Optimal road price and capacity

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1 Introduction

This paper addresses areas that much road pricing discussion overlooks, that is:
1. the dynamic interaction between pricing and capacity (ie taking existing road capacity as given and focussing only on pricing as a way to reduce demand);
2. the impact on close substitutes (alternative transport modes), including the public cost to expand infrastructure and increase operating subsidies;
3. the absence of competition for supply of road capacity and consequent monopoly behaviour and what that implies about prices.

Much road pricing literature, by failing to highlight the crucial interaction between road pricing levels and road capacity, leaves the simplistic impression that the aim of optimal road prices is to restrict traffic volumes within existing road capacity. This overlooks the need for prices to balance supply of capacity and travel demand.

Our proposition is that optimal road network prices must always be the lesser of the short run cost (including congestion) and the long run marginal cost of additional road network capacity and optimal capacity on alternative modes.

2 Scope

Transport planning and road pricing are large subjects, and we have to restrict our scope to economics, while acknowledging this discussion does not address many aspects such of road pricing such as integrated transport and land use planning, environmental and social effects, and sustainability issues.

Road pricing's role is to internalise externality costs and benefits such as congestion, health, social and environmental effects, so individuals face the real cost of different travel choices. Congestion charging dominates road pricing discussions because congestion costs are comparatively large, and vary widely by location and time. Unlike carbon charges for example, congestion charges cannot simply be added to existing flat pricing mechanisms (eg RUC and fuel excise). In our analysis, we assume road pricing covers only congestion costs.I

3 Road pricing principles

The principle of road pricing is sound. To revisit basic economic theory: marginal cost prices optimise the static allocation of resources. (And under pure competition, they optimise the *dynamic* allocation of resources.) Marginal cost pricing signals to consumers they need to get at least as much value out of using the product as the value "used up" in making it. If prices are lower, consumers 'waste' the product, and suppliers go bankrupt; if prices are higher, consumers unnecessarily avoid using the product thus missing out on productive value, while suppliers make super-profits, attracting additional suppliers who drive the price down.

Current road pricing includes petrol tax, Road User Charges, parking charges and vehicle licence fees. These are fairly blunt instruments, and because they are designed to recover total costs, they are average cost prices not marginal cost prices.

For many rural and suburban roads with no congestion, the bulk of the costs are fixed costs unrelated to traffic volume - use incurs relatively low maintenance and environmental costs. Thus average costs recover the cost of the road, but being higher than the marginal cost of use, they will unnecessarily dissuade some traffic from using the roads and suppress traffic below optimal levels. Some people who would get $2+ value from using roads will not use them and opportunities to generate wealth are lost

Conversely, for congested urban roads, the current prices are likely to be too low, encouraging 'too much' traffic. The price of roads also affects complementary markets: in urban areas, this low price will artificially suppress demand for alternative transport modes.

How do we know which case we are dealing with for a particular transport network?

4 Case Study: Wellington transport network

The paper looks at a corridor in the Wellington regional transport network. This corridor has highway and passenger rail immediately adjacent to one another. Four different philosophical approaches are applied illustrate these principles of road pricing.

1. 'Do Minimum': the favoured approach of central and local governments – defer spending on new road capacity AND avoid the political risk of road pricing (Figure 1).

2. 'Predict and Provide': expand road capacity to meet forecast demand (Figure 2).

3. 'Price and Punish': price to suppress demand within existing capacity (Figure 3).

4. 'Plan and Placate': plan road and public transport capacity so that LRMC and SRMC are in balance - optimal road pricing and optimal transport capacity (Figure 4).

Congestion can appear to improve if sufficient people leave the city. In order to avoid this, we adopt the approach that, for the scenarios to be comparable, each scenario must provide comparable levels of mobility. That is, the approach used here is to transport the same number of persons using different modes. For simplicity we restrict our discussion to road and rail.

In the figures below, the x-axis refers to the number of **persons per hour** needing transport on the corridor, as opposed to the more common frame of reference, years. These are linked because, over time as the city expands, the number of persons needing transport will grow, but different cities will experience different growth rates in transport need.

In the model, the road lanes are capable of carrying 2200 vehicles per hour and cost $7.1 million per lane per annum to add capacity. This assumes the corridor length is 50km and the capacity is funded through a loan over 30 years. The passenger rail units provide 144 seats per two car set and cost $0.53 million per annum through loan funding over 30 years.

4.1 Do Minimum

Figure 1 shows what would happen if the existing network in Wellington tries to cope with the increased demand. With no congestion charges and no added road capacity, when traffic grows travel times get larger increasing congestion costs. Increasing congestion stimulates greater public transport demand. The total capital cost for roads is zero, but the cost of delay approaches $230 million per annum at 12,000 persons per hour on the corridor with rail costs rising to $42.4 million per annum. Do Minimum suppresses overall mobility at a high cost to the country.

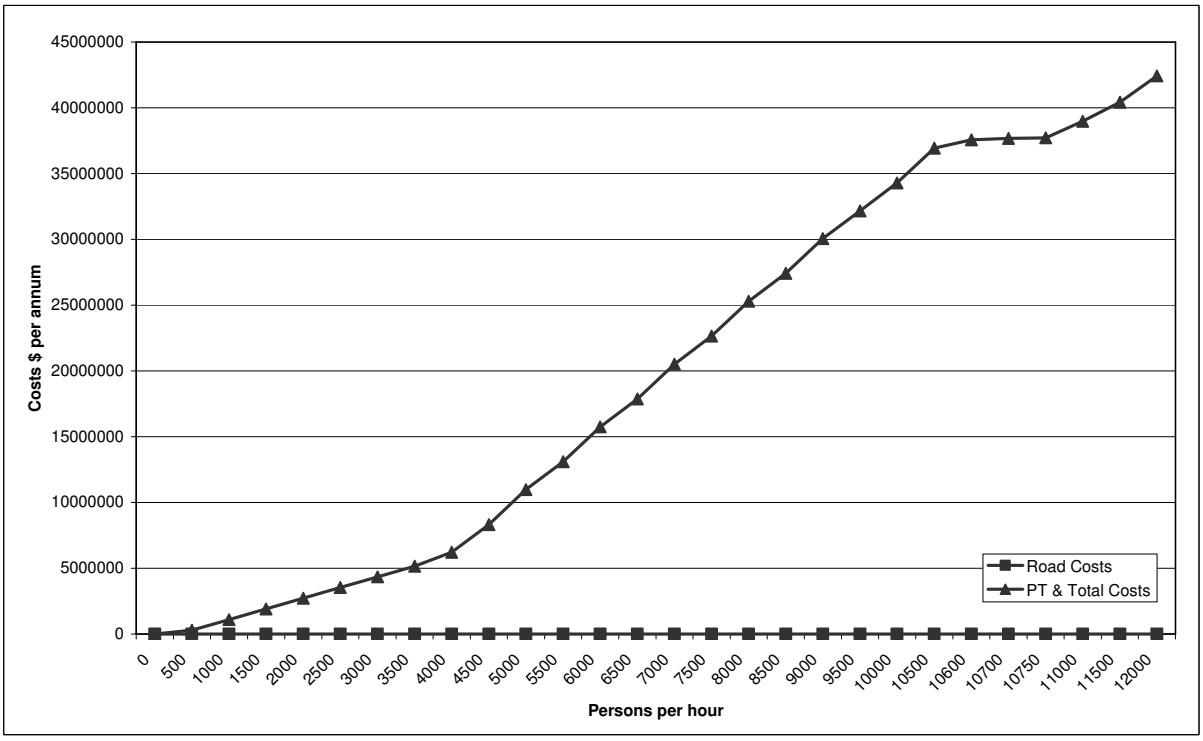

Figure 1 Costs per annum for Do Minimum

4.2 Predict and Provide

Figure 2 shows how costs for road and rail increase as the number of persons moved by the transport network increase over time. With no congestion charging, as traffic grows an additional motorway lane is required once persons/hour reaches 4000, again at 7500 and again at 11000. This leads to a lumpy investment profile for road capacity against volumes on the corridor. It costs $7.1m for an additional motorway lane, two lanes cost $14.2m and 3 lanes cost $21.3m per annum. Because capacity has been expanded so traffic is not congested, the congestion price (SRMC) is $0/vkt (marginal maintenance costs are assumed to be covered by petrol tax).

Expanded road capacity gives lower congestion and lower than optimal prices leads to the lowest increase in rail use compared to other scenarios. Rail capacity expands relatively continually, with costs growing steadily over the time period.

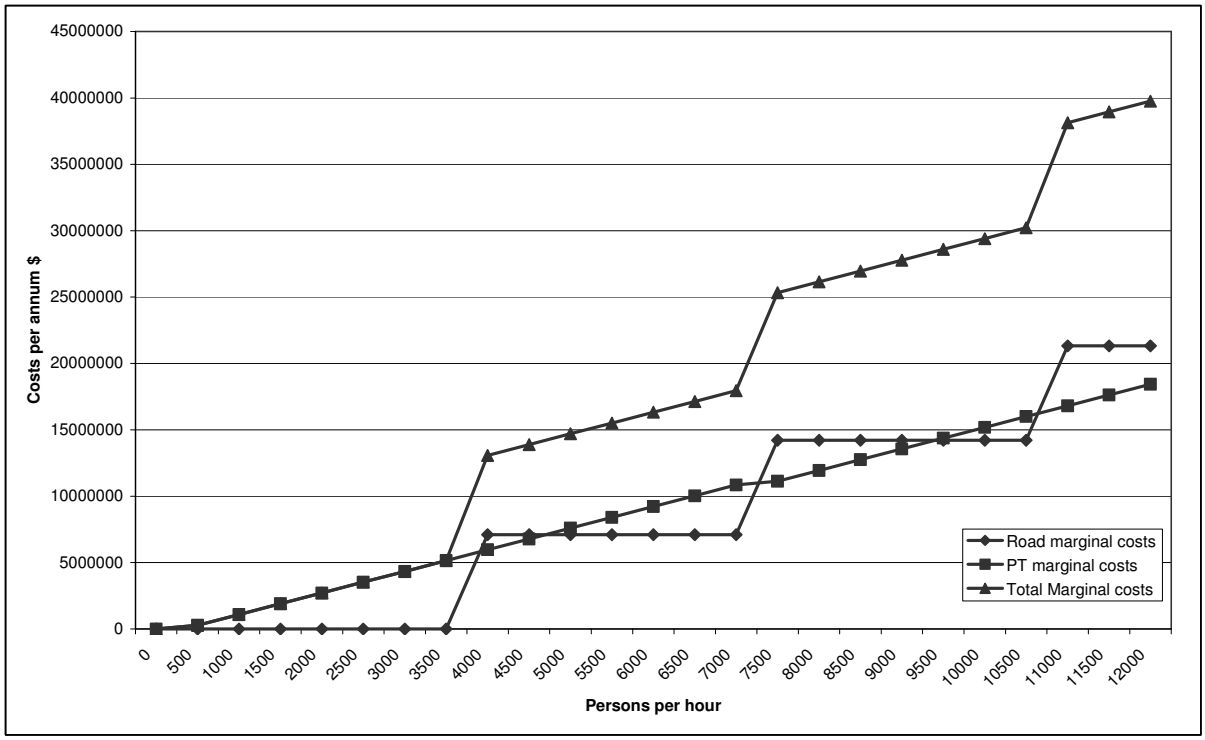

Figure 2 Costs per annum for Predict and Provide

The total cost at 12000 persons per hour on the corridor is $39.8m = $21.3m road + $18.4m rail per annum.

Because road capacity expansion costs $7.1c/vkt (LRMC), but the road price (congestion charge plus petrol tax) is only 6.0c/vkt (SRMC), this approach will generate some trips of less value than the cost of expanding the road capacity. Thus capacity has been expanded 'too far'. Meanwhile, with lower congestion and road prices below marginal cost, public transport, a competing good, remains underutilised, and no capacity expansion is required. Overall mobility is high, at a high cost to the country.

4.3 Price and Punish

Pricing at short run marginal cost produces the greatest (static) allocative efficiency. Unfortunately many have leapt to the 'price and punish' model: assuming that the purpose of congestion pricing is suppress traffic to existing capacity. "If we provide more road capacity, we will only encourage more trips – like digging a ditch in a bog."

Figure 3 shows the costs of the Wellington transport network with no capacity expansion, and congestion charges applied to suppress traffic within that existing road capacity.

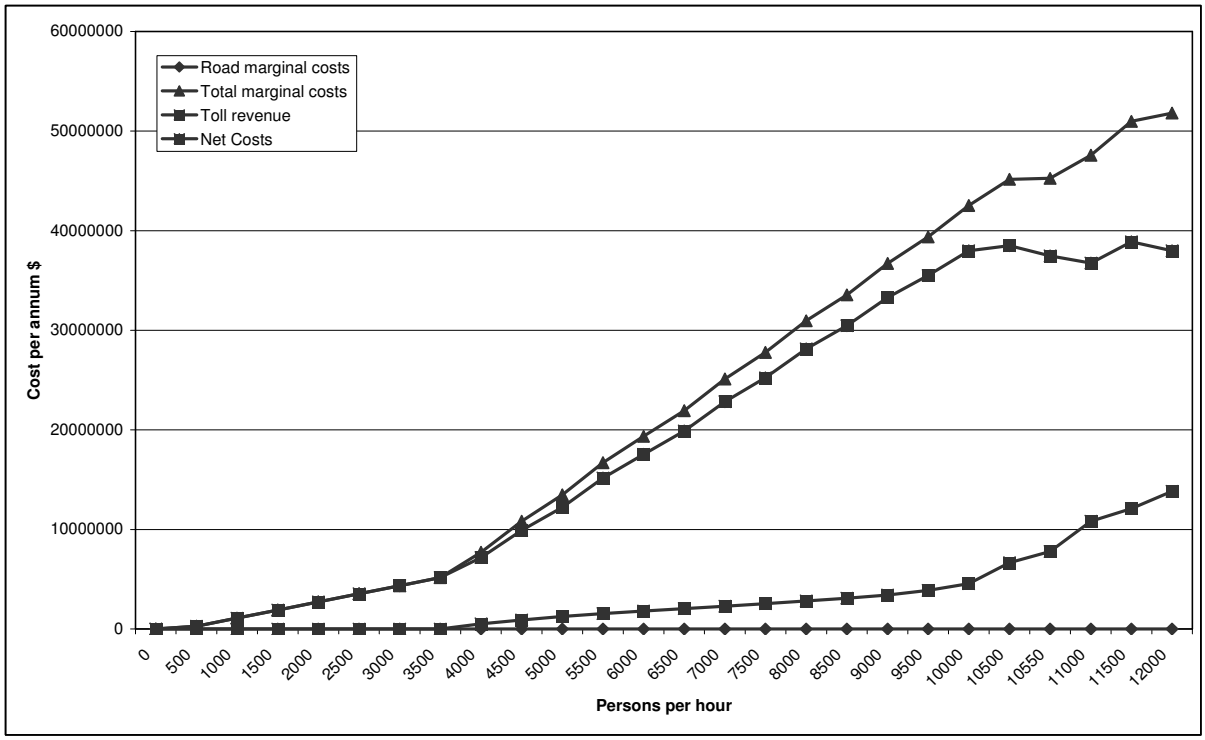

Figure 3 Costs per annum for Price and Punish

In this instance, the road prices exceed the cost of capacity expansion towards the end, so traffic is suppressed below what is desirable, with some users avoiding trips that would be advantageous for the country. With road pricing 'too high', public transport demand is artificially stimulated and public transport costs increase $51.8m per annum because of substantial investment needed in infrastructure and rolling stock to accommodate the trips.

In this case the roading capital cost (LRMC) is $0, but SRMC is $10.5c/Vkt at a corridor flow of 12000 persons per hour. Users are paying more to travel than the cost of expanding parts of the route.

The total cost is $51.8m = $0 road and $51.8m rail per annum. Public transport operating subsidies increase by $9.4m per annum over the Do Minimum

4.4 Plan and Placate

Figure 4 shows the section of network with an optimal combination of capacity expansion and congestion charges.

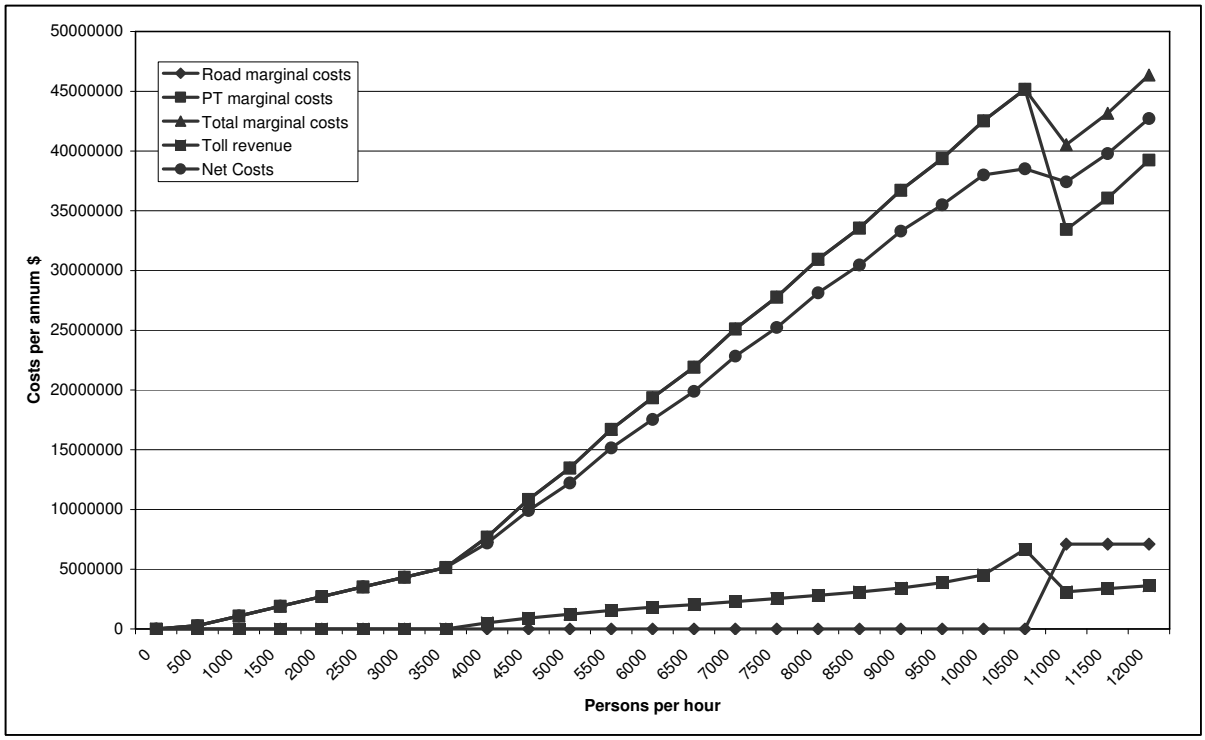

Figure 4 Costs per annum for Plan and Placate

Prices gradually increase as congestion increases, until around 11000 persons/hour, when the price reaches the cost of expanding capacity (SRMC reaches LRMC). Even after expansion, congestion charges continue to limit demand within the new level of capacity. The capacity is half that of the 'predict and provide' approach. Note however that the prices drop lower than the 'price and punish' approach. The public is more likely to accept prices that have an upper limit like this, particularly when they also experience the benefit of increased capacity.

The road prices still stimulate greater public transport demand, requiring investment in the rail system. The total capital cost is $43.2m = $7.1m road $36.1m rail per annum. Public transport investment is more affordable than under the "price and punish" scenario.

This scenario provides a more balanced plan than either the predict and provide or the price and punish. Both road capacity and rail investment are intermediate between the two more extreme models.

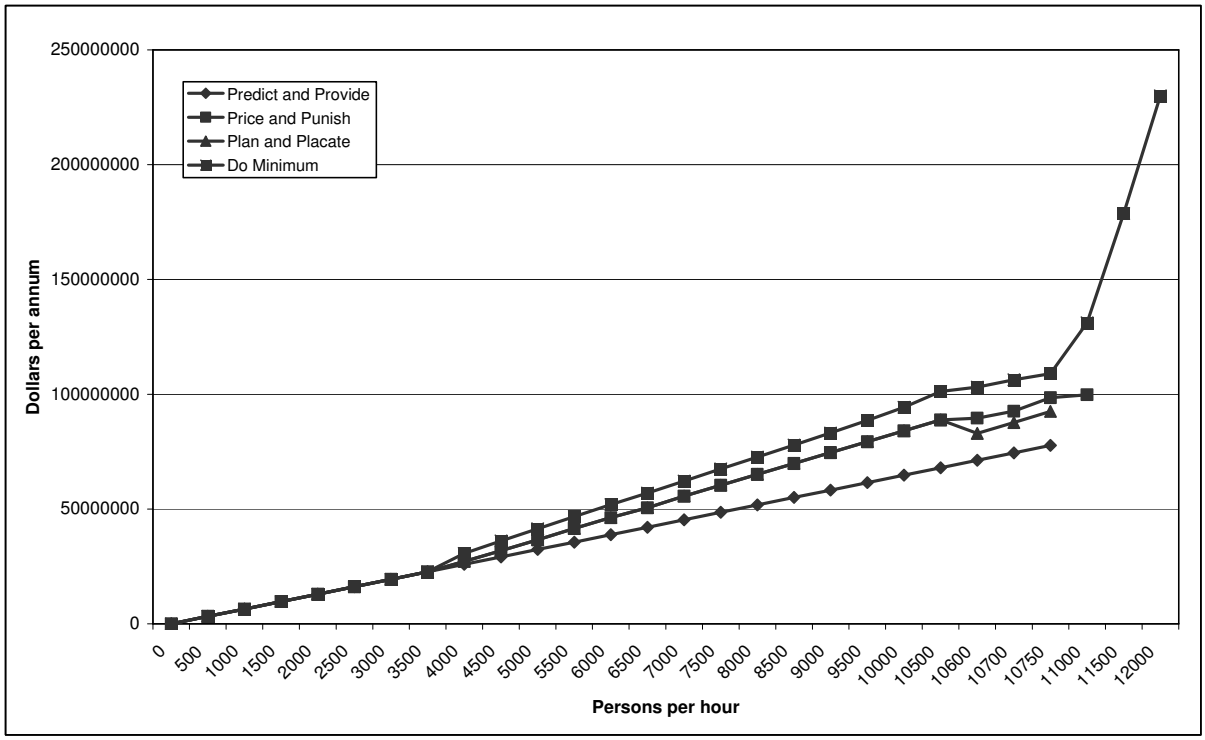

Figure 5 Total economic costs per annum

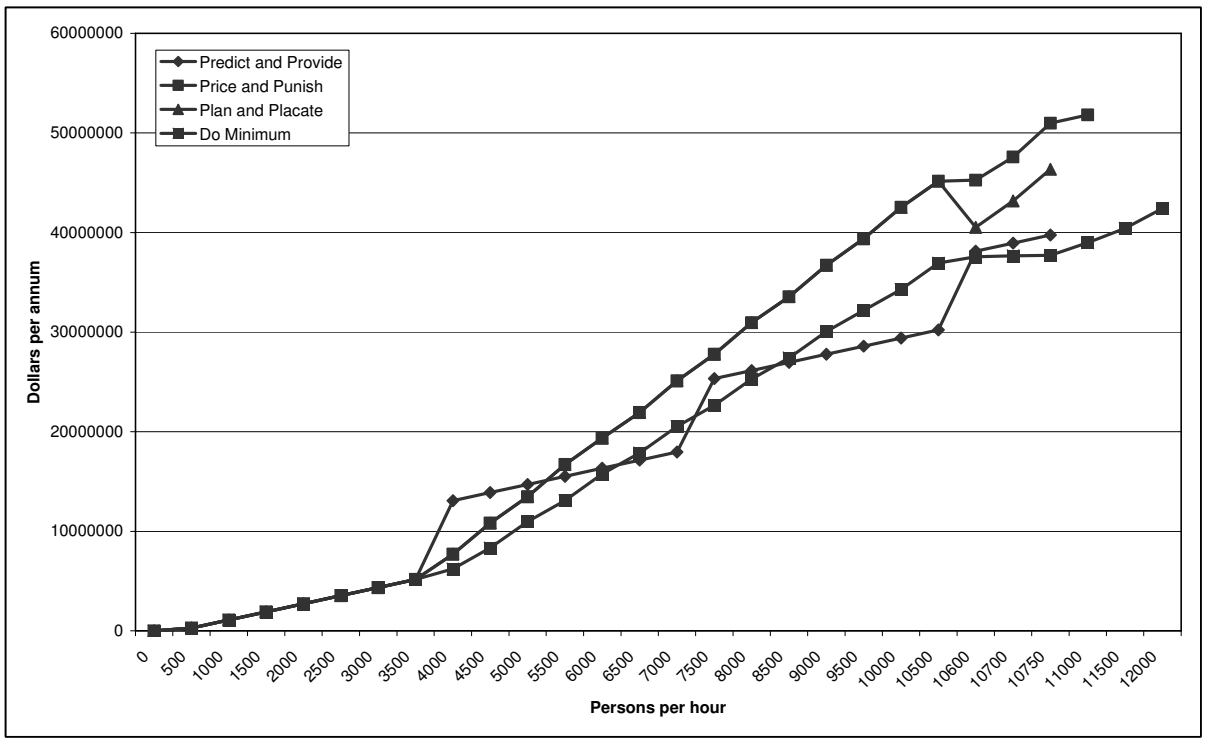

Figure 6 Total costs per annum for each approval

5 Discussion

There is growing recognition that the “predict and provide” approach to building roads was deficient, and resulted in wasted resources. Unfortunately many have leapt from there to the

'do nothing' approach "If we provide more road capacity, we will only encourage more trips – like digging a ditch in a bog."

There is increasing public frustration with the "do nothing" approach, supported by evidence that cities with the least road space per capita actually do have the worst congestion (Wendell Cox Consultancy, 2003), least affordable housing and lowest economic growth. Road pricing appeals as the logical intermediate approach.

However, if a road system is seriously below optimal capacity (from years of 'do nothing', as in New Zealand), then moving to a 'price to punish' approach, without expanding capacity to optimal levels, is simply different way to throttle desirable activity, distort the economy, reduce mobility and unnecessarily suppress a country's standard of living. Balancing road capacity expansion with prudent application of road pricing results in overall greatest welfare and mobility.

Given a serious shortfall of capacity, pricing roads to suppress traffic within that capacity, without allowing expansion, results in monopoly prices and monopoly profits, suppressing economically desirable activity and distorting regional economies and investment in alternative modes.

6 Short run and long run marginal cost pricing

When the cost of expanding capacity is prohibitive (eg central London), considering expansion is irrelevant. However, when congestion costs (SRMC) exceed the cost of adding capacity (LRMC), the socially optimal response is to expand capacity to an optimal point. This is not the same as predict and provide – less capacity should be added than the predict and provide model. Because capacity can only be added in step increments, working out the optimal capacity programme requires a multi-year analysis, comparing overall costs with and without the added capacity over time.

This approach will lead to varying congestion charges over time, with charges increasing as traffic levels grow.

If we are not to predict and provide fully, how much traffic demand should we cater for?

In a talk to the 5th Land Transport Summit (Feb 2005) Denvil Coombe, a specialist in Travel Demand Management from the United Kingdom, outlined his objective was to expand capacity to optimal levels but price to "lock in the benefits of widening". This was interpreted as "maintaining the pre-improvement levels (of traffic) on widened roads". It was suggested we should provide for "the traffic that would arise under an economically optimum area-wide road pricing scheme in the first year that such as scheme is justified".

We have concerns about the implied approach on several counts. One concern is the view that that benefits should be 'locked in' forever. Clearly, when the SRMC again exceeds the cost of new capacity, the appropriate response is to add capacity.

A second concern is that there is no logic in pricing to maintain some ad hoc pre-existing level of traffic. Pricing should maximise value from the system – generally to maximise throughput on the road.

A third concern is outlined in Managing Our Roads' third key principle: "New road capacity should be restricted to that which would be needed under economically optimal road pricing".

We would put this in the converse – before introducing road pricing on any road network, road network capacity should be expanded to that which would be needed under economically optimal road pricing". If capacity is not optimal, SRMC pricing will simply result

in monopoly profits, economically desirable activity will be unnecessarily suppressed to the detriment of the country, and the public will know they are being ripped off and are likely to say so at the ballot box.

The public are extremely suspicious of road pricing, intuitively understanding that the natural outcome will be extraction of monopoly rents (from them). If road prices are set to deliver free flow traffic within existing capacity, and fail to deliver additional capacity, the public will hold an entirely valid suspicion about road pricing altogether.

7 Market dynamics

Pricing at marginal cost produces the greatest (static) allocative efficiency. In a competitive market, SRMC incentivises optimal dynamic allocation of resources.)

What about the dynamics? Under pure competition, as demand increases beyond the cost of the next unit, producers vie to increase production at lowest cost. Supply expands as soon as it becomes financially viable.

Particularly in New Zealand, road reform analysis assumes it is the absence of pricing mechanisms, rather than of competitive markets, that drives optimal dynamic investment decisions. But consider that with roads, there is no potential for competitive expansion. If prices are too high, and there are superprofits, suppliers cannot line up to add capacity.

Moreover, there are considerable barriers to expansion other than cost, with legal, political and institutional delays. Costs can be added such as tunnels rather than surface options, or features added that make the project prohibitively expensive (eg added bus and cycle lanes).

Finally, there is no method to ensure funding reaches optimal levels, and few mechanisms for private funding. Thus, in the absence of clear mechanisms to ensure capacity supply can be achieved, optimal pricing is condemned to be no better than a ‘price and punish’ approach, with users being held to ransom by delay tactics and the wider benefits to the economy being lost.

8 Conclusion

In investigating future transport development plans across all modes, the lowest cost approach is to expand capacity at the point the congestion price exceeds the cost of capacity expansion. We would argue that congestion prices should never be set at above the LRMC for this reason, so that price gouging will not take place. Further, adequate rules to ensure timely supply of capacity are important for developing the lowest cost transport system and to ensure the long term well being of the country.

References

Coombe, D. (February 2005). *Keynote Address.* 5th Annual Land Transport Summit, Auckland New Zealand.

Wendell Cox Consultancy (2003). *The Public Purpose.* Travel Time Index Trend 1982 2001. USA.