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The Urban Transport Institute

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Variations in the Value-of-Time over Time

**A Report to Hyder Consulting
for the Lane Cove Expressway Consortium**

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1 Background

The assessment of the usage levels of a toll-road is critically dependent on the Value-of-Time (VOT) assumed for potential users of the facility. If potential users have a high VOT (i.e. they are willing to pay more for saving travel time) then the usage of a toll-road will be higher than if they have a low VOT (i.e. they are not as willing to pay more for saving travel time). Typically, such VOTs are found by the use of survey techniques such as Stated Preference (SP) surveys, wherein potential travellers trade-off time savings against cost penalties to reveal their VOT. Often, the VOT is expressed as a percentage of the average wage rate of the population in question. For travel time savings on trips performed as part of work, the assumption is usually made that the VOT is equal to the wage rate. For travel time savings on other trips (including commuting), the assumption is usually made that the VOT is equal to a fraction of the wage rate. This fraction varies with the population in question, but is often taken to be somewhere between 25% and 40% of the average wage rate.

An important issue, but one about which there is limited direct evidence, is how the VOT varies over time. Presumably at the most general level, a relationship between the VOT and income is expected to be preserved. However, will the relationship be empirically the same (i.e. stay at the same fraction) or will the relationship change empirically? More specifically, the question can be posed - what is the elasticity of the average VOT with respect to income (or GDP per capita)? This is a non-trivial question - for an economy with a growth rate of 2.5% and a discount rate of 6 per cent, the effect of assuming that the elasticity is 0.5 rather than 1.0 is to reduce the present value of a constant stream of time savings from a project with a 20 year life by 9%. Clearly, there is a need to explore this question to see what is the most reasonable assumption to make about the future VOT for a project.

2 The Options

The VOT is the ratio of the marginal utility of time, which is composed of effects attributable to:

- the opportunity cost and the disutility of time spent travelling (an increase in either of these will increase the VOT); and
- the marginal utility of money (a decrease in which will increase the VOT).

Variations in either of these can lead to variations in the VOT over time.

The marginal utility of money is expected to vary over time due to income growth, with individuals becoming less sensitive to changes in the prices of goods and services as their incomes increase (with a positive effect on the VOT). However, the progressive tax system means that the marginal utility of income may not fall as quickly as might be presumed from a consideration of changes in gross (before tax) income, since increases in before tax income do not translate into proportional increases in after-tax income.

The marginal utility of time can be influenced over time by a broader range of factors:

- Cars have become more comfortable and in-car facilities have improved. There have also been improvements in public transport comfort levels. These will have operated to reduce the disutility of time spent travelling.
- The opportunities for the productive use of travel time might vary. For example, the advent and widespread ownership and ability to use mobile phones in cars may have reduced the opportunity cost of travel time. Additionally, the possibility to use laptop computers on some modes may have had a significant downward influence on the VOT.

- Travel conditions have in some respects deteriorated, and may continue to do so. This is largely related to excess demand reflecting itself as congested driving conditions (as currently seen in the Sydney road network at peak hours) and to overcrowding on some public transport services. The increase in frustration, annoyance and discomfort will operate to increase the VOT
- The trend towards shorter working hours will reduce time constraints and can be expected to reduce the VOT.
- An increase in flexible working hours will reduce the pressure to arrive at work at a specified time, leading to a reduction in VOT for the journey to work.
- As the quantity and quality of leisure time activities increase, and there becomes more effective competition between activities, the opportunity cost of time spent travelling can be expected to increase
- There could be trend changes in preferences for and attitudes towards time savings.

Because of these multiple influences on the opportunity cost and marginal cost of time spent travelling, the future effect of these influences is unclear. Therefore the most robust way to examine how the VOT varies over time is clearly an issue for empirical determination. The methodologies that have been used in various studies to explore this issue have included:

- Longitudinal studies, in which changes in VOT have been measured over time
- Examination of cross-sectional income elasticities
- Meta-analysis of a large number of VOT studies

Arising from these various studies, and sometimes in the absence of any clear evidence, three basis positions have been taken with respect to changes in VOT over time:

- Elastic increases in VOT with respect to changes in income over time
- Inelastic increases in VOT with respect to changes in income over time
- No change in VOT over time

2.1 Elastic Increases over Time

The most widely held convention, and the one used by DTLR in the UK, is that VOT grows directly in line with income and no consideration is given to possible changes in the value of time for other reasons, i.e. the elasticity of VOT with respect to income is 1.0. In other words, all values of time (work and non-work) are updated for each year of the evaluation period by the expected real rate of growth of GDP per capita. Past studies, for example the 1st British National Value of Time Study, (MVA et al., 1987) considered this position to be reasonable pending further evidence.

Mackie et al, in their 2001(b) study concluded that for business travel the case for a close link between the VOT and income can hardly be questioned for business travel. Since using the wage rate as an approximation to the employer's value of travel time savings during working time is regarded as reasonable, it follows from this that we should expect the average value to the employer of working time savings to grow proportionately to the average growth in real wage rates. Note that as GDP per capita rises, wage rates are likely to rise faster since fewer hours are being worked to earn this income. Therefore, we should expect the employer's value

of working time savings to increase somewhat faster than proportionately to the growth in GDP per capita.

Mackie et al. (2001b) also argue that they would expect values of non-working travel time savings to rise less fast than wage rates, but nevertheless probably about as fast as GDP per capita. Considering the special case in which working hours per week (and therefore also leisure hours) are held constant as real income rises, one would expect the value of travel time savings to rise proportionately to wage rates. In practice, however, people take out some of their increased real wealth in extra leisure and part in extra income, so that per capita income will not rise as fast as wage rates. In other words the income effect is on average stronger than the substitution effect. Thus Mackie et al. (2001b) argue that a reasonable long-run expectation is for the value of savings in non-working travel time to increase proportionately to per capita income growth.

The World Bank also argues for an elasticity to income of 1.0 for both working and non-working travel time savings (Belli et al, 1998). While they recognise that some studies have suggested a lower elasticity, they state that "the findings, however, are not yet universally accepted. In view of the limited evidence, a rule of thumb is to assume that the value of time (for employer's business trips) will increase proportionally to income, or more precisely, to GDP per capita, unless there is evidence to the contrary in the country where the project is being undertaken". They then state that "it is less clear that the value of non-work time should be adjusted in the same way. On the one hand as wages increase, it might be expected that the willingness to pay for leisure (generally regarded as a superior good), and hence the payment required to forego leisure, should increase even faster. On the other hand, if technological developments were predominantly labor saving, average hours of work might decline to an extent that the scarcity of leisure time, and hence its value is reduced. Given this theoretical indeterminacy, and the absence of strong empirical evidence on the matter, as a rule of thumb, non-work time should be valued at a constant proportion of the wage rate over time". Holding the VOT for non-work time "at a constant proportion of the wage rate" is equivalent to saying that the elasticity of non-work VOT with respect to changes in wage rate is equal to 1.0, since a 10% increase in wage rate will also see a 10% increase in VOT.

2.2 Inelastic Increases over Time

The 1st British National Value of Time Study (MVA et al., 1987), having stated that an elasticity of 1.0 would be reasonable, also concluded (MVA et al., 1987, p122) that for personal VOT's they had "clearly demonstrated the existence of an income relationship, which has never been done before with any conviction" and that "the value of time as a proportion of income is a decreasing function of income, rather than a constant as has hitherto been assumed". The second British study (Accent and Hague Consulting Group, 1996; p31) concluded that, "The findings of this study, supporting those reported in The Netherlands, are that VOT is indeed related to income, but the relationship is not one of proportionality. Rather, income elasticities of around 0.5 have been found". National studies in Sweden (Algers et al, 1996), Norway (Ramjerdi et al., 1997) and Finland (Pursula and Kurri, 1996) all found cross-sectional income elasticities somewhat less than one. All these studies have used cross-sectional studies in which differences in personal VOT have been observed across income groups, and elasticities implied therefrom.

The Netherlands results mentioned above are also described by Gunn (2001), and are illustrated below in Figure 1. It can be seen that the personal VOT's (converted to English currency) rise with increasing household income, but not proportionally.

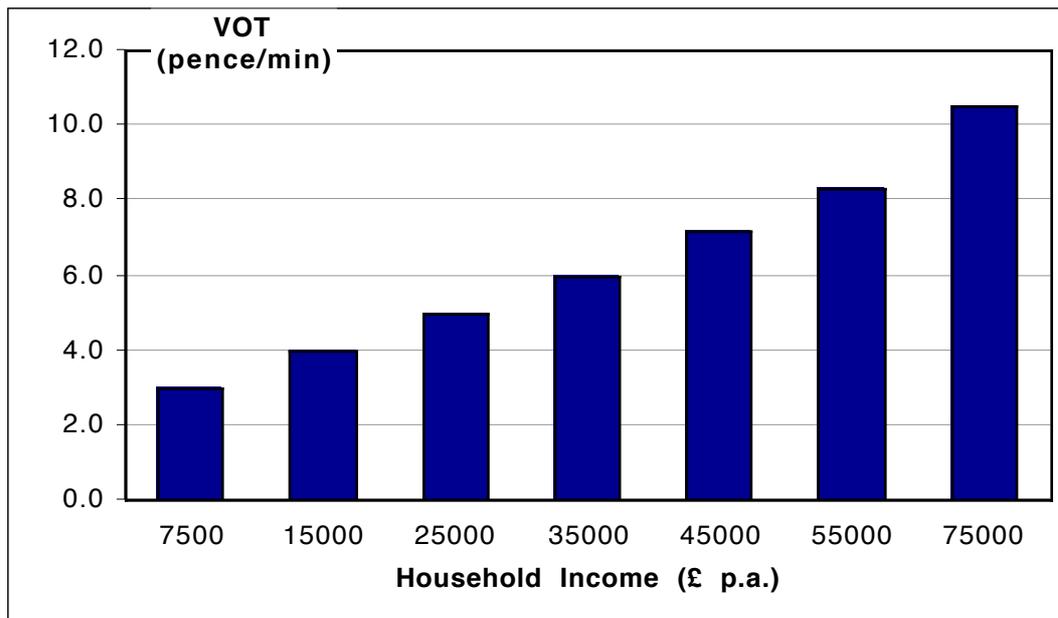


Figure 1 Cross-Sectional Changes in VOT with Household Income (Netherlands)

When the elasticity of change in VOT is calculated with respect to income, it can be seen in Figure 2 that the elasticity is less than one and varies between 0.33 and 0.70.

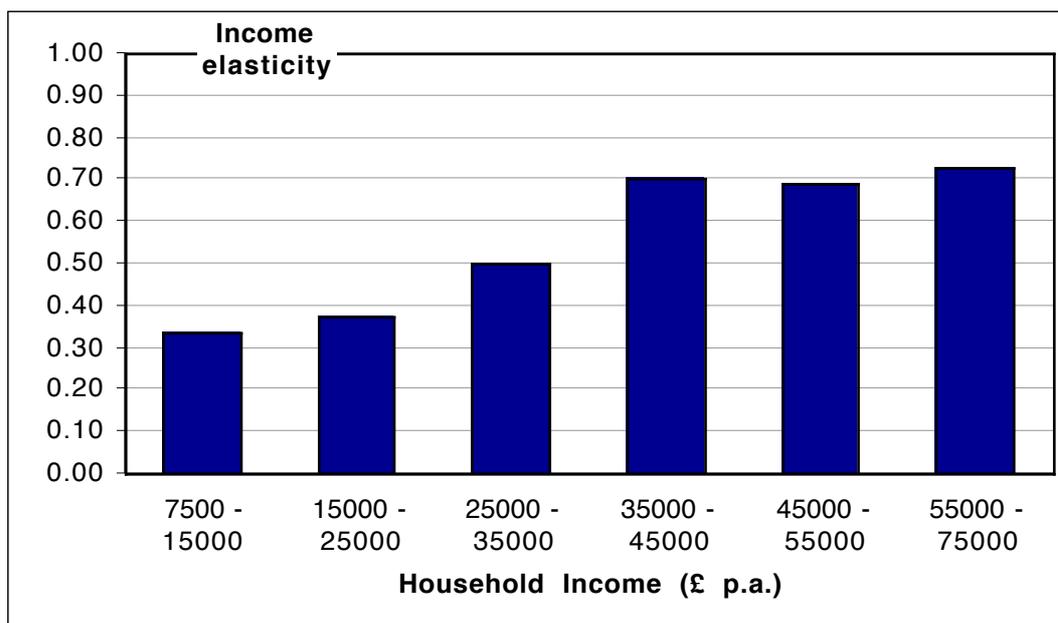


Figure 2 Elasticity of VOT w.r.t. Income as a function of Household Income (Netherlands)

Similar results have recently been found in a VOT study conducted in Singapore by The Urban Transport Institute. In that study, an Adaptive Stated Preference survey method was used which allowed the estimation of individual VOTs for each of the 3000 respondents. Since the personal income of each respondent was also known, it was possible to relate the VOT to the personal income on a case-by-case basis. The relationship between Personal Income and non-work VOT is highly significant, as shown in Figure 3. Those with the highest income have the highest VOT, and vice versa.

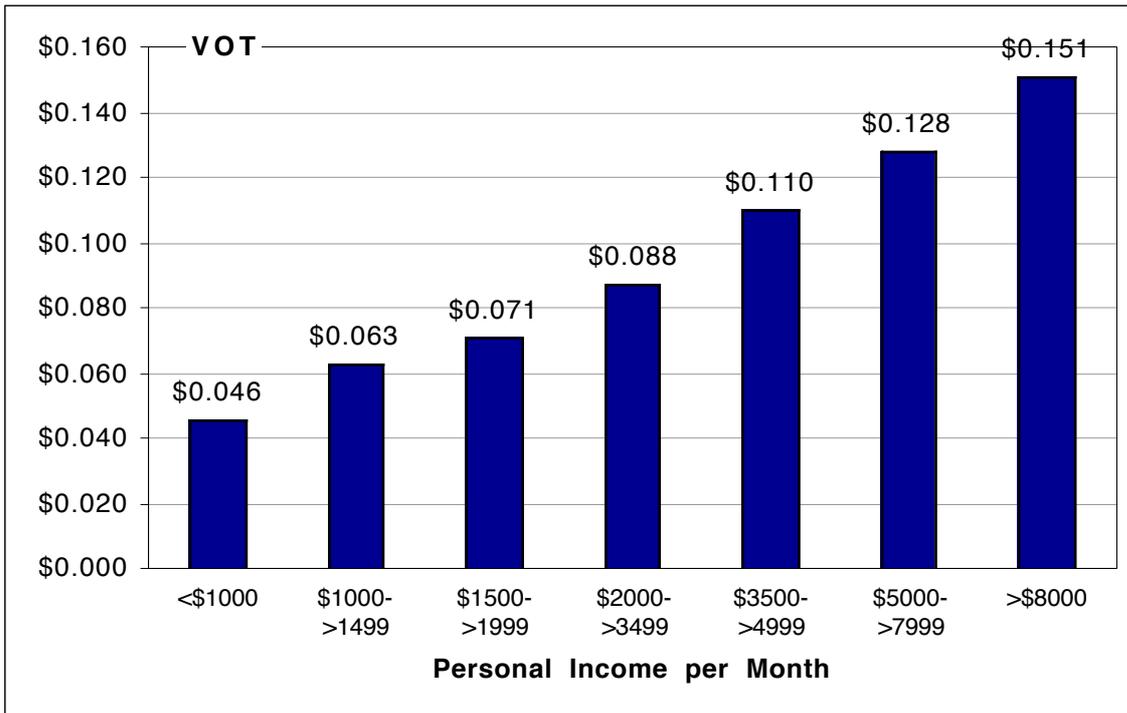


Figure 3 Cross-Sectional Changes in VOT with Personal Income (Singapore)

However, the VOT is not directly proportional to personal income. If one divides VOT (per hour) by hourly income (assuming 180 work hours per month), one obtains the relationship shown in Figure 4.

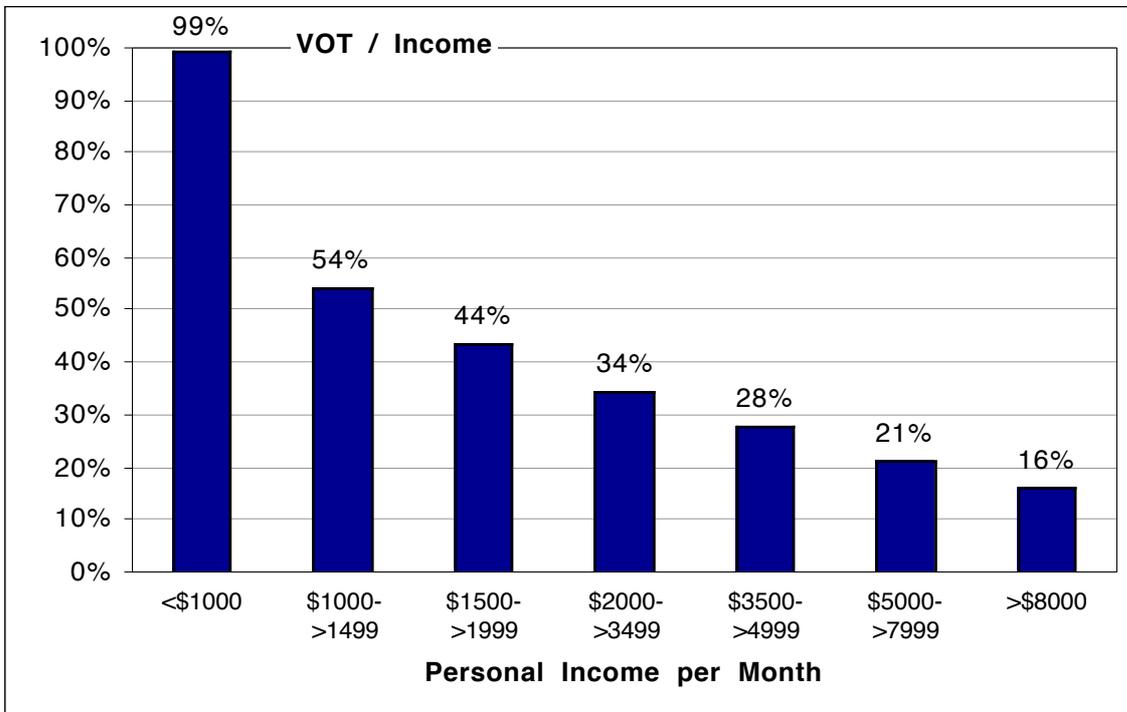


Figure 4 VOT/Income as a function of Personal Income (Singapore)

It can be seen that, while the average VOT is 30% of the average personal income (for those in employment), this ratio is not constant for all income levels. It falls from a ratio of 99% of personal income for the lowest income group down to 16% of income for the highest income

group. The ratio of 99% does not just mean that those in the lowest income group would be willing to spend all their income in order to save travel time. It also means that they would be prepared to accept longer travel times if they were paid an amount equal to their hourly income rate. While those on lower incomes would be willing to pay or accept less in absolute terms for travel time changes, these amounts are a higher proportion of their personal income.

If one compares changes in VOT to changes in income as one moves up the income scale, it can be seen below that the cross-sectional elasticity of VOT with respect to personal income is about 0.4 across the entire range of personal incomes, as shown in Figure 5.

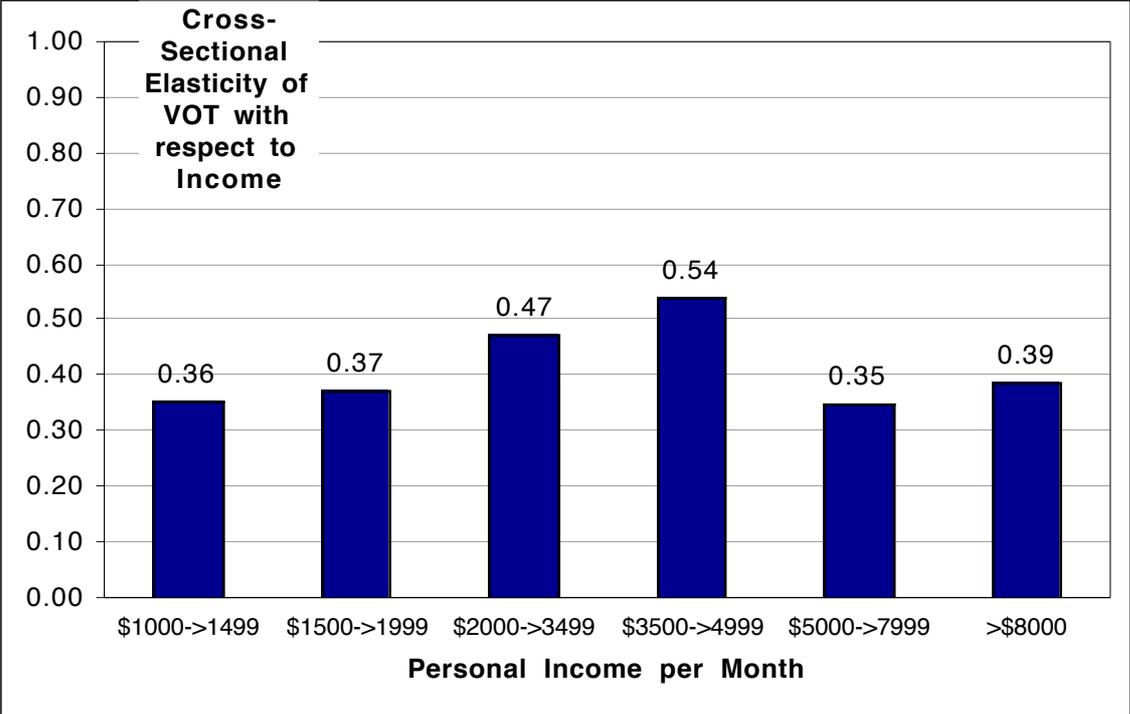


Figure 5 Elasticity of VOT w.r.t. Income as a function of Personal Income (Singapore)

While the above findings are generally in line with those found in Europe and elsewhere, a further finding is of significance. As well as being related to VOT, personal income is also closely related to mode usage. As shown in Figure 6, the distributions of personal income for Public and Private Modes are very different, with Public Mode users grouped at the lower end of the personal income scale and Private Mode users grouped at the higher end of the personal income scale.

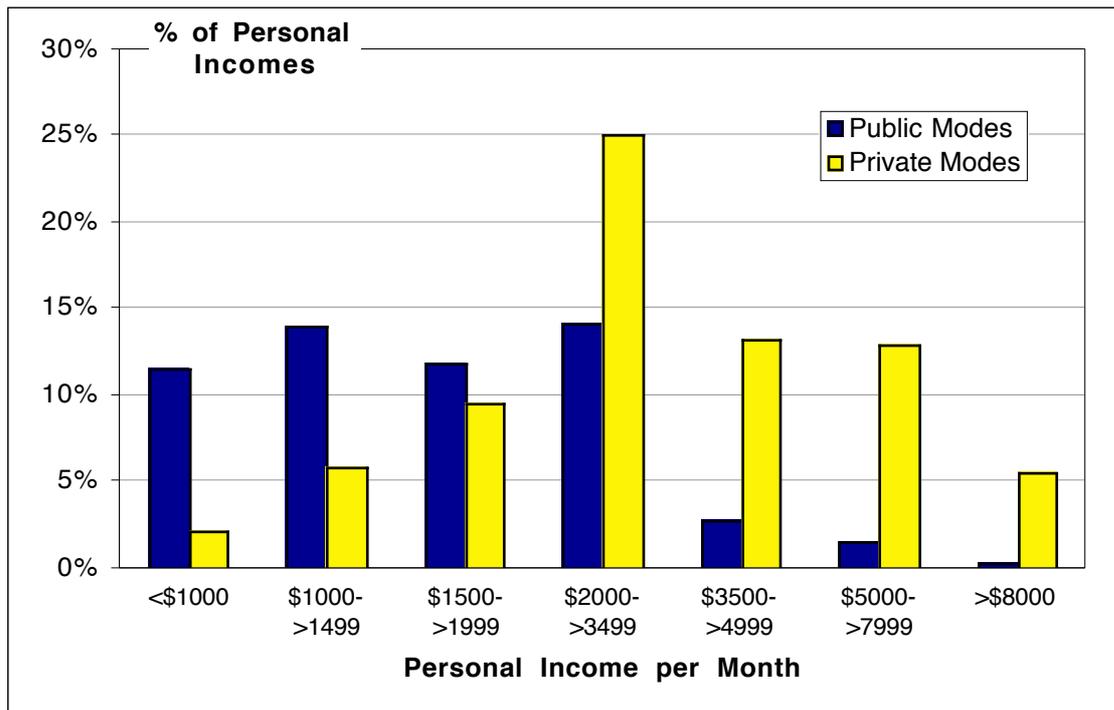


Figure 6 Mode Usage as a function of Personal Income (Singapore)

These differences are even more striking if one considers the probability of using a Private Mode with changes in income. As personal income rises, the probability of using a Private Mode increases proportionally, as shown in Figure 7.

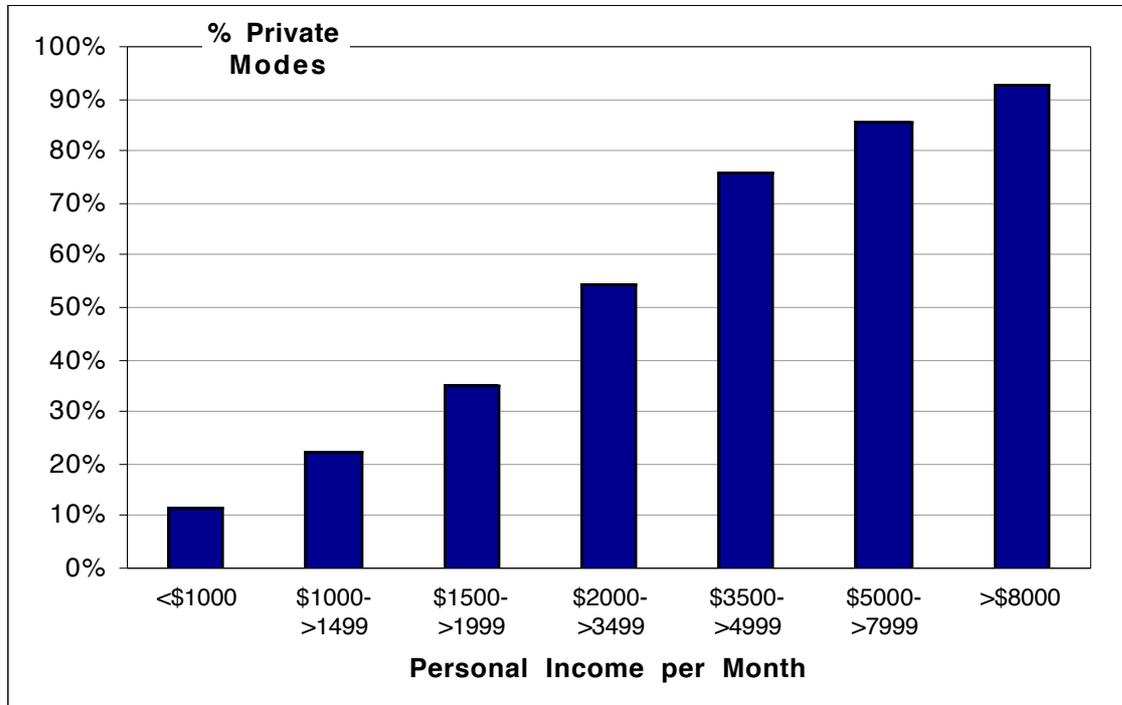


Figure 7 Probability of Using a Private Mode as a function of Personal Income (Singapore)

Within each of the mode groups, there is a relationship of VOT with personal income, as shown in Figure 8. However, these relationships are not as strong as the overall relationship between personal income and VOT shown earlier. This indicates that the overall relationship

is a combination of the relationship between VOT and personal income within the mode groups, and the transition from Public Modes to Private Modes as personal income increases. Clearly, the elasticities of VOT with respect to income are much lower within the modes than in the population as a whole. Indeed, the elasticity for private mode users is about 0.10 while the elasticity for public mode users is about 0.13.

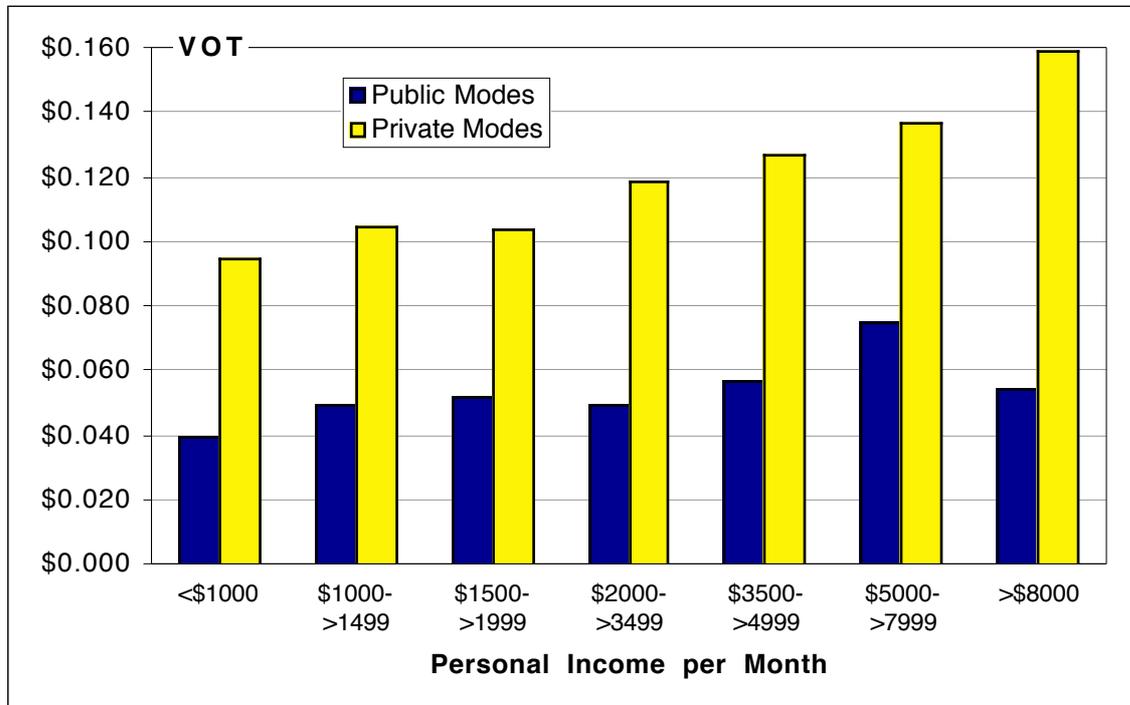


Figure 8 Changes in VOT with Personal Income by Mode Used (Singapore)

This finding has implications for all cross-sectional studies of variation in VOT with income. It is (implicitly) assumed that the variation in VOT with changes in income over time would be similar to the variations in VOT with changes in income over the population at one point in time. However, in comparing VOT across users, there may be many more things changing than just their income (in the above case, their mode also changed). To the extent that these other changes affect their VOT, the elasticity of VOT with respect to income will be reduced.

This conclusion is at variance, however, with that reported by Mackie et al. (2001a), where they state that "we must point out, however, that cross-sectional income elasticities may be expected to be lower than time series based income elasticities and hence should not be used directly in forecasting how the value of time will vary over time. This is because they have been obtained from choice based samples and self-selectivity issues arise. For example, high income bus users will have relatively low values of time otherwise they would not be using the bus whereas low income car users may well have high values of time since this has led them to be a car user". In the Singapore study however, it was found that there were very few high income bus users and very few low income car users. Therefore the self-selectivity bias noted by Mackie et al. (2001a) may not be a strong influence in reality.

Inelastic changes in VOT have also been reported by Wardman (2001) and Mackie et al. (2001a) using a significantly different study method. He collected 157 values of VOT segmented by income drawn from 20 British studies. He then examined how the values varied with income by developing a regression model which had the ratio of two values of time as the dependent variable and the ratio of two mean income levels as the independent variable. In this way he estimated an elasticity measure across a range of studies. Over all studies, the income elasticity was 0.578.

2.3 No Changes in VOT over Time

A number of studies have argued that there should be no change in VOT over time. However, these studies are more exploratory in nature and are less widely recognised as statements of recommended practice.

An early study by Beesley (1971) (quoted in Mackie et al., 2001a) examined the issue of inter-temporal variations from a purely theoretical point of view and, on the basis of the uncertainty as to even the direction in which the values might vary, he argued in favour of a zero trend value. The 1st British National Value of Time Study (MVA et al., 1987) also concluded that on theoretical grounds a constant real value of time was "equally logical and defensible", although the study also recognised that there did seem to have been an increase in the value of time over time. The final conclusion of the MVA study was that without carrying out any specific work on this topic within their program, and given the existence of plausible arguments in contrary directions, no firm conclusions could be reached.

A more recent analysis by Gunn (2001) also argued that VOT has not changed over time. Using a longitudinal study design, the analysis compared results from two comparable studies of VOT in The Netherlands in 1988 and 1997. In contrast to the studies cited above, Gunn concluded that the marginal utility of time had in fact fallen by 9% between 1998 and 1997. However this was compensated for by the increase in income over that period, resulting in a VOT that stayed essentially constant over that period. The importance of the Netherlands results reported by Gunn are that they consider changes in the marginal utility of travel time savings, as well as changes in the marginal utility of income. While incomes will undoubtedly rise in the future, Gunn (2001) argues that the effects of these income rises on VOT may well be compensated for by reductions in the marginal utility of travel time savings (as a result of increased free time, increased utility of time spent travelling due to improved telecommunications and a range of other factors).

Some evidence of similar similar results were been reported by Mackie et al (2001a) using data from Newcastle (UK) collected in 1985 and 1994. However, considerable uncertainty surrounds the results of the study with a number of outcomes described by the authors as "not credible".

3 Conclusions

A review of recent studies on the change in VOT over time demonstrates that different methods of analysis have been used with different types of data to reach different conclusions.

However, most studies agree on the likely changes in the value of time for trips on employer's business, recommending that the VOT should change by the same proportional as the change in GDP per capita.

The conclusions for non-work VOT are less consistent. The majority of empirical studies have been carried out on a cross sectional basis. These studies of the elasticity of VOT with respect to income demonstrate a range of positive elasticity values of between 0.3 and 0.7, with a general consensus that a figure of 0.5 is most appropriate. The results of the very few longitudinal studies that have been conducted, suggest that as well as a decrease in the marginal utility of income (as incomes rise) which would lead to a higher VOT there may be a decrease in the marginal utility of time savings (due to increased free time, increased utility of time spent travelling due to improved telecommunications and a range of other factors). However, the small number of these studies, and the inherent uncertainty in longitudinal studies (which is recognised by the authors in producing their results) reduces the confidence that we have in these results.

Therefore, on the basis of the majority of research reported so far, it seems that the most prudent conclusion would be to assume an elasticity of VOT with respect to GDP per capita

of 1.0 for business travel, and an elasticity of VOT with respect to personal income of 0.5 for non-business travel.

4 References

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