000) and Becker (2002) estimate these costs via the willingness to pay method, which is also applied here. For New Zealand, this method resulted in $2,546,000 for fatal, $254,700 for serious, and $10,200 for minor injuries (LTSA, 2001a, 2001b). It is often argued that the valuation of a human life is neither reliable nor appropriate. Nevertheless many studies show that this figure is far from negligible. Therefore, it is more accurate to incorporate it with high uncertainties than to bias the result by not valuing a persons' life. For the high uncertainty reason a very conservative value is applied here, which is much lower than compared to other studies, e.g. $5.2 million – ExternE Project (1995 in Schade 1998), $6.2 million – ISI Fraunhofer Institute (1997 in Becker 2001). The NZ$2.546 million figure was derived for the Ministry of Transport (MoT 2002b), and is widely used in studies of transport economics in New Zealand.

However, these costs are applied only to people involved in the accidents who were not at fault. This is based on the assumption that drivers of road vehicles are aware of the personal risk of crashes, which therefore is internalised. They do not however, account for the additional risk drivers pose to other road users and hence have to be estimated (Hohmeyer, 1995; Maibach, 2000).

Neither the LTSA nor ACC have statistics for how many people have been at fault in relation to injury severity. Therefore it is assumed here that 50% of all injury involves people being at fault, and 50% of people being not at fault (Table 6). Nevertheless, this is an underestimate as usually there are more non-fault victims in a car crash on average than people at fault. As the cost estimate should be conservative, only 50% of all injuries are considered not at fault.

Insert Table 6 about here

3.1.5 Property damage

Car crashes often involve damage to the vehicle or damage to properties. In the case of people being at fault, costs arising are imposed on them either directly or via an increase in their insurance premium. For people being not at fault damages are covered by the driver at fault or by the third-party insurance. Thus in either case costs are paid by motor vehicle users and hence can also be classified as internal costs (Becker, 2002; Maddison, 1996)

3.1.6 Adjustment for non reported injury crashes

With the exception of fatal crashes, not all motor vehicle accidents are reported, and as such they are not included in statistics. Consequently, an adjustment factor, established by LTSA (2001a), which is 2.7 for minor and 1.9 for serious injuries in urban areas will be used. For rural areas the adjustment factors are even higher. Therefore this study again looks at a lower estimate to calculate the overall costs.

3.1.7 Total external accident cost

Summarising all the external costs arising from motor vehicle related accidents in Auckland gives a total value of NZ$344 million (Table 7), or $573 per registered motor vehicle.

Insert Table 7 about here

In total, accident costs are 2.6% per person GDP in Auckland. Of the total external costs, car related accidents, excluding taxis, are the highest proportion. Only 0.45% of the total costs can be related to public transport. Therefore public transport related external costs amount to just $1.6 million in 2001, compared to $278.7 million for private transport (Figure 1). The remaining $63.8 million is attributable to trucks and freight transport.

In summary, with 0.45% of the total cost relating to public transport, the external accident costs in 2001 in the Auckland region were $0.06 per km from this mode compared to $0.04 per km on private transport (Table 8). However, per passenger kilometre the external costs of accidents caused by public transport were less than by private transport.

This shows that motor vehicle users do not account for $0.030 per kilometre of the cost they impose on society, compared to $0.0023 of public transport users. For accident costs, therefore, society subsidises private transport by $0.028 pp/km more than public transport.

Insert Fig 1 about here

Insert Table 8 about here

3.2 Air Pollution Costs

Air pollution caused by motor vehicle traffic has significant health, agricultural, ecological, climatic and aesthetic effects on society. Our study, in accordance with international research (Becker, 2002; Litman, 2002; Maddison, 1996; Maibach, 2000), assumes that all effects caused by traffic related air pollution are external. This can be stated on the basis that all costs arising from air pollution are covered by the Government, via taxes or insurance companies (which is only a minor contribution), that do not differentiate between private vehicle owners or non-owners (Becker, 2002). The main health costs are covered by the Government and therefore pose costs to the general public.

Internal transport costs arise solely from people who pay rates/taxes and experience personal health damage while driving, but only if these costs are not covered by insurance companies. According to Becker (2002), however, these damages are minimal compared to the overall traffic-related air pollution effects.

3.2.1 Health damage

From all the various vehicle air emissions, several studies suggest that PM_{10} is the best indicator for evaluating motor vehicle health impacts (Becker, 2002; Fisher, 2002; Maddison, 1996).The method establish by Maibach (2000) was therefore chosen as the most appropriate for calculating air pollution related health costs caused by motor vehicles, as this study estimated an average European value for illnesses arising from PM_{10} pollution based on WHO (World Health Organisation) suggested illnesses. The cost per illness is estimated by multiplying the value by the number of cases arising per 10 µg/m³ PM_{10} (a measure of the fine particulates emitted in vehicle exhausts) increase. The result is then multiplied with the traffic related PM_{10} value, which is 16 µg/m³ for New Zealand (Fisher, 2002), to obtain the total health cost.

When applying this method, the costs for each illness have to be attributed to the New Zealand situation, as medical costs, for example, are lower in New Zealand than in Europe. Therefore each illness is less expensive in New Zealand than the costs stated in Maibach (2000).

The difference can be estimated via the value of one statistical life (VOSL), which has been assessed for both New Zealand and Europe/Germany. Due to income differences, the New Zealand value is only 85% of the German value. The other values are adjusted accordingly to 85% of the European values (Table 9).

Insert Table 9 about here

Uncertainty arising from this method lies in the fact that only the PM_{10} value as a pollutant is considered. Thus this estimate neglects other pollutants and their health impacts e.g. 1,3 butadiene, which is suspected of causing cancer (Maddison, 1996). Therefore this method is an underestimate of the real costs.

With a PM_{10} value of around 16 µg/m³ caused by motor vehicle exhaust (Fisher, 2002), the additional illnesses amounted to $422 million (range: $298 million to $795 million) in 2001. This is 57% of the total health cost arising from PM_{10} in the Auckland region (Table 10). Including tyre and brake wear (Joynt, 2002), the total costs amounted to \$554 million (range: \$429 million to \$926 million). Therefore it is calculated that \$554 million in additional health costs in 2001 are due to motor vehicle PM_{10} pollution, totalling 1.7% of the GDP produced by 1.2 million Aucklanders, or \$466 per capita. Of the total value, 38.2% (\$211.6 million) was due to private vehicles, whereas 3.1% (\$17.2 million) came from public transport.

The remaining \$325.2 million is attributable to truck and freight transport. These health costs are not 'out of pocket costs' but perceived welfare loss of the population, estimated with the willingness to pay method.

Insert Table 10 about here

With a PM_{10} background level of 7.5 $\mu g/m^3$, premature mortality from vehicle air pollution is more than three times the death rate from motor vehicle accidents in 2001 (Figure 2) and is already referred to as the 'hidden road toll' (Fisher, 2002).

Insert Figure 2 about here

These results, which are similar to those found in international research, show that air pollution health impacts are far from negligible (Figure 2). Air pollution may increase in the future with more and more motor vehicle use and the current trend of increasing private diesel vehicles. Therefore to obtain long-term health benefits, it is necessary to reduce substantially traffic related air pollution.

3.2.2 Damage to vegetation and buildings

Assessments were made using standard methodologies of the damage to vegetation and buildings in the region (Jakob, 2003). These were found to be very minor compared to other costs, amounting to less than \$10,000 per year for Auckland. This is due to the relatively low levels of ozone, which represents the major source of damage in many other developed countries.

3.2.3 Total air pollution costs

In summary, of the total air pollution costs in 2001 in the Auckland region, \$211.1 million can be attributed to private vehicles, and \$17.2 million is a result of public transport operations in the Auckland region. A further \$325.2 million is attributable to truck and freight transport (heavy duty and light duty commercial vehicles) (Table 11). All of these can be considered external costs and are underestimates. The remaining \$0.6 million is attributable to others such as motorcycles. Figure 3 demonstrates this relationship.

Insert Table 11 about here

Insert Figure 3 about here

These figures translate into cost of $0.64 per km on public transport, compared to $0.034 per km on private transport (Table 12). On a passenger per kilometre basis, the costs are comparable for public and private transport.

Insert Table 12 about here

With current transport patterns, private transport is 10 fold more subsidised by society compared with public transport. Having regard to air pollution costs per passenger kilometre, society subsidises private transport as much as public transport. The public transport cost is high relative to many developed countries and shows that buses in the Auckland region are of poor quality when considering air pollution emission factors.

3.3 *Climate Change Costs*

In recent years the discussion on worldwide climate change has increased, and there is now considerable evidence that there is an anthropogenic impact on the global climate as a result of greenhouse gas (GHG) emissions (Bruce *et al*., 1995). Large uncertainties underlie the cost calculation of global climate change, as the assessment of damage to the climate is fraught with many difficulties (Litman, 2002; Meyer, 1998).

The impact on the global climate involves long term processes, where the dose-response relationship is not clearly known. Several studies have calculated the damage, and included the loss of agricultural productivity, health costs and the increase of the oceanic level with its potential impacts. However, none include the impacts of extreme weather events, like cyclones, droughts and floods, as they are currently impossible to estimate (Becker, 2002). Because of these factors, the effects of the current emission of greenhouse gases on future generations cannot be determined exactly.

The inability to quantify effects however, should not justify inaction. This was emphasised by the United Nations Environmental Programme (UNEP) and Intergovernmental Panel on Climate Change (IPCC) (Litman, 2002), which stressed the importance of reducing GHG emission. The CLIMPACTS (2001) Synthesis report, for example, concluded that New Zealand will experience GHG-induced climate warming, although it might be less than the worldwide rate of global warming due to New Zealand’s maritime location.

This study calculates these costs for the Auckland region on an 'at least' approach, which is consistent with the previous assessments. To evaluate climate change cost, a unit cost per tonne CO_2 is applied as in accordance with international studies e.g. Maibach (2000), Becker (2002). It appears that a unit cost of $270 per tonne of CO_2 is the best available at present (Jakob, 2003). The New Zealand government however decided the carbon tax to be not higher than NZ$25 during the first commitment period (2008-2012) (MGCC, 2002). Therefore the research bases the climate cost calculation on NZ$25 per tonne CO_2. However it should be kept in mind that this unit cost is somewhat lower than European or North American unit costs. (Note added in proof: As of late 2004, the NZ Government set a carbon tax, to apply to all emitters of CO_2. This is NZ$15 per tonne, to apply from 2007.)

With this unit cost, the total costs from private and public transport in Auckland were $58.4 million in 2001. Of this, public transport contributed $0.67 million in costs, with $57.8 million coming from private transport. Referenced to the Gross Domestic Product produced by the 1.2 million residents of Auckland, this calculated monetary value results in 0.2 % of GDP (Statistics NZ, 2002b).

3.3.1 Total climate change cost

All climate change costs arising from carbon dioxide emissions are external costs. Despite high carbon dioxide emission differences between buses (1000 g/km) and cars (350.5 g/km) (NIWA, 1998), private vehicles, due to their numbers, produce 99% of overall transport related carbon dioxide emissions (Figure 4).

Insert Figure 4 about here

The IPCC estimated in 1995 that most studies calculated annual transport emissions costs in the range of 0.5% to 2% of GDP for OECD countries (Bruce, 1995). These costs were 0.2% in 2001 for the Auckland region. The difference among these studies mainly results from the fact that New Zealand applies a much lower unit cost per tonne CO_2 than European countries.

In summary, the climate change costs in the Auckland region in 2001 were $0.025 per km on public transport compared to $0.009 per km on private transport (Table 13). However, per passenger, the climate change costs caused by public transport were less than by private transport. In other words, motor vehicle users do not account for $0.007 pp/km driven of the cost they impose on society, compared to $0.001 from public transport users. Regarding climate change costs therefore, society subsidies private transport by $0.006 pp/km more than public transport.

Insert Table 13 about here

3.4 Total External Cost

This study has examined the three largest external costs of transport: external accidents, air pollution and climate change costs using the methods of Becker (2002), Maibach (2000) and Maddison (1996). International studies have shown that these costs account for 77% of the total external costs (Becker, 2002).

For the Auckland region, the study estimates these costs to be $956 million (range: $831 million - $1,328 million) for 2001, which is 2.9% of the GDP produced by the 1.2 million Aucklanders or $805 per citizen. This result fits well with international research. In Germany, for example, the same costs were assessed to be $1,368 per person or 2.7% of the GDP produced by the 4.4 million citizens of Saxony (Becker, 2002). Whereas another study (by Rottengatter in Maddison (1996)) assessed external costs to be 4.2% of Europe's GDP in 1994.

Of the overall amount, 36% are due to external accident costs, 58% due to air pollution, and the remaining 6% are due to the costs arising from transport induced climate change (Figure 5).

Insert Figure 5 about here

The relationship between private and public components of transport related costs ($567 million) is 96.6% due to private transport, and only 3.4% are attributable to public transport. Per registered motor vehicle external private transport costs amount to $913 per year.

In summary, the external costs arising from transport (private and public) in the Auckland region in 2001 were $0.08 per km on private and $0.73 per km on public transport. However, as demonstrated, per passenger, costs arsing from private transport are higher. In total these amounted to $0.062 pp/km, compared to $0.027 pp/km from public transport. Therefore private transport is subsidised by 3.5 cents pp/km more than public transport (Table 14).

Insert Table 14 about here

If motor vehicle users were to pay the full amount of the costs they impose on the society and the environment, the 2001 petrol and diesel prices would both need to be increased by $0.68 per litre. With regards to public transport, an increase in diesel price will most likely automatically lead to an increase in passenger fares as well. By how much depends on the fuel consumption and vehicle kilometres travelled of each bus company.

However, it would be inappropriate to just raise the fuel price as a consequence of internalising external costs, as a tax on fuel does not reflect total motor vehicle costs (Litman, 2002). For example, external parking costs demand an increase in the parking fee whereas air pollution requires an emission fee. Raising just the fuel tax would be an injustice to low emission vehicle drivers. Therefore, internalising external costs requires expenditures across a number of areas. Nevertheless, the aforementioned increase in fuel price, which would cover the external costs of transport, illustrates the extent of the problem.

Generally it can be concluded, that with current transport patterns, public transport generates $528.1 million less in subsidies paid for by society compared to private transport. However, air pollution and climate change, (as well as external accidents costs to some extent), are not 'out of pocket costs' or tangible costs as such, but perceived welfare losses to the general society.

It should be noted that these estimates are based on average vehicles and conditions. The monetary value might vary significantly depending on specific factors, for example, the type of vehicle, location and time (Litman, 2002).

4. CONCLUSION AND RECOMMENDATIONS

Motorised transport has become an essential part of present day developed society. However, worldwide, the current level of independent vehicle fossil fuel based transportation is increasingly causing social, environmental and economic problems. An efficient, economically and environmentally sound transport system can only be a result of a thorough transport cost assessment, which includes the valuation of products that at present have no market value e.g. clean air. This research has focused on assessing the total cost of private vs. public transport. It estimates the external and internal costs for transporting one person per kilometre in the Auckland region of New Zealand.

The focus has been on a costs assessment from a societal perspective, as it is not relevant here how much individuals pay to purchase their cars, nor the costs they face through other factors such as congestion delays. When designing an efficient transport system, however, it is essential to know how much the government and society in general pay to support transport. This can indicate where subsidies may be provided and will allow society to determine whether these are producing desired or perverse outcomes.

Our study found that external costs of transport in the Auckland region were $956 million (range: $831 million - $1,328 million) for 2001, which is 2.9% of the GDP produced by the 1.2 million Aucklanders or $805 per citizen. This result is consistent with results from international research. For Germany the costs were assessed to be $1,368 per person or 2.7% of the GDP produced by the 4.4 million citizens of Saxony. Whereas others assessed external transport costs to be 4.2% of Europe's GDP in 1994).

The estimation for Auckland results from the evaluation of the three largest external costs according to Becker (2002), Maibach (2000) and Maddison (1996): external accident, air pollution and climate change. Together these comprise 77% of the total external costs.

In comparison to the $956 million in external costs, total revenues collected from private and public transport were $687 million in the Auckland region for 2001. Figure 4 shows the split of revenues collected and total transport cost (internal + external) of public and private transport with their origin.

Insert Figure 6 about here

Internal (or user 'paid') costs for private transport were $625.5 million and for public transport were $22.3 million. External (or user 'unpaid') costs were $547.6 million for private transport and $19.4 million for public transport. Assuming that these external costs represent only 77% of total external costs as was found in other international studies (Becker, 2002) and extrapolating to 100%, to include all potential external costs, results in total costs of $25.2 million for public transport and $711.1 million for private transport. Therefore in Auckland public transport generates $685.9 million less in subsidies paid by society compared to private transport. Public transport users literally subsidise private transport users and not the other way around as often claimed. The external cost differences can be argued to result from private transport being used more than public transport. For that reason it is important to look at the passenger cost per kilometre.

In summary, private transport is subsidised 4.7 cents per person per kilometre more than public transport (Figure 7). Air pollution and climate change, (as well as external accidents costs to some extent), are not 'out of pocket costs' or tangible costs as such, but perceived welfare losses to society in general.

Insert Figure 7 about here

In ideal circumstances all incoming transport taxes and rates would be spent on public and private transport costs. To what extent internal costs (revenues) are transferred from the 'National Roads Fund' to pay for external costs can only be assessed by governmental estimates as precise figures are not available. The external cost of at least $736 million per annum is not covered as revenues raised are spent primarily for direct costs such as road construction, LTSA or police (MoT, 2002b) which in total amount to $687 million (see section 2).

Although it cannot be said exactly how much of the external cost is not paid by transport users, the results can still aid more efficient transport decision making. Each policy can be evaluated for how much it might reduce overall expenses. This study showed that up to $287 million (climate change and air pollution costs) can be saved by reducing emissions. If the local government for example implemented zero emission public transport buses, up to $18 million could be saved per year[6]. Decreasing private vehicle usage by 10% results in up to $71 million saved, whereas a 10% decrease in private vehicle PM_{10} emission would result in $21 million saved. Such a policy for example could be to check air emission during the warrant of fitness, as is already implemented in many European countries.

There are various transport decisions which aim at efficient, sustainable and environmentally friendly transport policies (Jakob, 2003). One potentially effective solution is to ensure that prices reflect marginal costs. This means charging drivers for the costs they impose on the society, for example for their pollution. An emission tax on private transport is likely to reduce overall usage and hence their effects. Correcting the current belief that public transport users are subsidised more than private car users is especially necessary. No attempt has been made to evaluate all different transport policy options in detail.

Overall, the solution to the current transport problems in the Auckland is neither subsidised public transport nor an extension of the current motorway system but an efficient public transport system combined with a private transport system that pays more of its external costs. Policies should aim at firstly reducing and secondly internalising these external costs.

Reducing and internalising external costs would lead to transport decisions that are more efficient in economic, environmental, administrative and social aspects. They would be in accordance with Ministry of Transport objective that "*by 2010 New Zealand will have a transport system that is affordable, integrated, responsive and sustainable*". Imposing appropriate user fees, would encourage innovations in the transport sector, decrease vehicle use and enhance the demand for alternative modes of transport. The result would be a better transport system - less pollution, less congestion, and fewer accidents. A city, which is designed for people, for their mobility, for quality of life, and for future generations - rather than just for cars.

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[6] This includes not the acquisition cost of zero emission buses nor facilities, but focuses just on the annual emission reduction and consequently saved costs.

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Table 1

Total internal costs arising from transport in the Auckland region in 2001 in NZ$.

Internal Costs	Per km	Per passenger/km	Total Tax
Public transport providers	0.837	0.032	22,347,006
Private transport users	0.095	0.073	625,504,880
Local government contribution			39,430.054
TOTAL			687,281,940

Table 2

Legal and court costs per person at June 2001 prices (LTSA, (2001a); New employment costs on the basis of findings from Becker (2002), adjusted to New Zealand dollars.

External costs	Fatal	Serious	Minor
Legal costs	$6,600	$1,400	$300
New employment costs	$3,615	$3,615	$0

Table 3

Total Direct and Indirect Cost and the proportion caused by motor vehicles and public transport in NZ$.

Factor	Direct/Indirect Costs
Medical Costs	$6,300,000
Legal and Court Costs	$1,974,900
New Employment Costs	$2,143,695
TOTAL	$10,418,595

Table 4

Costs due to loss of production in NZ$ in 2001, calculated according to Becker (2002), LTSA (2002), and Fisher (2002), and proportions due to private motor vehicle and public transport

Type	Casualties	Cost per Causality	Total
Fatal	65	$417,978	$27,168,570
Serious	528	$54,337	$28,689,936
Minor	2689	$2,717	$7,306,013
TOTAL			$63,164,519

Table 5

Non-market costs in 2001 in NZ$. Calculation according to BAST (1999) cited in Becker (2002), Statistic NZ (2002), SBD (2002a).

Type	Undisclosed Earnings	Housekeeping	Sum	Casualties	Total
Fatal Injury	$98,382	$322,077	$420,459	65	$27,329,835
Serious Injury	$2,936	$10,524	$13,460	528	$7,106,880
Minor Injury	$146	$372	$518	2,689	$1,392,902
TOTAL					$35,829,617

Table 6

Humanitarian Costs in NZ$ arising from motor vehicle crashes in 2001 in Auckland for non-fault victims. Calculation according to LTSA (2001a, 2002).

Type	50% casualties	Value of a statistical life	Total value
Fatality	33	$2,546,900	$84,047,700
Serious	129	$254,700	$32,856,300
Minor	1345	$10,200	$13,719,000
TOTAL			$130,623,000

Table 7

Total external accident costs in the Auckland region in 2001

Statistics	Fatal	Serious	Minor	Total
Causalities in Auckland	65	528	2689	3282
Causalities adjusted*	65	1003	7260	8328
Costs				
Medical				$6,300,000
Legal and Court	$429,000	$1,404,480	$2,178,090	$4,011,570
New Employment	$234,975	$3,626,568		$3,861,543
Loss of Production	$27,168,570	$54,510,878	$19,726,235	$101,405,683
Non-Market	$27,329,835	$13,503,072	$3,760,835	$44,593,742
Humanitarian	$84,047,700	$62,426,970	$37,041,300	$183,515,970
TOTAL				$343,688,508

* Adjusted to account for unreported accidents

Table 8

External accident costs of public transport compared to private transport in 2001 in the Auckland region.

External Accident Costs	**Public Transport**	**Private Transport**
Per km	$0.06	$0.04
Per passenger and km	$0.0023	$0.03
To society	$1.55 million	$278.7 million

Table 9

Additional illnesses per 10 μg/m³ PM_{10} estimated using the willingness to pay method by Maibach (2000) and adjusted to Auckland's population for each age group (Statistics NZ, 2002c).

Health effect	**No. of cases**	**Value [NZ$]**	**Unit**
Mortality (adults > 30 years)	225	1,553,609[7]	Per lost life
Admission to hospital due to respiratory diseases (all age groups)	197	13,379	Per case
Admission to hospital due to cardiovascular diseases (all age groups)	372	13,379	Per case
Chronic bronchitis (adult >=25 years)	300	355,300	Per case
Bronchitis (children <15 years)	1121	223	Per case
Activity restriction (adults >= 20 years)	203,195	160	Per case
Asthma attack (children < 15 years)	651	53	Per attack
Asthma attack (adults >= 15 years)	5,608	53	Per attack

Table 10

Health costs due to motor vehicle PM_{10} exhaust only emission in the Auckland region in 2001 ($ million), calculated with different background levels as in Fisher (2002).

	High cost	**Most likely**	**Low cost**
Total health costs	$1,118m	$745.3m	$621m
Road traffic related health costs (vehicle exhaust only)	$795m	$422m	$298m

Table 11

Total air pollution cost as a result of damage to human health, agriculture and forests.

[7] This willingness to pay value represents only 61% of €1.5 million, as the average mortality age due to PM_{10} pollution rises with increasing age, and thus is much higher than the average age of accidents (Maibach, 2000). This is in accordance with the Ministry of Transport, who indicated that a traffic accident death has twice the impact on public health of non-external death (dying from air pollution). This results from the fact that accidents affect young people (loss of potential life-span 33 years) whereas air pollution death faces on average a loss of a potential life span of 14 years (Fisher, 2002). The same approach has been applied by other studies e.g. Seethaler (2002).

Air Pollution Cost	Public Transport	Private Transport	Truck / freight Transport	Total
Health Cost	$17,200,000	$211,600,000	$325,200,000	$554,000,000
Agricultural Damage	$357	$5,077	$5,066	$10,500
Forest Damage	$4	$52	$56	$112
Total	$17,200,361	$211,605,129	$325,205,122	$554,010,612

Table 12

Air pollution costs to individual and society from public transport vs. private transport.

Air Pollution Costs	**Public Transport**	**Private Transport**
Per km	$0.64	$0.032
Per passenger and km	$0.024	$0.025
To society	$17.2 million	$211.1 million

Table 13

Climate change cost to individual and society arising from public vs. private transport.

Climate Change Cost for unit cost NZ$25	**Public Transport**	**Private Transport**
Per km	$0.025	$0.0088
Per passenger and km	$0.001	$0.0067
To society	$0.67 million	$57.76 million

Table 14

Total external costs arising from transport in the Auckland region in 2001.

External Costs	**Public Transport**	**Private Transport**
Per km	$0.73	$0.08
Per passenger and km	$0.027	$0.062
To society	$19.4 million	$547.5 million

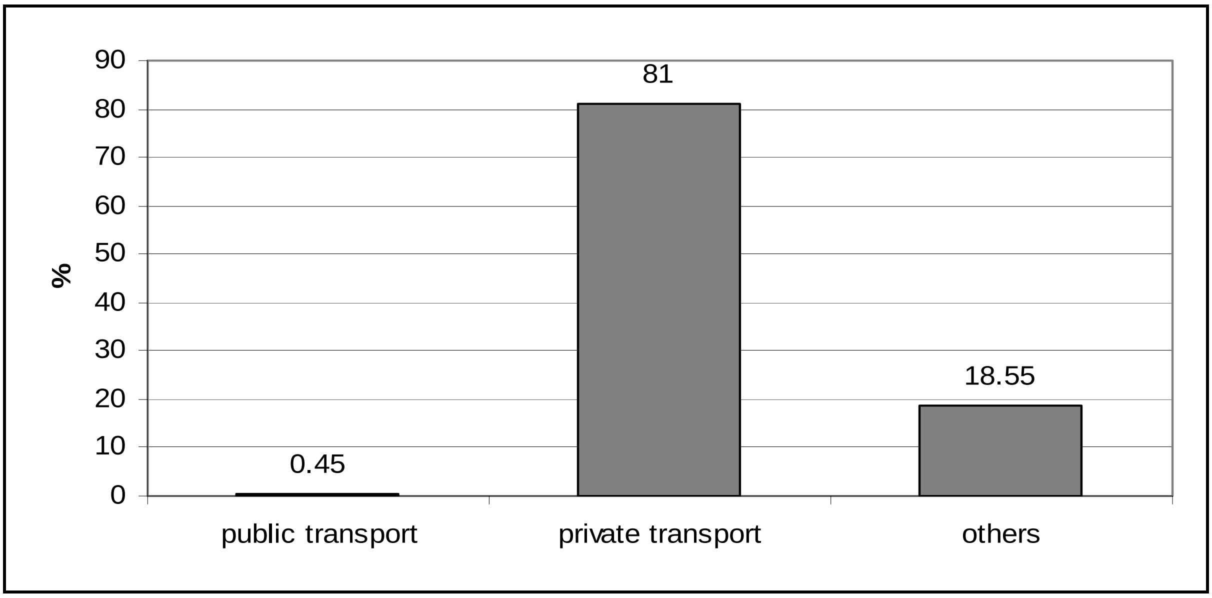

Figure 1: Proportion of public vs. private transport on the external accident costs. “Others” represents truck and freight transport.

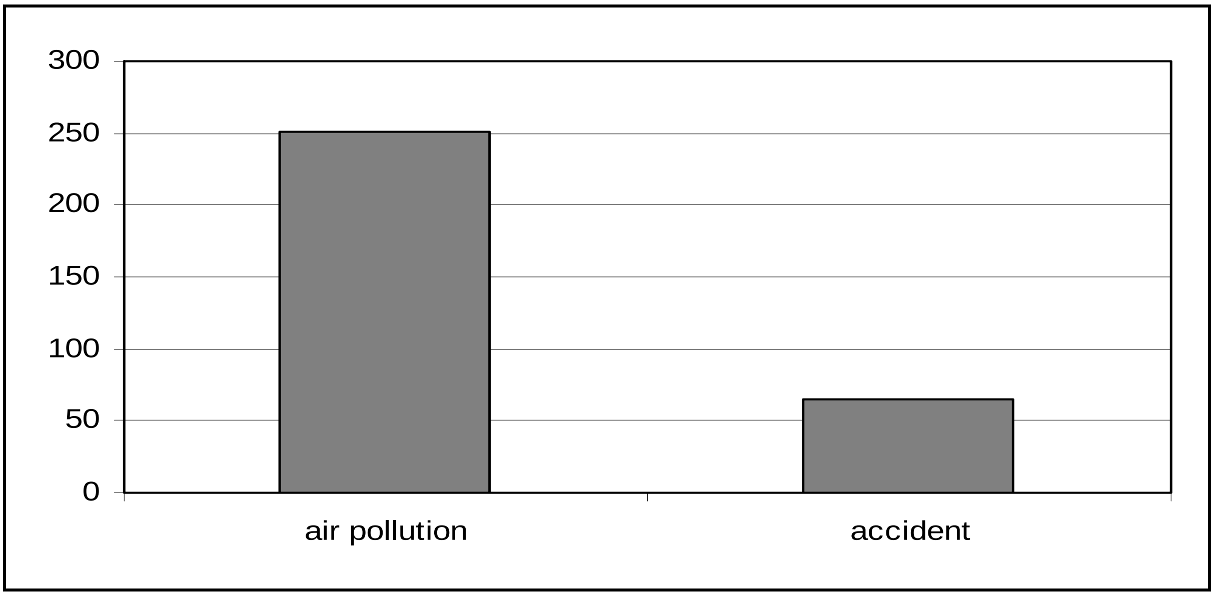

Figure 2: Mortality in 2001 as a result of air pollution vs. motor vehicle accidents (LTSA, 2002c).

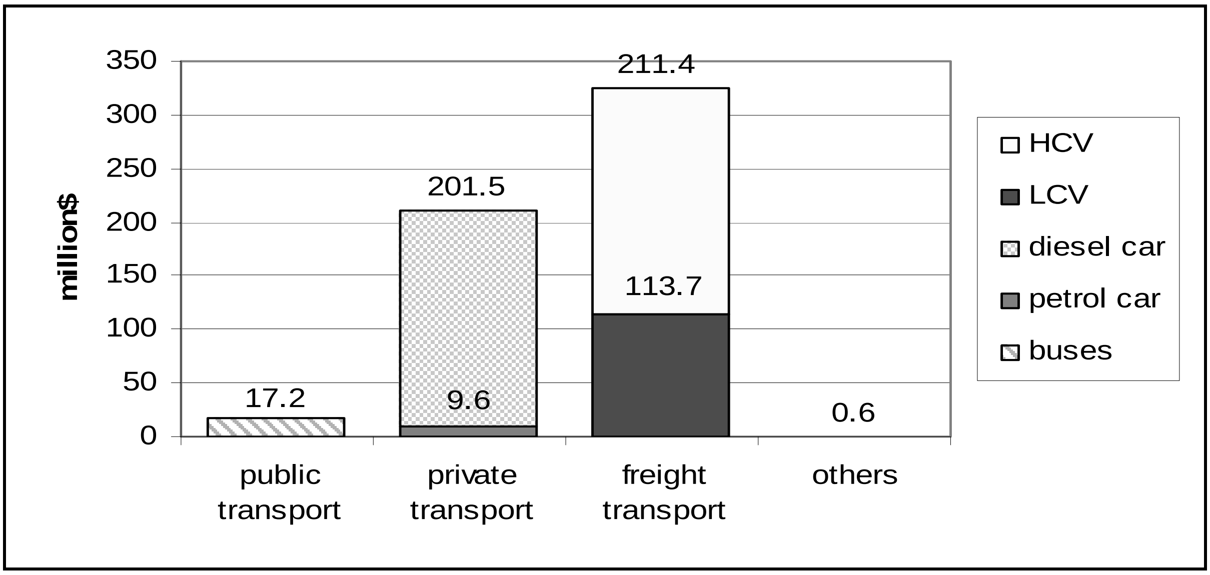

Figure 3: The contribution of public, private and other transport to the overall air pollution cost in the Auckland region for 2001.

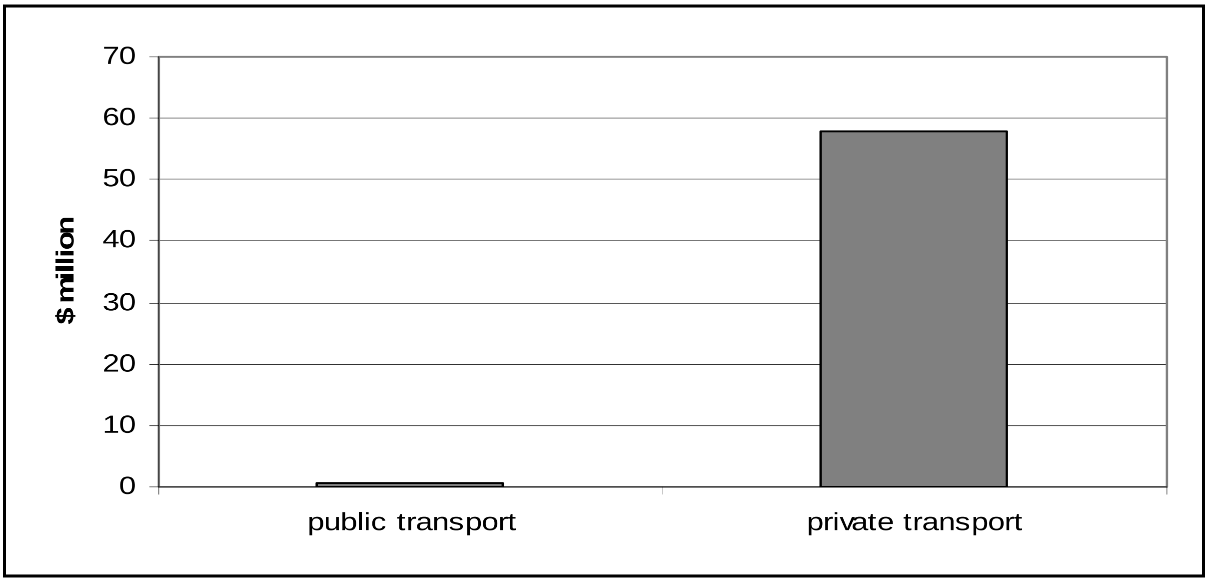

Figure 4: Climate change costs caused by public transport vs. private transport

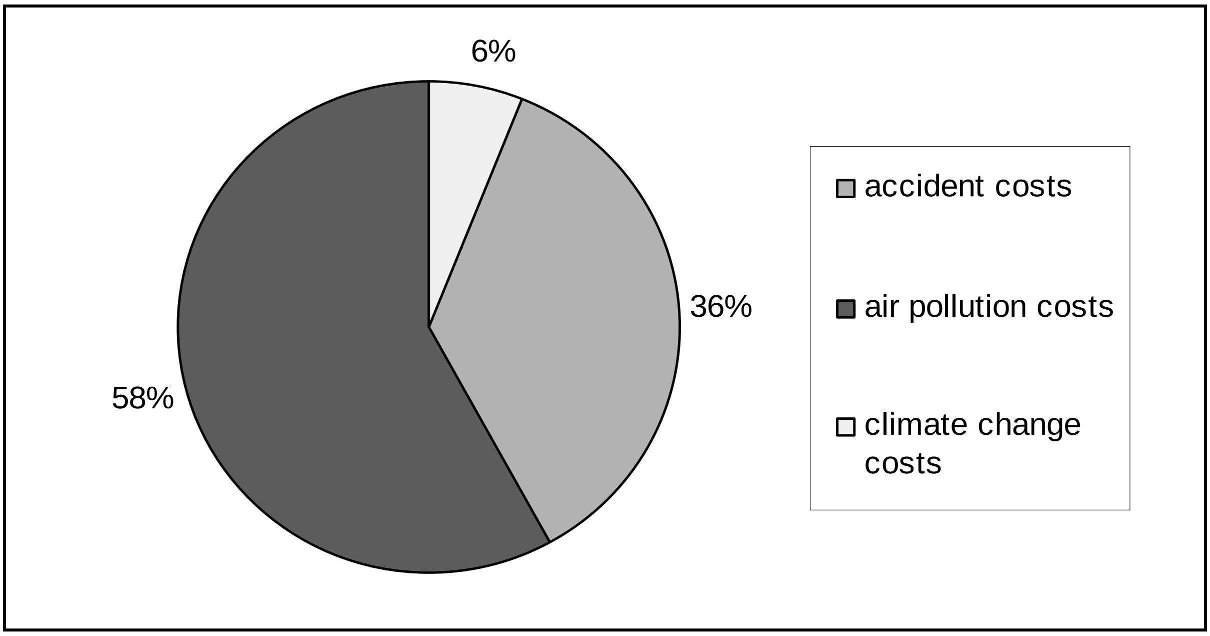

Figure 5: The proportion of external accident, air pollution and climate change costs on the total external cost arising from transport in the Auckland region in 2001

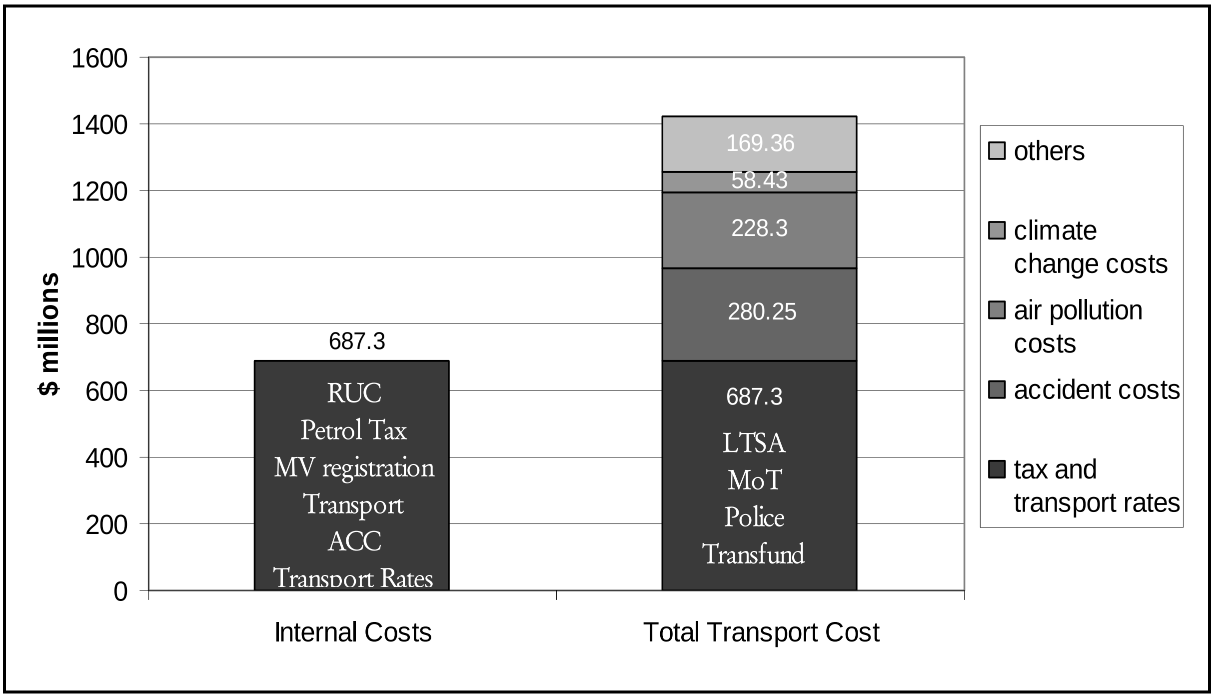

Figure 6: The total transport cost (external and internal) of public and private transport in the Auckland region in 2001 (MoT, 2002b). *"Others" includes: external cost of noise, parking, land use change, water and soil pollution, resource use, barrier effects, waste and equity (Litman, 2002).*

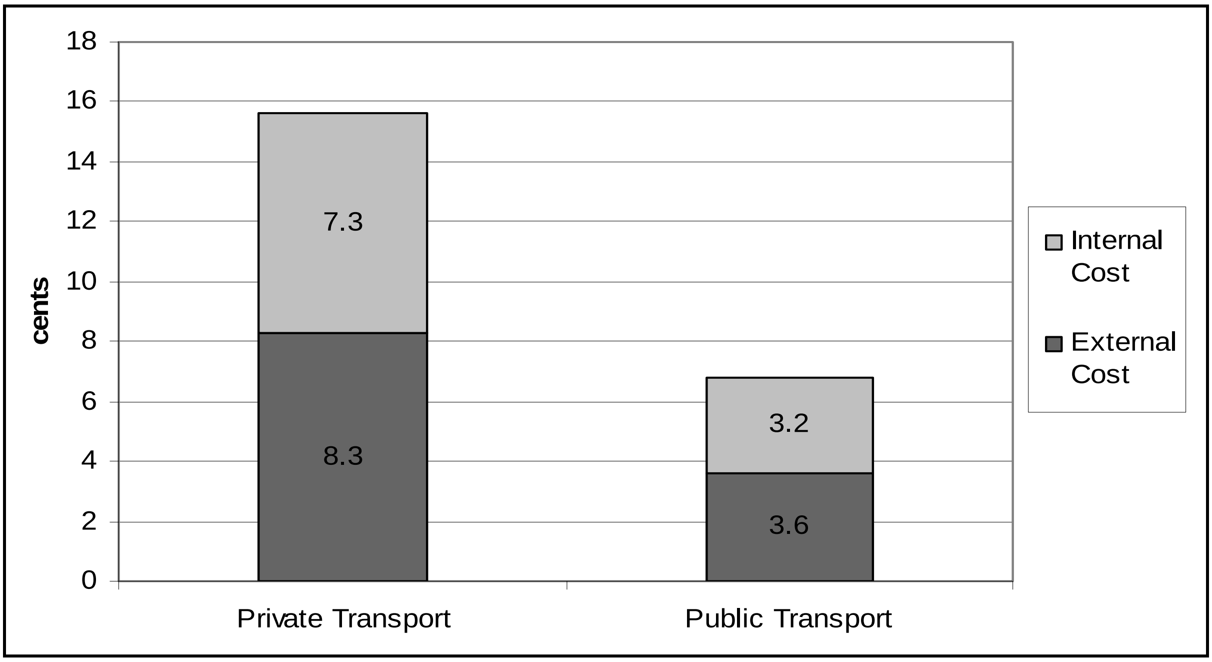

Figure 7: The external and internal cost of public and private transport per person kilometre in the Auckland region in 2001.