THE FUTURE OF URBAN TRANSPORT SUBSIDIES

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ABSTRACT: *The paper examines the reasons commonly advanced for subsidising urban public passenger transport and summarises recent theoretical work supportive of large subsidies. Conclusions are drawn as to their validity, and they are compared with other means of achieving the same ends. Comments are made on the New Zealand setting.*

Conclusions are also reached as to the means by which subsidies should be dispensed. Practical factors are illustrated by the New Zealand situation, in which central government plays a dominant role in determining expenditures in both public transport and roading, which interact with each other.

Finally, the possible future role of urban public transport is explored in the context of rapid social, economic and technological change. In doing so, the paper draws upon recently published scenarios that looked 50 years into the future. It is conjectured that in some circumstances the role of urban passenger transport may change radically, and with it the need for subsidy.

INTRODUCTION

Subsidy is the amount by which costs exceed income. This definition seems unambiguous until one confronts definition of costs, revenues and even the product being addressed.

The complexity of subsidy issues is exposed by examination of cross-subsidies Definition of cost is not just a matter of deciding accounting conventions; by definition, joint and common costs cannot be uniquely attributed to particular outputs. Likewise, revenues cannot necessarily be allocated uniquely; for example, there is no immutable reason why a return fare should be allocated equally to the two legs of the journey when one direction of travel is at a "profitable" time of day and the other at an "unprofitable" time of day.

Public Transport is Commonly Subsidised

Nevertheless, taking a simple view of public transport overall, it is common knowlege that public transport is generally subsidised in the western world. The extent to which it is subsidised may be less well known As reported by Sir Peter Masefield (1983), past chairman of the Chartered Institute of Transport:

> *when we look outside the UK, we find that there is a series of accepted "farebox ratios to operating costs" or - conversely - accepted percentages of costs recovered by subsidy. These percentages range from only 27% of operating costs paid out of subsidy in London (where fares, currently, cover 73% of cost) - through, 52% of expenditure subsidised in Chicago and Paris, to 83% in Milan, and 86% in Rome - where fares account for only 14% of operating costs. The average of a large number of cities in Europe and N America, works out at subsidies amounting to 54% of costs On average the fares charged on these urban services cover, therefore, only 46% of expenditure. Those figures exclude capital grants When they are added, total subsidies for urban transport in major cities overseas, average about 75% of total expenditure and investment.*

In the Buses White Paper (1985, p xiv) the Transport Committee of the House of Commons reported similarly:

Fare revenue as a Percentage of Basic Operating Cost*

	%
Britain	75
Austria	70
Switzerland	65
West Germany	63
France	43
Scandinavia	37
Italy	18

* Basic operating costs exclude depreciation and renewals, interest and taxation.

Such high levels of subsidy can be justified when cost/benefit analyses show that maintenance of public transport is cheaper than bulding transport infrastucture to cater for more private cars Yet funding dilemmas arise due to a clash with an increasingly common policy objective of *user pays*, and even *privatisation*, for public utlities.

WHAT IS BEING SUBSIDISED

A sufficient condition for a service to be "loss making" (and thus in need of subsidy) is that its termination will save more in costs than the revenue forgone. The need for subsidy will not, however, be totally eliminated by terminating every service that is loss-making under this criterion.

Superficially, it appears to the general public that the services requiring subsidy are those carrying less than full loads of passengers[1]. Sometimes this *is* so. In New Zealand, some late night buses fail to meet even the cost of the fuel used. There is no doubt they are being subsidised.

On the other hand, a subsidy may be needed to run *full* buses carrying a maximum standing load. This counter-intuitive situation arises because peak passengers determine the fleet size and, by implication, the number of drivers employed. Inflexiblilty of the labour force (limitations on part-time drivers and split shifts) results in peak travellers determining a large part of the wages costs of drivers, in addition to the cost of investment in fleet capacity.

It has been reported in the United Kingdom (and this presumably applies wherever off-peak patronage is substantial) that the between-peaks and Saturday services do not receive a cross-subsidy; indeed, they make a positive contribution to fixed costs and overheads, *ie* they make a "profit" over and above their direct operating costs. In New Zealand the density of population is less, and a lesser proportion of the public is captive, through lack of a car, to public transport. In New Zealand there is reason to suspect that services at *all* times of day generally make a loss, although there are undoubtedly some particular routes where this does not hold true.

Cross-subsidies

Cross-subsidy occurs when services generating revenue in excess of their costs contribute revenue to support services that do not fully meet their costs.

In the past, cross-subsidy has been condoned by regulating in favour of monopolies. This has facilitated the maintenance of off-peak services at times when fares do not cover operating costs. In yesteryear this approach had logic. The people using public transport at the loss making times were essentially the same people as used public transport at times when it was profitable. It would probably have made little difference had the fares been higher in the peaks and lower at other times[2].

Today, the profile of public transport users has changed. The ubiquitous motor car is the first choice of all. Public transport is chosen only when it is impossible to use the car, as is the case for workers who cannot afford parking in the centre city. Users of public transport in the peak periods are no longer the same group as those who use public transport at other times.

Users of services generating surplus revenue are either receiving a lower level of service or are paying too much, resulting in a lower level of use of the service. On the other hand, those using the subsidised services are being encouraged to use them when the economic benefit is insufficient to warrant that use. On both counts there is a loss of benefit, *ie* a loss of "consumer surplus".

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1 Which is why the general public thinks mini-buses would be a "good thing" for off-peak periods.

2 As it was, in New Zealand at least, the peak user was given a *discount* by means of a worker's concession. This strange way for a monopoly to treat a captive market (encouraging peaks of demand) probably stemmed from a traditional attitude of giving discounts for bulk purchases or to encourage customer loyalty. The passenger service licensing system had a lot to do with it.

WHY SUBSIDISE URBAN PUBLIC TRANSPORT?

The popular arguments voiced in support of public transport subsidies can be grouped under four headings

(1) **Intrinsic worth** of public transport (akin to a *merit good*, in economic parlance) - just as education is available free of charge, it benefits the nation for people to have a basic level of personal mobility at a price they can afford.

(2) **Public transport subsidy can promote wider goals** - give aid to the underprivileged; redistribute income; serve town planning objectives, such as promoting a planned urban form, and maintaining the vitality of the central business district.

(3) **Public transport is disadvantaged when competing with the car** because car users do not perceive, or even pay, their full costs - in which case public transport operators cannot be expected to recover their full costs and still compete with the car.

(4) **Subsidising public transport is cheaper than the alternatives,** which may be to build new motorways or to simply to allow congestion to worsen and eventually stem the growth of peak traffic.

The first two arguments have little force

There is no support for the "merit good" argument for encouraging (by subsidy) the consumption of public transport services. Mobility is within easy reach of most people, without subsidising public transport. It is doubtful whether making public transport cheaper would much effect the amount that people travel, or the benefit that people derive from it.

As to the second argument, namely the promotion of non-transport goals, it is presumptuous to make public transport "cheap" so it can be used more by people thought to be unable to afford it. These people may have priorities higher than public transport for use of any assistance monies Income redistribution is far more effectively achieved by more direct interventions, such as through the taxation or social welfare system. And public transport subsidies, in New Zealand at least, appear to be channelled largely through the "middle classes" who constitute a large proportion of ridership.

Turning to town planning objectives, Gwilliam (1984 pp30,31) addresses the efficacy of fare subsidies as means of influencing the distribution of land use. He points to the capitalisation of transport subsidies in the values of properties benefitting from them, and concludes:

> *subsidies .. can easily be transmuted into economic rents to be enjoyed by others Hence subsidies may finish up redistributing income, perhaps in directions which are not only unintentional but undesirable, rather than sunbstantially affecting the location of activities*

The third and fourth arguments do have substance, and are viewed in an economic framework as "market failures'[3]

The following market failures are common economic rationales for subsidies.

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3 A new approach to market failure is emerging. It identifies the 'failure' of the market place as being due to the absence of tradable property rights and examines the transaction costs associated with such trading.

Monopoly

It is often said that scheduled urban passenger services have economies of scale and co-ordination, making it more efficient for a single operator to serve a region. This is the reason for giving an exclusive franchise to an operator subject to government regulation

Internal cross-subsidy results from regulation, for social reasons, of prices and service levels. These cross-subsidies make the transport operator susceptable to competition, spawning a need for subsidy The required amount of subsidy depends on cross-elasticities of demand between transport modes and any regulations imposed on competing modes.

Externalities

Subsidies are a 'second best" method of dealing with externalities. The externality of greatest concern is congestion cost Each additional road user imposes extra congestion on all other concurrent users of the road[4] The cost he imposes on other users does not enter into a traveller's decision to use the road Yet the extra congestion experienced by others *is* a cost consequence of his decision to travel

Imperfect Information

There is an argument that individuals misperceive the relative costs and travel times of travel by public transport and by car. There is evidence to suggest that car owners take account of only the marginal costs of their travel - and even then they do not perceive the occasional bulk purchases for motoring as sharply as they do the smaller, but more regular, ticket purchases for public transport. Because they arise intermittently, too little account is taken of expenditures on wear and tear; owners prefer to regard major overhauls, and even new tyres, as being capital investments adding value to the vehicle.

For public transport trying to compete with the private car, underestimation of the cost of private motoring is a real disadvantage An even more potent factor, however, has emerged in the modern phenomenon of the *company car*. For those with company cars the cost of using the car is no longer cheap; it is now free. A survey of Auckland harbour bridge traffic was conducted last December, during the morning peak. Vehicles travelling from the North Shore to the main employment centres on the other side of the harbour had their number plates recorded. Vehicle ownership records revealed that 44% of vehicles in the morning peak were company-owned. Self-employed persons and those receiving mileage allowances would probably raise the number of people not paying the full cost of their trips to well over 50%. The survey also revealed that car occupancy may have declined

There is growing body of modern economics that calls for government intervention, such as subsidy, to be justified on a comparative basis. It questions whether subsidy is a better way of correcting for market failure, or meeting social needs, than other government or private sector options. Examined from this angle, justification of subsidy depends on its level and means of delivery.

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4 As traffic volumes approach the road system's capacity to cope, traffic congestion increases asymptotically (which is *more* severe than exponential). Mathematically, congestion becomes infinite if capacity is exceeded. Road users do not experience infinite delays because the road system is overloaded for a finite time, after which congestion subsides to normal again. It is easy to appreciate why there is little congestion other than at peak times Due to the asymptotic nature of congestion it is not manifest until the system is nearing its capacity.

EXTENSIONS TO THE EXTERNALITIES ARGUMENT

In the last decade a series of important papers has widened the ambit of externalities to be considered when assessing the rationale for subsidy. They include milestone papers by Turvey and Mohring (1975), Jansson (1979) and Else (1986). The paper by Turvey and Mohring (described by Jansson as "path-breaking") critically examined marginal cost pricing in the context of bus services, explaining that the marginal cost includes more than costs incurred by the operator:

> *The right approach is to escape the the implicit notion that the only costs which are relevant to optimisation are those of the bus operator. The time costs of the passengers must be included too, and fares must be equated with marginal* **social** *costs*

This paper introduces the interactive effects of passengers on each other. The time taken by passengers boarding and alighting affects other passengers in like manner to the congestion effect arising with road traffic. The paper's principal conclusion, however, stems from the effect that passengers collectively have on the frequency of service. By showing that marginal social costs are below average social costs, Turvey and Mohring establish that:

> *We have a classical case for subsidy in order to achieve optimal resource allocation. This case has nothing to do with congestion. It is just coincidence that considerations arising from congestion also point in the same direction, to subsidising buses or to taxing or restraining private car use. Conversely, a failure to subsidise buses or tax car-use sufficiently accelerates a shift from buses to cars for two quite separate reasons. One is a matter of congestion costs. The other, which is the subject of this paper, is that a decline in the total number of bus journeys which results in fewer runs causes a further decline, frequency being an important factor in determining demand. Less means worse and worse means less*

Jansson extended the analysis to include the long-run costs of the bus operator. He showed that:

> *the coexistence of significant vehicle* **size** *economies in producer costs, and vehicle* **number** *economies in user costs, ..(makes) scheduled passenger transport a pronounced decreasing-cost industry in the sense that optimal pricing will result in a relatively large financial deficit. ..The total revenue from marginal-cost-pricing can always be predicted to fall short of the total producer costs.*

It is not new to conclude that revenue from marginal-cost-pricing will not cover total costs. What *is* new is the *reason* why this is so. From a conventional cost accounting point of view, marginal-cost-pricing would result in a deficit equal to total overhead costs. Correctly calculated, on the basis of marginal *social* costs, **the deficit has nothing whatsoever to do with overhead costs**[5].

Else takes the analysis to the point of determining the optimal fare (and hence the optimal subsidy). He assumes a monopoly supplier of a network of reasonably homogeneous passenger services, and (as is supported by empirical evidence) that there are no economies or diseconomies of scale. The analysis of the optimal fare builds through three steps

5 There is empirical evidence (*eg* Jansson p283) that the overhead costs of urban bus undertakings is strictly proportional to fleet size over a wide range, from near zero to 750 buses. The graph of total operator cost *versus* total demand therefore passes through the origin, and is linear. When user costs are added in, Jansson's analysis shows that the graph of total cost still passes through the origin but now bends toward the horizontal, reflecting a diminishing-cost characteristic. The benefit-maximising fare is represented by the gradient of the tangent to the curve at the appropriate level of demand. This tangent is a straight line intercepting the ordinate at value greater than zero. Its estimation is *not* achieved by (erroneous) attempts to estimate fixed costs.

The first step seeks to maximise net social benefit by setting the fare equal to short-run marginal cost. The optimal fare is shown to be the operator's cost per passenger-kilometre[6] divided by the expression

$$1 - e_M/e_F$$

where
e_M is is the service elasticity of demand
e_F (< 0) is the fare elasticity of demand.

For example, putting $e_M = 0.6$ and $e_F = -0.3$ the divisor becomes 3, implying that under optimal pricing only one-third of total costs would be recovered from fare revenue. Indeed, provided public transport usage is more sensitive to service level than price (*ie* $e_M > -e_F$) the divisor is at least 2, and **less than half the operator's costs would be recovered from fare revenue under optimal pricing.**

The second step introduces the "congestion" costs passengers impose on each other. The optimal fare must now reflect the operator's marginal cost *plus* the difference between the marginal and average passenger congestion cost. In other words, it includes a congestion tax component to internalise the costs passengers impose on each other. This congestion cost adds another component to be recovered in an optimal fare; the numerator is increased by a term equal to the marginal passenger congestion cost one additional passenger imposes on all other passengers. Since the divisor remains the same, namely $1 - e_M/e_F$, the effect on the congestion cost component of the fare is the same as for the operator's cost, *ie* to reduce it by a factor of $1 - e_M/e_F$ to perhaps to a half or a third of the full amount. The optimum subsidy *decreases* accordingly.

The third step extends the passenger congestion cost analysis to include other externalities, such as the beneficial effect use of public transport has on road congestion, accident costs and environmental costs. These factors *increase* the optimal subsidy.

In summing up these results, Else states:

> *even if one talkes a fairly conservative view of the effects of externalities, subsides to maximise net benefit could amount to 60% or more of the operating costs of passenger transport undertakings ... This may seem, to some at least, a surprisingly high figure ... Nevertheless it does not seem to be unduly out of line with results obtained in recent cost benefit studies which have approached the problem from a different angle*

Comment. By acknowledging user costs, these theoretical advances place pricing analysis on a par with cost-benefit analysis. For years, cost-benefit analysis has taken account of both operator costs and user costs. In seeking the optimum balance between private and public transport, cost-benefit analysis tallies operating costs, capital investments and user costs. The fare that achieves this optimum balance can be calculated from the modal split assumptions. This determines the optimal subsidy.

Else notes that his results are in general agreement with recent cost benefit analyses. Time will tell whether the two approaches are in total accord. The pricing analysis is at such a level of theoretical abstraction that it is difficult to be sure that one is just the obverse of the other. In any event, these recent advances in pricing analysis add greatly to our understanding of the mechanisms giving rise to a justification for subsidy, and yield insights into how best to deliver them.

6 Or per passenger, if that is how the fares are structured

ALTERNATIVES TO SUBSIDY

The fact that subsidies will yield benefits at the margin is not a conclusive justification of subsidies For a start, it takes no account of the fact that a dollar collected from taxpayers is worth a dollar to them, but a dollar spent on subsidy is worth *less* than a dollar to consumers[7]. On top of this, public funds may have more beneficial uses elsewhere. This raises the question of whether there are other ways of achieving the objectives of subsidy

Two-part Tariffs

Sherman (1967) introduced the notion of two-part tariffs for public transport by noting that, whereas travellers pay only the *marginal* cost of additional car travel, they pay the *full* cost of travel by public transport A two-part tariff can lower the marginal cost of public transport without violating the balanced-budget constraint.

Citing United Kingdom experience, Else notes that in addition to public transport, other decreasing-cost public utilities (*eg* telephones, electricity) operate under a "user-pays" constraint of full cost-recovery. In those cases, two-part (or multi-part) tariffs can reconcile the full cost recovery constraint with pricing to achieve economic efficiency.

The principle is to marginally cost use of the service, and top-up the revenue derived to cover full costs by a making a lump sum charge. For telephones and electricity this can take the form of an annual connection fee unrelated to usage. For public transport the lump sum fee could be collected through taxation, but that is not the only way. A "travel card" system has the same effect. The traveller pays an annual (or quarterly) lump sum for a card entitling him to travel a reduced rates.

A bonus of the travel card approach is that it permits accurate targetting of subsidies to disadvantaged persons. Travel cards can be purchased at discounts commensurate with individual needs. In Auckland at least, observation of who rides buses indicates that blanket subsidies result in capture of the benefits by middle-class commuters, initially Ultimately, however, the benefits are likely to be capitalised into property values - the *economic rent* aspect addressed earlier

Browning (1983) details the advantages of using a magnetic strip credit card for purchase of bus travel. At both boarding and alighting the card is read by on-bus equipment. A central computer bills monthly. Revenue increases because staff no longer handle cash and passengers cannot understate distance travelled.

More importantly, for present considerations, the fare charged can be varied by time of day and by route. This permits the ultimate discrimination Subsidies can be varied between routes (or parts of routes) and time of day. The subsidy dollar can be spent where it has best effect; and a minimum amount of subsidy is needed to achieve the desired effect.

"Internalising" The Road Congestion "Externality"

Throughout the above commentary the *assumption* is made that nothing can be done to "internalise" (*ie* inject into the decision making of individuals) the "external" congestion costs imposed on others by an individual's decision to take the car

7 If a consumer needs a subsidy to encourage him to consume more, it follows that he values his extra consumption at less than the unsubsidised price His incremental benefit is thus less than the subsidy

This is assumption is not necessarily correct In a ideal world a "congestion toll" would be charged for peak period travel in congested traffic corridors Charging a toll is not often realistically possible, but three proxies can be considered:

- charging a premium for all-day parking;
- licensing vehicles entering congested areas (as in Singapore); and
- electronic road pricing (as in Hong Kong).

Parking premium. By increasing the cost of parking for all-day users the cost of commuting by private car can be increased. For all-day parkers the amount by which the price of parking exceeds the cost of providing car parks would be a proxy for a congestion toll. Public parking in downtown Auckland already penalises a long stay. But this measure does not prevent vehicles from being taken out and put back in the car park in the middle of the day, to avoid the penal rates.

One answer is to impose a lump-sum surcharge on, say, cars arriving before 10am and another surcharge on cars leaving after 4pm. This method would not be perfect since some vehicles may *appear* (in terms of parking behaviour) to be adding to peak period congestion when they are not. And the fact that different vehicles travel on roads of different congestion levels would not be taken into account. Nevertheless it would be a move in the right direction. By increasing costs of peak period car use it would provide a measure of congestion pricing, even if by proxy.

Area licensing. The area licensing system operating in Singapore has been described as a "resounding success" by Yee (1985) who reported as follows:

> *Known as the Area Licensing Scheme (ALS), and introduced in June 1975, it requires that cars and taxis possess and display a supplementary licence to gain access to a defined restricted zone (RZ) during the morning peak period. The restricted zone covers 620 hectares of the most built-up parts of the city. To simplify policing of the scheme, control is only at the entries to the RZ, which are identified by large overhead gantries. All public buses, school buses, private buses with capacities for 12 or more persons, goods vehicles, emergency vehicles and police and military vehicles are exempted. Cars and taxis with four or more persons are also exempted to encourage a higher occupancy of vehicles*
>
> *As a novel traffic management measure the ALS has been a resounding success. Over the last ten years the city has grown by 30% in terms of the number of jobs. However, the present total inbound volumes during the morning peak is still 20% less than the pre-ALS figures of early 1975. The scheme has also resulted in the greater use of public transport, particularly for the journey to and from work in the city. Today 70% of trips into the city are by public transport. In 1975 the figure was 33%.*

In some respects it is a variant of the parking scheme outlined above. One difference is that there would be no discrimination between drivers parking in private *versus* public areas.

Electronic road pricing. Electronic road pricing is a means by which road users are charged according to the amount of congestion on the roads they use. Prices are set so that during periods of high demand the price of using the road is higher. Such a road pricing pilot scheme is operating in Hong Kong. 3000 vehicles are fitted with transponders emitting unique vehicle identifying codes when interrogated by roadside equipment. The presence of a vehicle on *that* road section at *that* time of day is automatically logged by a central computer. The vehicle owner is billed retrospectively.

The roadside stations cost about $1500 each and the vehicle mounted transponders about $75 each. If a passing vehicle fails to acknowledge a roadside station an automatic camera can be triggered The vehicle is then subject to a fine.

In New Zealand, there would seem to be no practical or cost impediment to instituting such a system New Zealand-wide. The cost of a transponder is less than seat belts for rear seats. New Zealand adopted a much more costly solution (involving hubodometers, manual recording, and licence purchase) when it sought to get its prices "right" for heavy road transport vehicles

Looking to the near future, video map displays will soon be incorporated in vehicles. In a comprehensive paper prepared at the request of the US Federal Highway Administration, Rothenberg (1985) wrote:

> *Recent developments in electronics have created opportunities for electronic devices to be mounted inside vehicles to give instructions as to which exit to take at each successive junction. The electronic design of route guidance systems seems to call for no significant advances beyond current practice. Several types of guidance systems (eg fixed-time and adaptive guidance) have been, or are being studied in Europe*
>
> *Fixed-time systems function as an electronic map. They indicate the route that, under typical conditions, is best at that time of day. This route information may be obtained via a short-range radio link from a roadside electronic unit .*
>
> *An adaptive guidance system has some form of central data collection, analysis, and decision processes to up-date route guidance on a real-time basis Roadside electronic units are connected into a city- or country-wide data network*

Looking further ahead, Rothenberg added:

> *The automated highway may first be implemented as a private toll road. The incentive here might be to allow a higher speed limit for vehicles using the highway. This could assist the financing of such a project which given the costs of the control system would no doubt be substantial.*

Some of the technology to achieve this probably exists now. Satellites can guide military vehicles on the ground to within an accuracy of 50 metres For nose-to-tail traffic, land-based beacons can surely do much better We need more powerful computers for simultaneous control of thousands of vehicles in real-time But, as described in a subsequent section entitled *Looking to the Future*, it will not be long before computing power is not a limitation

Reserved Bus Lanes

By enhancing the convenience of public transport relative to the motor car the user-cost balance between private and public transport can be altered

Reserving lanes exclusivly for buses at peak times has the effect of expediting bus travel. If the reserved lanes were previously used by cars also, the *exclusion* of cars from these lanes will result in a quantum leap in congestion experienced by cars. By this means, private decisions can be influenced in the most socially desirable directions

WHO SHOULD RECEIVE THE SUBSIDY

If it is decded that, in spite of the alternatives to subsidy, a subsidy *will* be dispensed, the next question is to whom should it be delivered Should the subsidy be paid to the *user* or the *operator*? And *how* should it be paid? The answer partly depends on the subsidy objective, but there are strong pointers to subsidising the *user*

The Buses White Paper (Transport committee of the House of Commons 1985) concluded that:

> *What we are convinced of . is that the chances of subsidy being frittered away through inefficiency, or captured by employees rather than being passed on to customers, are substantially increased where the subsidies are hidden and subject to no external check.*

Subsidies Leak Into Inefficiencies

If the operator is subsidised there is strong evidence of leakage of subsidies into higher operating costs. Bly, Webster and Pounds (1980) estimate a 1% increase in subsidy is associated with a decrease in productivity of between 0 2 and 0.6%. Employees wages were observed to be 0.2 to 0.3 % higher, relative to prices, and 0.2% up relative to average earnings Output per employee appeared to be down by between 0.15% and 0.30% and unit costs were up by between 0.4 and 0.6%.

Subsidy Monies Have More Utility in the Hands of Users

As we have previously observed (footnote 7), a dollar taken from a taxpayer's pocket was worth a dollar to the taxpayer, whereas examination of the consumer surplus of the recipient demonstrates it is worth less than a dollar to him, if he receives the subsidy by travelling more due to the reduced fares. Moreover, if the user receives the subsidy directly, rather than in the form of reduced fares, the user can spend his subsidy dollar in the best way he sees fit. The subsidy may be a cash amount which is, in *economic* terms, the most efficient means of subsidy delivery. The user can then use the subsidy money for something *other* than public transport if there is a better way in which it can be spent.

On the other hand, to signal the decreasing-cost nature of public transport services (in the sense of Else *et al*), fare reductions do promote optimal use of public transport. Tagged subsidy, which *must* be spent on travel purchases, therefore has economic justification. The travel card option is a particularly worthy means of subsidy delivery since it permits accurate targetting of variable levels of subsidy when assistance is aimed at social (as well as economic efficiency) objectives Alternatively, if it is considered that the subsidy must be limited to the purchase of public transport services, the subsidy can be issued in the form of vouchers

By whatever means, subsidising the user (rather than the operator) spurs the operator to do better. There would be less risk of providing services that were subsidised, but not justified in terms of need. Operators would be encouraged to innovate. They would regain a *profit* incentive, and would feel no stigma from actually showing a profit To the extent that subsidy of public transport is intended as social assistance to the needy, the quantum of support can be varied according to need. The degree of individual need would determine the discount on face-value of the coupons or travel cards purchased And this form of monetary support would be confidential to the recipient, an important ingredient for the acceptance of any such scheme

A case for subsidising the *user*, rather than the operator, is established.

WHO SHOULD PAY THE SUBSIDY

This is much more difficult question to answer and is worthy of a separate paper in its own right. It requires careful consideration of the distributional effects of the different methods of funding, and who benefits It also should take account of the funding methods for roads, since a prime purpose of urban transport subsidy is to achieve the optimal modal split between public transport and the private vehicle.

In New Zealand, meeting the subsidy is shared equally by central government (the tax payer) and local government (the ratepayer). Tax payer contribution can be challenged on the basis that there is no good reason for sheltering the urban dweller from the cost consequences of his choice to live in the city To subsidise out of taxes risks cross-subsidy from the rural sector - but then it may only compensate for the traditional New Zealand support for rural life by way of subsidies on electricity reticulation, postal services, television broadcasting, national pricing of fuel and other goods and services including road funding. The National Roads Board takes account of "ability to pay" when the rural counties request subsidy of road works. This means there is a considerable cross subsidy to rural areas from the urban areas contributing much of the NRB's revenue

A study (Guria *et al* 1985) of tax incidence and income distribution aspects of urban transport subsidies in New Zealand concluded that:

> *taxation is progressive, rates are regressive, but the net impact of in terms of subsidy is progressive ... there is a clear redistribution of income from high to low income groups under the current subsidy system*

Beyond that we cannot take the matter in this paper.

LOOKING TO THE FUTURE

After scrutinising such complex matters at close quarters it is good to step back and look at the issue in a wider context.

As a member of a team that constructed four scenarios of social, technological and economic change, each looking 50 years into the future, the author has had the benefit of probing future realms and gaining an appreciation of the potential for change that is in store (Boshier *et al* 1986). The following exposition can be regarded as the author's interpretation of some of the technology-driven "hard trends" that are already evident.

There is no sign that rate of technological development abating. On the contrary, technolgical innovation appears to be *accelerating*.

Computers are now used to design computers. The next generation of chips will make the term "silicon chip" an anachronism New techniques have been developed to make sandwiches of compounds, such as gallium arsenide, through which electrons travel three times faster.

On the leading edge of practical research, the photon is displacing the electron. AT&T's Bell Laboratories are building an experimental computer that uses light rather than electricity. Super-efficient lasers can be put on chips in large numbers to make optical computers. GTE, another American firm, has recently "grown" a wafer with built-in lasers of 0.2 square micron cross section. (Five million of these lasers have a combined cross section of only 1mm x 1mm.) These new "optical transistors" are likely to switch light 1000 times faster than transistors switch electricity (the fastest transistor is unlikely to switch in less than a billionth of a second). In principle, a single "optical transistor" could contain up to a million switches. Laser beams could be split into sub-beams to carry out different tasks simultaneously, unshackling machines from one-step-at-a-time processing.

Out on the pioneering frontier of computer development is molecular electronics. Under development are optical transistors comprising only one molecule!

The popular image of computers in the workplace is that they move drafting pens ("computer aided design") or give instructions to robot arms performing repetitive welding or painting tasks on an assembly line. Or the computer is seen as the invisible hand at the wheel of the tractor driving up and down, through day and night, ploughing, sowing and harvesting wheat fields.

Such limited applications reveal little of the revolution that is happening. Factory automation will soon combine "computer aided design" with "flexible manufacturing systems", leading ultimately to "computer integrated manufacturing". The factory of the future will be able to receive orders for customised products and, within hours, determine whether the product will work, how it should be made, and how much it will cost ... and then manufacture the product. Automation will make short production runs and "one-offs" economical, heralding the era in which *economy of scale* no longer applies in the fabrication and manufacturing industries.

In realms hitherto reserved for human beings, the development of computers and sensors is resulting in machines that can feel, smell, hear and see. Artificial taste and smell are the result of the development of biosensors. Biosensors use biological molecules or cells which when exposed to appropriate chemicals respond by emitting a measurable electrical signal. Mitsubishi, for example, has produced a silicon chip combined with membranes formed from immobilised enzymes which sense glucose and lipids simultaneously, making the sensor a versatile tool for monitoring processes in chemical plants.

Emulating vision is termed "image processing". Until recently the amount of information needing to be processed had been too great for artificial vision to respond in "real time". But the computer speed and capacity bottleneck is quickly disappearing and it will not be long before sight-dependent tasks such as grading of fruit can be mechanised.

Soon the range of applications of computer-driven automation will be limited only by man's imagination. Already the Japanese automation company, Fanuc, has a factory manned by robots making robots.

Paralleling advances in computers, there has been a major breakthrough in communications technology. Glass fibres can now carry digital code at enormous transmission rates.

Fibre optics technology became a practical reality in 1970, when Corning demonstrated a process to make gossamer strands of glass that performed as "light pipes". Also in 1970, AT&T's Bell Laboratories successfully tested the first semiconductor laser. It was small enough to fit through the eye of a needle. Until then lasers had been bulky gas-filled tubes.

In 1984 Bell Laboratories perfected a tiny laser that flashed two billion times a second, *ie* could transmit information at two billion bits per second. At that speed the entire contents of all copies of Time magazine published during the last 10 years could be transmitted in one second. In 1985 Bell multiplexed ten such lasers to transmit and receive at 20 billion bits per second. By 1986 GTE had developed a *single* laser that transmits at that rate.

Such revolutionary advances in data transmission offer equally revolutionary possibilities of changed lifestyles No longer will it be so advantageous to live in large urban areas. It will not be necessary to leave home for medical advice, libraries, films, supermarkets, bridge games, etc Business meetings will be able to be conducted without participants leaving their offices, which may be in different cities. Indeed, the "office" in this context may be a workstation within the home, eliminating the need to commute to and from work

In this setting the technologically advanced countries will be able to maintain world leadership through *intellectual capital*, secured by having access *via* communication links to information bases and computing power. The advanced countries will transfer much of their heavy industrial activity, which today forms such a large part of world economic productivity, to the less developed nations currently pursuing technological development by way of steel mills, petrochemical plants and other "smoke stack" industries

Transfer of these basic production industries from the developed to the less developed world will open the way to new forms of social structure. Different patterns of final-demand consumption will also emerge An increased emphasis on social goods and services can be foreseen.

In the developed countries lifestyles could alter radically. Just as transport enabled industry to move away from sites near sources of raw materials, telecommunication enables service sector activities to locate away from the information sources constituting *their* raw materials. Microcomputers and terminals, already common in offices and homes, foreshadow new forms of social and commercial organisation

The "need" to meet *face-to-face* is often said to defeat the use of telecommunications for meetings Teleconferencing is still in its infancy, however. Split-screen or multiple-screen video arrangements common in the United States *are* only a partial substitute for face-to-face meetings But the main "problem" with teleconferencing is still sheer lack of experience[8]. The electronic meeting *is* different from a face-to-face meeting. This difference can, however, be exploited to *advantage*, as explained by Johansen (1985):

> *Face-to-face meetings and electronic meetings will become less and less alike, as we move beyond the current "horseless-carriage" stage. It will become easier to gather the right people at meetings, to have better preparation before and during meetings, to co-ordinate better with decentralised sites, and to spread expertise within the company.*
>
> *Undoubtedly, the tone of the meetings will change, as the requirements of business communication, rather than the protocol of face-to-face meetings, become the driving force "*

Education is perhaps the prime illustration of the combined application of telecommunications and computers. Boswell (1984) has described some likely changes in education:

> *Mary will get her geometry programmes .. down the telephone line ...she can work at her own pace at times she chooses and...may well learn faster than she did at school and learn subjects that are more relevant...to her. .... (School) will become concerned with giving pupils social skills and providing them with recreation Instead of teaching, the school will provide advice on courses to take and will monitor pupils' progress. Many students will find such an approach better. good teaching programmes will be fun to use...more patient than teachers and able to cope with children working at their own speed "*

8 In North America, home telephone answering machines are commonplace, accepted and used Many New Zealanders still suffer stage fright when encountering an answering machine

If the information age does this for students, so too does it offer radically new work modes for workers. As Nilles (1982) has put it:

> *Telework may soon make daily long-distance commutes obsolete while enhancing worker productivity and satisfaction. The Great American Dream is to live in a suburban setting at some little distance from the neighbours. The automobile provided this option and cities changed as a consequence. Today microelectronics technology is beginning to do the same for information workers. The microcomputer is the analog of the automobile: the telephone line and the communications satellite serve as the highways. The major difference is that* information *is transported rather than information* workers, *who then have the potential to become "telecommuters". In principle, the telecommuter has access to anyone with a computer - with a near-zero transit time."*

"Telework", as Nilles terms it, accommodates an emerging trend of job sharing and part time work.

In advanced countries the affects of automation and "intelligent" machines will be to change the nature of work. The boundaries between work and leisure will become blurred. Flexibility of when work is done, and by whom, will result in highly flexible use of personal time. Regimented attendance at office or factory will be a pattern of the past.

Patterns of travel and settlement were transformed last century by rail transport, and again this century by the car Next century they will be transformed again by telecommunications. The nature of this change will be of a different character, because of costs. Once the telecommunications infrastructure is installed, the cost of use is very small and almost independent of distance.

In an information society there will be no rush-hour of workers commuting to offices and factories to start work on-time Many factories will never stop; they will be automated. Those persons who continue to commute, to jobs still beyond the capabilities of "intelligent" machines, will not be bound by such rigidities as prescribed start and finish times. The busy period for travelling will therefore span much longer than an hour or two. It might not even be discernable above the traffic concerned with the day's other activities

Consequences for Subsidy

In these circumstances, public transport becomes a service geared for not for brief peaks but for all day services. The "big bus" strategy of bus operators disappears and more flexible, smaller units come to the fore Indeed, the "bus" system of tomorrow might be more akin to shared-taxi service. There is already a trend in New Zealand for a proportion of taxis to be be vans rather than cars

Taxis are not currently subsidised because they are regarded as a premium service, secondary to buses. As a primary service, offering shared use (like buses) there should be no objection to subsidising them. Nevertheless, there would probably be little to be gained by subsidising them, given the transport-substitutes available through telecommunicatioms and the elimination (or at least the reduction) of peak period congestion

CONCLUSION

From our description of a dimly foreseeable future, it appears that the days of the urban transport subsidy are numbered Meanwhile, subsidy of public transport (ideally through a "travel card" system) does yield economic gains, but too little is being done to apply congestion pricing, or proxies for it, during periods of peak traffic

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