A BENCHMARKING METHOD FOR SETTING EFFECTIVE MODAL TARGETS FOR EMPLOYMENT SITE TRAVEL PLANS

Xiaodong Sean Zhang
JMP Consulting Limited

1. INTRODUCTION

In the UK, Transport Assessment (TA) is a widely used method for informing the planning process. For many developments, the TA leads to development of a sustainable Transport Strategy for the site, which is implemented through a Travel Plan (TP). This ensures that good planning intentions are implemented in the actual land use activities. However, one of the key questions concerning travel planning that is frequently asked by all involved parties is "how do we set realistic yet challenging mode targets for a particular Travel Plan?"

Guidelines for setting TP targets are available. However, they were not developed to enable detailed target setting. In practice, negotiations take place and lead to agreements on mode targets, but in many cases, the planning authorities can find it difficult to justify desirable targets as there is no clearly defined method based on quantified evidence. Therefore, there is a role for a new method that can bring more certainty and confidence into the target setting process, and TPs as a whole.

In Scotland, the use of mode share targets and TPs as part of the development control process is increasing. However, many businesses, developers and land users express their concerns on the validity of the procedure for target setting. They also, quite rightly, point out that there are factors outwith their control, such as accessibility issues, domicile distribution and travel behaviour of the end users etc, which make it difficult for them to achieve modal targets.

Broadly speaking, there are two different categories of problems when it comes to mode share target setting. The first category relates to occupied sites whose site users' travel pattern can be identified, and the second relates to speculative developments. The latter category is more complicated because the ultimate occupier or users are not identified at the time of target setting. Within each of the two categories, there are sub-categories defined by land use types.

This paper concentrates on the simplest case, namely target setting for employment sites already in use with site users' travel pattern known. It is felt that if a solution can be found for this simplified case, the methodology could be adapted and applied to other categories of problems. The research has been undertaken as part of JMP Consulting's role as term consultant to Transport Scotland.

A list of abbreviations is provided below to explain the terms and definitions used in this paper.

List of Abbreviations:

Arithmetic Mean Profile – The average "accessibility vs. mode share" profile for a group of sites, calculated based on an arithmetic method as defined in Textbox 2.
P2PJT – Postcode to postcode journey time
PT – Public Transport
r – Pearson's Product Moment Coefficient
TA – Transport Assessment
The Mean Profile – The average "accessibility vs. mode share" profile for a group of sites
The Profile – The "accessibility vs. mode share" profile for a particular site
The Ratio – The ratio of the P2PJT by car to the P2PJT by PT
TP(s) – Travel Plan(s)
Weighted Mean Profile – The average "accessibility vs. mode share" profile for a group of sites, calculated based on a weighing method as defined in Textbox 1.

2. DEFINING THE RESEARCH

The key subject of this research is to find out how to set reasonable yet challenging mode targets using a simple method. This section identifies problems with the current target setting process. A few fundamental questions have also been considered at the outset so that the boundaries of the current research can be cleared defined.

2.1 Current Problems

Based on previous experience and a literature review, the following problems have been identified.

(1) There is a critical lack of good baseline information on mode share for existing developments *(Colin Buchanan, 2001)*;
(2) There is a lack of method for assessing mode share targets against site users' accessibility to key transport services;
(3) The use of historical data and trip generation databases tend to replicate past travel patterns. This encourages developers to provide for more car travel than is necessary, rather than promoting sustainable modes as current government policy advocates *(Colin Buchanan, 2001)*;
(4) The guidance on mode shift targets given in Planning Advice Note 75 *(Scottish Executive, 2005a)*, or PAN75, is only simply related to infrastructure provision and does not concern the origins/destinations of trips and the distribution of site users. It has been noted that the guidance **must** be adjusted for local circumstances *(Colin Buchanan, 2001)*, but no clear method is available to enable this crucial

adjustment. Instead, practitioners often use the rule of thumb as it is without looking at its applicability; and

(5) It is felt that planning polices should emphasise the role of mode share targets in development control; and yet there is a lack of confidence on both the planning authority and the land users' part in the validity of the mode share targets. Consequently, targets can often only be set loosely, losing their purpose in the first place.

2.2 Appreciation of the Subject

The subject of the study is to develop a simple method for setting reasonable yet challenging mode targets. To enable the study, a few critical questions need to be answered first.

(1) The first question is, when trying to set mode targets for a particular occupied site, do we try to simulate and forecast how the site users could actually travel, or instead establish a mode share that is "right" and "reasonable" for the site?

The former method needs to take account of all factors affecting travel behaviour and can be very complex, especially as human will is involved. The latter, however, simplifies the target setting process. It is much easier to justify a "reasonable" mode split for a site. The challenge then is to establish a benchmarking system to confirm the proposed mode split is reasonable.

When an "expected" mode share target is proposed and justified by a benchmarking system, the difference between it and the "baseline" mode share will be the modal shift target. To further simplify the problem, the current research concentrates on the modal split between car and non-car travel modes. As to the split between different non-car modes, it was considered too complicated to be included into the current study.

(2) The second question is, whether it is logical to construct a benchmarking system based on a method that only considers transportation factors?

It is difficult to predict a particular person's travel behaviour. This is mainly because the way each individual travels is determined not only by factors relating to transport provision, but also numerous social, economic and, indeed, random reasons. If a target setting mechanism is based on grounds such as habits, income level and car ownership rate, there will be no level playing ground in target setting since the whole process would be distracted by numerous factors whose effects and merits are difficult to quantify and justify.

From a social inclusion point of view, it is difficult to justify the consideration of some economic and social factors, such as income level, in the target setting process. For example, a group of people of higher income have ***no*** more or less right than others to use their cars. Therefore, this research does not try to separate the effects of non-transport factors on travel behaviour from target setting process. Instead, the idea is to accept that despite the differences caused by social and economic factors, there is a 'mean' level of sustainable travel that can be used as a norm for benchmarking purposes.

(3) The third question, is if the target setting process excludes non-transport factors, how do we address the effects of these factors on travel behaviour?

The author holds the view that it is appropriate to have a two-staged process in travel planning. The first process aims at setting "expected" mode share targets against a benchmarking system purely from a transportation point of view. This stage is named as the ***"benchmarking stage"***. The second stage allows the development of packages of measures for achieving modal shift targets. The success of this process relies on detailed analysis of individual travel behaviour. Therefore this second stage is named as the "***micro-analysis stage***". The former stage is mainly used for setting targets, while the latter concerns the realisation of modal shift. The author's view is echoed by the recommendations given in the Transport Assessment and Implementation: A Guide *(Scottish Executive, 2005b)*, which states that "it may be appropriate to confine the Transport Assessment only to infrastructure matters that can be provided by the developer and require a Travel Plan to encourage behavioural change from the occupier".

2.3 Simplification of the Problem

Based on the discussion above, the primary aim and approach of this study is to separate the mode share setting process from considerations on non-transport issues and factors, and link the mode share targets closely to accessibility assessment. It should be noted that, in this paper, the term "accessibility" refers to individual commuters' accessibility to transport infrastructure and services.

In reality, the ***"benchmarking stage"*** would take place before a TP is approved by the Planning Authority, and the "***micro-analysis stage***" takes place after a TP is approved and baseline travel pattern is established. The "expected" mode share targets are determined in the ***"benchmarking stage"*** without having to take into account individual commuters' travel behaviour. Nevertheless, the ***"benchmarking stage"*** and the "***micro-analysis stage***" processes should interact. Conclusions drawn from the latter stage should be fed back into the former so as to optimise the benchmarking system in the long run.

3. THE BENCHMARKING APPROACH

It was proposed to construct a benchmarking system that can make different sites comparable in terms of their key transport characteristics. The benchmarking system will be used in the ***"benchmarking stage"*** to evaluate proposed mode share targets against surveyed data (accessibility and mode share) in order to reveal whether they are fair, realistic and challenging.

3.1 Main Factors Related to Car Mode Share

To enable the construction of the proposed benchmarking system, factors that are of the strongest correlation to mode shares need to be identified. The identified factors must be relevant to all sites so that they can be made comparable despite their different locations, level of public transport provision, infrastructure provision and the domicile distributions of site users.

As part of the research carried out for TRICS *(Faber Maunsell, 2002)*, the relationship between 17 factors and Car/Non-car mode share were investigated. Table 1 shows the list of factors and their correlation coefficient *r*, Pearsons Product Moment [1], to mode share. According to Table 1, accessibility to public transport services [2] has the highest correlation to car mode share. Figure 1 further illustrates that, generally speaking, a site with a higher accessibility to public transport will have a lower car mode share. According to Table 1, car park availability (both on-site and off-site) has a "statistical relationship" with car modal share, although of a lower order.

Echoing the above findings, PAN75 *(Scottish Executive, 2005a)* points out that modal share targets should take into account three factors, including local levels of transport accessibility, types of development and car parking controls. It also points out that absolute accessibility measures are of little value in assisting with the evaluation of modal share targets; and relative accessibility is a more important measure that will influence the mode share at the development *(Scottish Executive, 2005a)*.

Based on the above research, it became apparent to the author that two factors, namely relative accessibility and provision of parking space are perhaps of the strongest correlation to car mode share. Due to the complexity in defining "types of development" and constraint in time, this study has not been able to take this factor into account [3].

Table 1: Correlation between various factors and mode share

Rank	Statistical Relationship		No Statistical Relationship	
	Parameter	'r' Score	Parameter	'r' Score
1	PTAL Accessibility Index	0.905	Walking Catchment Population	0.397
2	Location Category	0.734	PT Catchment Population	0.367
3	Plot Ratio	0.727	Cycling Catchment Population	0.322
4	Private Car Catchment Population	0.636	Employment Density	0.299
5	Parking Spaces per Employee	0.534	Potential Accessibility Index	0.194
6	Population Density within 1 mile	0.436	Car Ownership	0.157
7	Off-Site Parking Restraint	0.425	Car Availability	0.141
8			Population Density within 5 miles	0.121
9			TRICS Catchment Population Method	0.121
10			GFA per parking Space	0.033

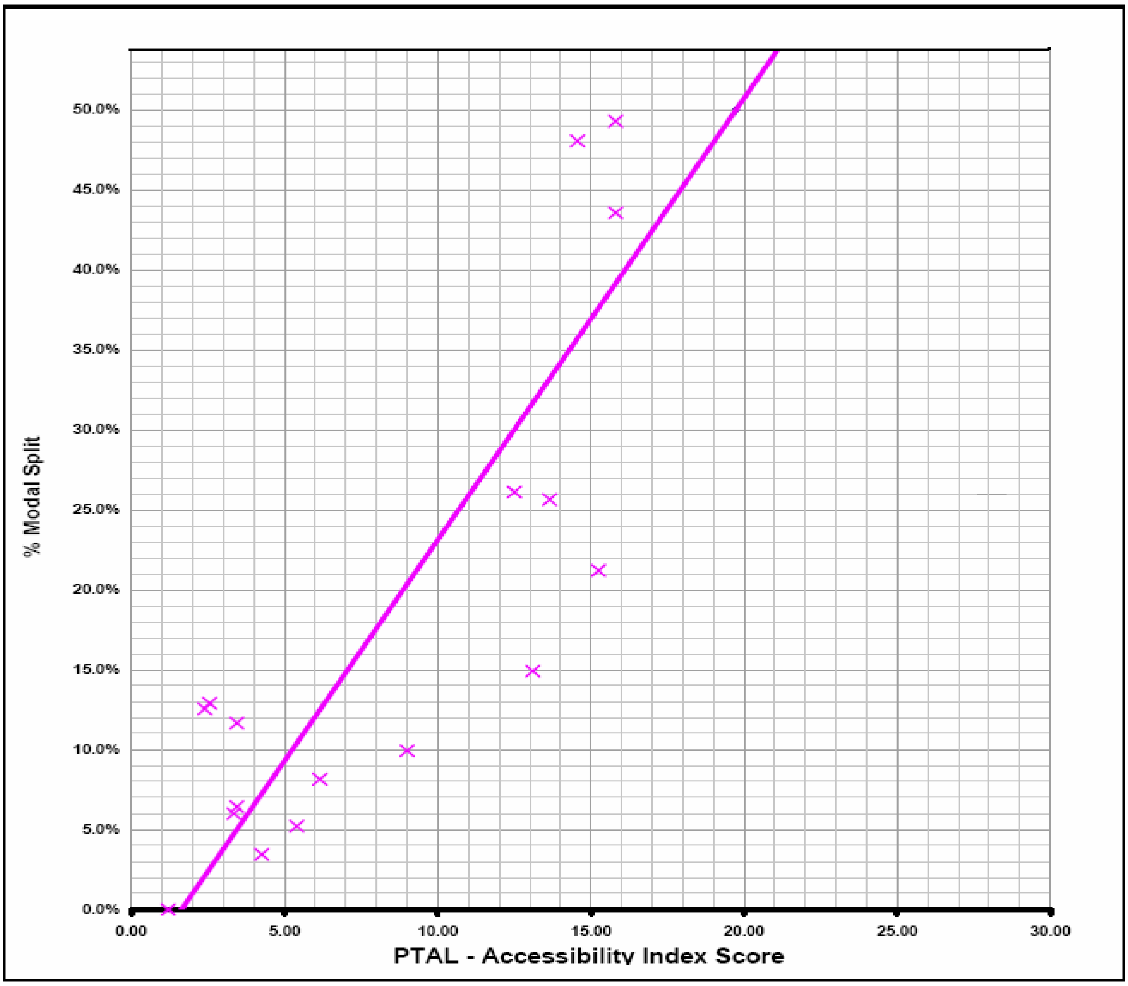

Figure 1: Correlation between accessibility to public transport n service and car mode share

3.2 The Expression of the Benchmarking System

As discussed before, accessibility to transport infrastructure and services can strongly affect people's choice between car and non-car modes. It is generally believed, and supported by research, that better public transport provision means lower car mode share. However, because the home addresses of commuters are distributed across a wide area, they will have various level of accessibility. Therefore, to make comparable two sites whose site users' domicile distributions are different, the benchmarking system must be able to express mode share as a function of individual's accessibility. Only in this way, can the effect of domicile distribution on mode share be isolated from the effects of other factors. This means the benchmarking system will not compare the overall mode shares of the two sites, but rather the relationships between accessibility and mode shares that occur at the two sites. The relationships can be expressed in a graphical way, which takes the form of an 'accessibility vs. mode share' profile (***"the Profile"***). Details on the method for obtaining such a profile are given in Section 4.3.

A benchmarking system based on the Profile, can now compare travel behaviour of different groups of people commuting to different workplaces. For example, when Organisation-A (Org-A) and Organisation-B (Org-B) are of the same type and of similar level of accessibility, it is "fair" from a transport point of view to expect that they should have similar profiles. To bring the argument one step further, if Organisation-A is found to have a more sustainable mode share than Organisation-B, it would also be "fair" to expect that the latter has further scope for improvement.

It is worth pointing out that the Profile concerns only the relationship between commuters' accessibility and mode share, and not the overall mode share. The overall mode share is determined by both the Profile and the actual distribution of site users across the spectrum of accessibility. However, because the distribution is to a great degree outwith any organisation's control, it is important and appropriate to separate this factor from the benchmarking system.

Because the above method can compare how sustainable the travel patters of one site are over another, it is named the **Sustainable Modal Profiling (SMP)** method.

4. THE SUSTAINABLE MODAL PROFILING (SMP) METHOD

The SMP method attempts to find an easy-to-calculate indicator to represent the relative accessibility to public transport services, and link the indicator directly to mode share. To do so, a trend analysis was carried out to observe the relationship between accessibility and mode share.

4.1 Trend Analyses

A dataset of 942 records containing staff home postcodes and travel modes was acquired from a large organisation (Org-A) in Glasgow. The data were obtained before the organisation introduce its travel plan. These home postcodes and the postcode of the site formed 942 Origin-Destination pairs. Using data available from Transport Direct, postcode-to-postcode journey times (P2PJT) by public transport and car and driving distances were generated respectively.

As a first attempt, it was decided to use the ratio of P2PJT by car to P2PJT by PT (or ***"the Ratio"***) as the indicator to measure individuals' relative accessibility to a particular site.

It was assumed that car modal share can be calculated using the following equation:

Car modal share = 100% - Walking modal share - PT modal share - others *(Eq.1)*

in which:

Walking modal share = a ? g(driving distance) + b *(Eq.2)*

and

PT modal share = A ? (the Ratio) + B *(Eq.3)*

In Eqs.2 and 4, *a, b, A* and *B* are parameters whose values are to be determined by observing the relationships between walking and PT modal shares and driving distance and the Ratio.

4.2 Function *g* and Values for Parameters *a*, *b*, *A* and *B*

The relationship between the car driving distance and walking modal share was fitted and is shown in Figure 2. The figure indicates that the values for *a* and *b* were -0.41 and 0.46, and function *g* is ln(driving distance).

The relationship between ***"the Ratio"*** and PT modal share was also revealed by the data. Figure 3 below shows the strong positive relationship between the two quantities and the values for *A* and *B* were found to be 0.43 and -0.05.

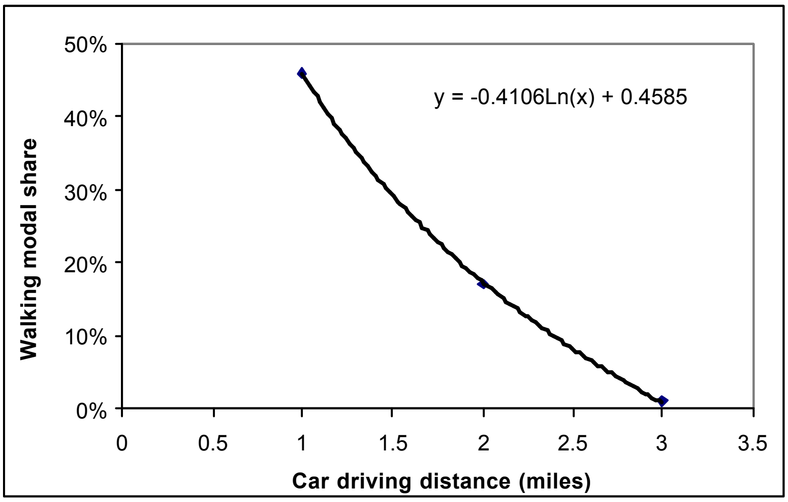

Figure 2: Relationship between car driving distance and walking modal share (Org-A)

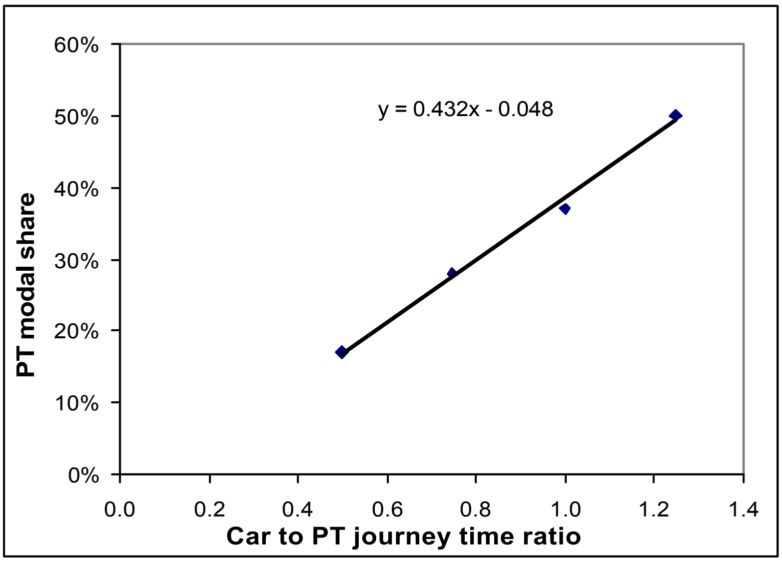

Figure 3: Relationship between "the Ratio" and PT modal share (Org-A)

4.3 The Accessibility vs. Car Mode Share Profile

Figure 4 below shows that, with the increase of the value for ***"the Ratio"***, the car mode share tends to drop. This relationship is reflected in Eq.1 and is in line with the trend shown in Figure 3.

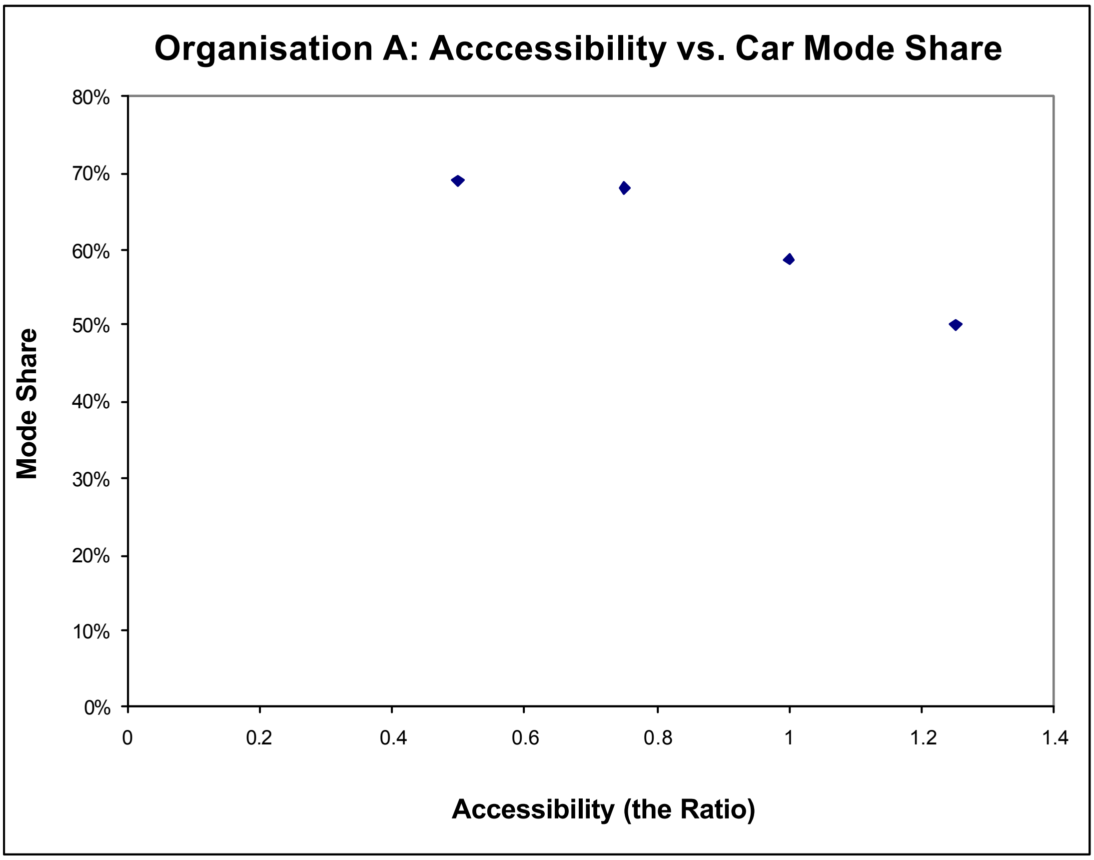

Figure 4: Observed relationship between accessibility and mode shares (Org-A)

4.4 The Implications of the SMP Method

The proposed SMP method assumes that for two groups of people, if their accessibility levels (currently represented by relative accessibility indexes) are the same and there is no other non-transport factors influencing travel behaviour, their car mode share should be of the same level.

If we agree that the above premise is logical, we can also assume that if two groups of people who have the same accessibility indexes have different car mode shares, the difference is caused by non-transport accessibility factors (which are often social and economic). In reality, Travel Plans are implemented after developments are implemented and sites occupied. Their main role is to promote sustainable travel using non-infrastructure related techniques. It therefore logical to expect Travel Plans to used to identify and tackle these non-transport issues so that the differences in car mode share can be eliminated.

This paper therefore proposes to use the SMP method in the ***"benchmarking stage"*** to set mode share targets based on a **mean "accessibility vs. car mode share" profile** (or ***"the Mean Profile"***) developed based on real travel mode data. The main task of this stage is to set mode share targets based on the assessment of accessibility, independent from various non-transport related factors. The derivation of ***"the Mean Profile"*** will be a gradual and on-going process, and it can take time, but it nevertheless provides a "fair" benchmarking system for setting car mode share targets.

Once car mode share targets are set and agreed by both the planning authority and land users, the travel planning process can go into the "***micro-analysis stage***" in which non-transport related factors are investigated, and detailed measures and modal shift targets are identified. It should be noted that, at this stage, personalised journey techniques must be employed to look into each individual site users' travel behaviour so as to understand how non-transport related factors can be used to promote sustainable travel. This level of detailed work is best carried out within an organisation, preferably led by a Travel Plan Co-ordinator.

Setting the time frame for achieving modal shift targets is a difficult area which requires further research. A previous study *(Scottish Executive, 2005b)* points out that, one area of concern is the paucity of research that can predict the effects of measures designed to alter modal split. Many research projects have been undertaken to measure the effect on modal split of measures varying from new light rail networks to traffic calming, and persuasion campaigns. Research findings often contradict one another, and the caution on the part of researchers can cast doubt that many measures would have any significant measurable effects *(Scottish Executive, 2005b)*. Although the current study does not concern this subject, the methodology proposed in this research is conducive to the solving of this problem.

5. CONSTRUCTING THE BENCHMARKING SYSTEM USING THE SMP METHOD

The construction of the proposed benchmarking system requires mode share data from real cases. It is believed that for each land use type, a "big enough" sample data is needed to identity ***"the Mean Profile"***. Using two real cases, this section demonstrates how the SMP method can be used to develop the benchmarking system and set car mode share targets. Due to the lack of resources, the only available alternative dataset was from an organisation ("Organisation-B") which is also based in Glasgow but of a different land use type. Therefore, the use of the data only serves for demonstration purposes.

5.1 Developing Benchmarks

Procedures described in Sections 4.1-4.3 were repeated for Organisation-B. The total number of origin-destination pairs available was 210. The observed relationship between car driving distance and walking mode share is represented in Figure 5. The figure indicates that the values for parameters a and b were -0.77 and 0.97. The relationship between the Ratio and public transport mode share is shown in Figure 6. The values for parameters A and B were found to be 0.26 and 0.40.

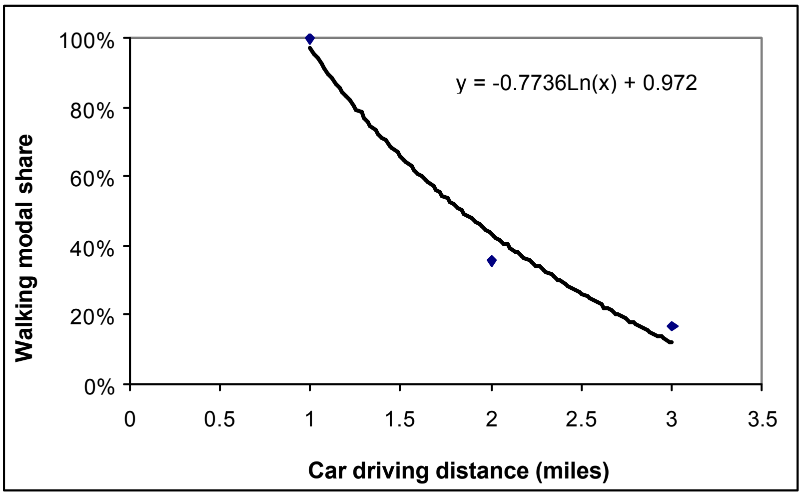

Figure 5: Relationship between car driving distance and walking modal share (Organisation-B)

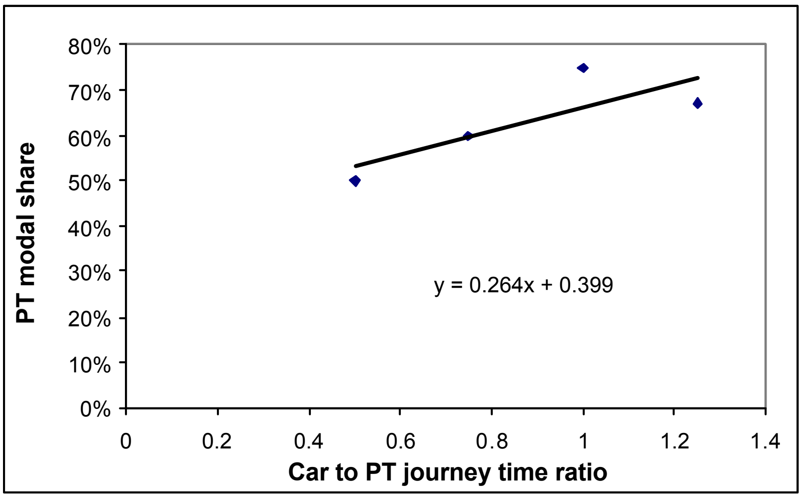

Figure 6: Relationship between "the Ratio" and PT modal share (Organisation-B)

Figure 7 below shows that, as before, with the increase of the value for the Ratio the car mode share tends to drop or stabilise.

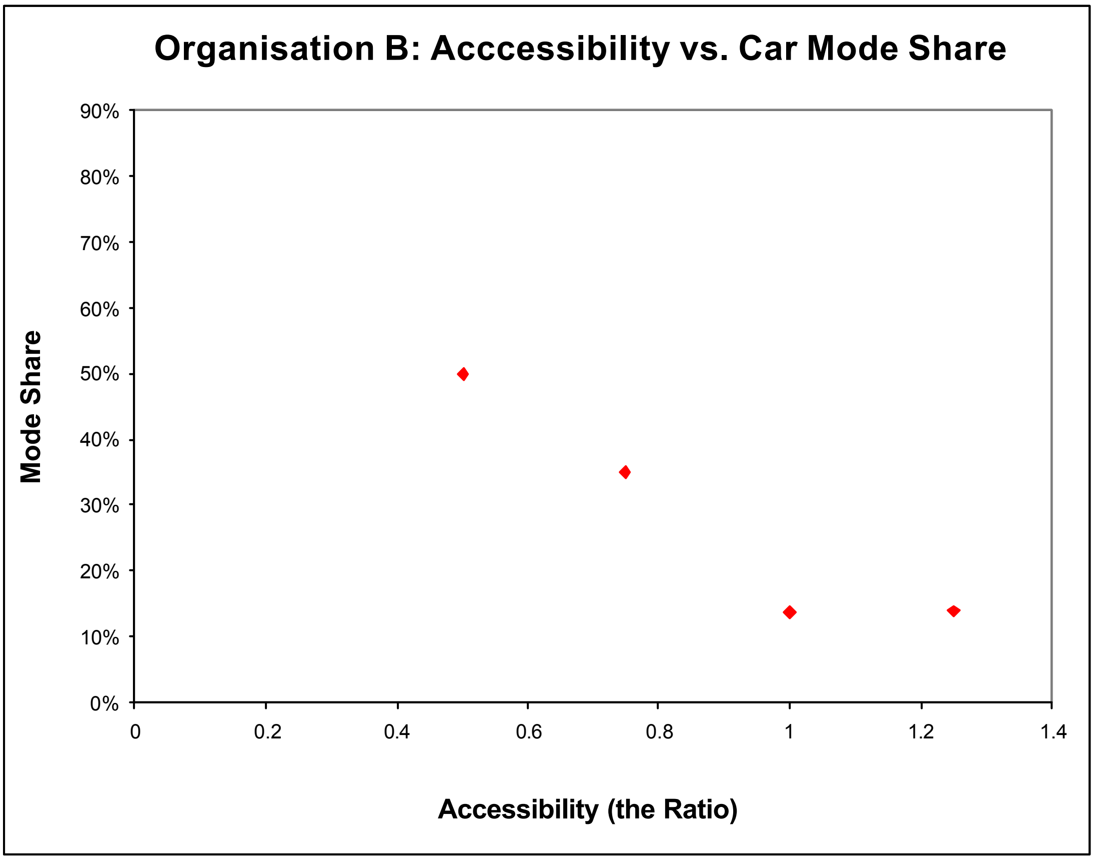

Figure 7: Observed relationship between accessibility and mode shares (Organisation-B)

It is now possible to compare the two profiles for Organisation-A and Organisation-B and find out which is more "sustainable" in terms of their travel pattern. The two profiles for car mode share are shown in Figure 8.

Figure 8 shows that Organisation-B has lower car mode shares than Organisation-A across the whole accessibility spectrum. Therefore it seems that Organisation–B has a more sustainable travel pattern than Organisation-A.

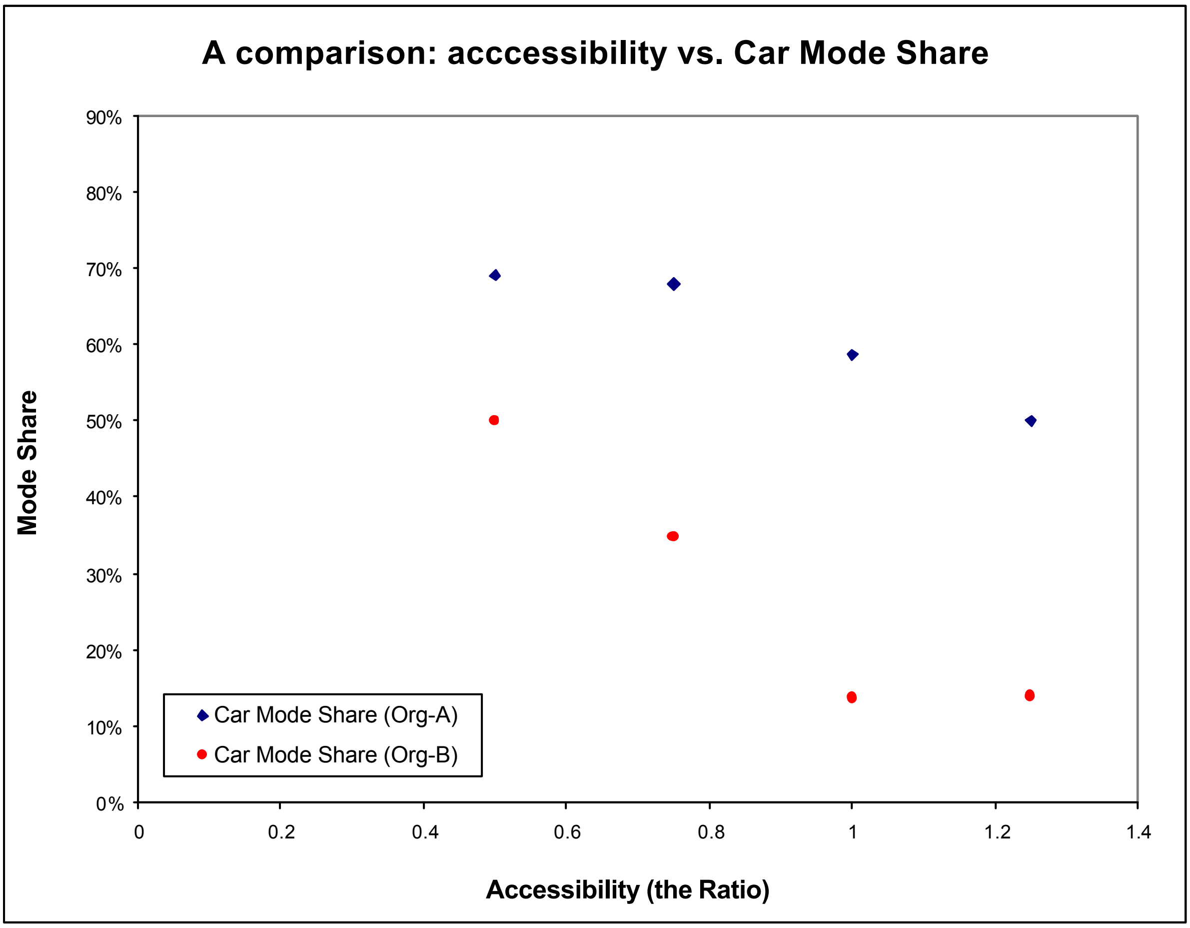

Figure 8: A comparison of the Profiles of Organisation-A and Organisation-B

Therefore, assuming Organisation-A and Organisation-B were of the same land use type, two ***"Mean Profiles"*** can be obtained. Firstly, the ***"Weighted Mean Profile"*** takes into account the actual number of commuters from both organisations and represents how most people currently choose their travel modes. Textbox 1 below shows how a ***"Weighted Mean Profile"*** is derived.

A ***"Weighted Mean"*** car mode share is calculated as:

$$\textit{Weighted Mean car mode share} = \frac{\textit{No. of people use car in Org-A + No. of people use car in Org-B}}{\textit{Total No. of people in Org-A + Total No. of people in Org-B}}$$

Textbox 1: Calculating a weighted mean car mode share value for an accessibility range

Secondly, the ***"Arithmetic Mean Profile"*** represents the view that organisations of different size should carry the same weight in assessing the mean car mode share. Therefore, arithmetic mean car mode share values are calculated regardless the number of commuters in Organisation-A and Organisation-B. Textbox 2 shows how an ***"Arithmetic Mean Profile"*** is derived.

An ***"Arithmetic Mean"*** car mode share is calculated as:

$$\textit{Arithmetic Mean car mode share} = \frac{\textit{Car mode share of Org-A} + \textit{Car mode share of Org-B}}{2}$$

Textbox 2: Calculating an arithmetic mean car mode share value for an accessibility range

To summarise, two benchmarks representing two different types of means, weighted and arithmetic have been constructed. The two profiles are shown in Figure 9 and Figure 10 respectively. The ***"Weighted Mean Profile"*** is more conservative because it tends to represent the status quo. Car modal shift targets derived from this benchmark is therefore moderate. The ***"Arithmetic Mean Profile"*** however argues that groups of people of the same accessibility should in principle achieve the same level of sustainable travel. This means the benchmark represented by the ***"Arithmetic Mean Profile"*** can be more sensitive to best practice cases where low car mode shares are achieved. If cases where car mode shares are much higher than weighted mean values are excluded from the calculation of *Arithmetic Mean values,* then mode share targets derived from the ***"Arithmetic Mean Profile"*** are more challenging than that from the ***"Weighted Mean Profile"***.

The calculation of the two mean values is illustrated using a simple example in Textbox 3.

For example, consider two groups of people who are of the same relative accessibility.

Group-A has 1000 people and Group-B 100. If the car mode shares for Group-A and Group-B are 60% and 30% respectively, then the 'Weighted Mean' and 'Arithmetic Mean' car mode shares derived from the above data are calculated as follows:

'Weighted Mean' car mode share = (600 + 30) / (1000 + 100) = 57%; and
'Arithmetic Mean' car mode share = (60% + 30%) / 2 = 45%;

Therefore, in this case, 'Arithmetic Mean' mode share is more challenging than 'Weighted Mean' mode share.

Textbox 3: Illustrating the difference between Weighted Mean Arithmetic Mean values

5.2 Setting Modal Shift Targets

Two car modal shift targets for Organisation-A, one relatively conservative and the other more challenging can now be calculated using the profiles developed above.

5.2.1 Car modal shift target based on *"Weighted Mean Profile"*

Based on this profile, it is now possible to calculate the more conservative car mode share target for Organisation-A first. The difference between the current car mode share at Organisation-A and the benchmark is illustrated in Figure 9. The targets are 3%, 6%, 8% and 6% of car mode share reduction for site users of accessibility ranges of 0.5, 0.75, 1.0 and 1.25 respectively. To derive the overall mode share target, the profile of domicile distribution across the accessibility spectrum as shown in Figure 11 is required.

According to Figures 9 and 11, the "expected" car mode share for Organisation-A would be 64%, representing a drop of 4% from the original level of 68%. This means to achieve the modal shift target and bring Organisation-A up to standard, 39 of its site users currently commuting by car would need to change their travel modes. The calculation is detailed in Table 2.

Table 2: "Conservative" car modal share targets for Organisation-A

Accessibility (ratio of car vs. PT journey times)	number of site users	current number of car users	modal shift targets	mode shift number
0	0	0	N/A	0
0.25	27	15	N/A	0
0.50	576	398	3%	20
0.75	290	197	6%	17
1.00	46	27	8%	4
1.25	2	1	7%	0
1.50	0	0	N/A	0
			Total	41

5.2.2 Car modal shift target based on *"Arithmetic Mean Profile"*

Based on the above profile, a more challenging modal shift target can be calculated for Organisation-A. The difference between the current car mode share at Organisation-A and the benchmark is illustrated in Figure 10. The targets are 10%, 17%, 23% and 18% of car mode share reduction for site users of accessibility ranges of 0.5, 0.75, 1.0 and 1.25 respectively. Once again, the profile of domicile distribution across the accessibility spectrum was used to derive the overall mode share target.

According to Figures 10 and 11, the "expected" car mode share for Organisation-A would be 56%, representing a drop of 12% from the original level of 68%. This means to achieve the modal shift target, 114 site users currently commuting to Organisation-A by car would need to change their travel modes. The calculation is detailed in Table 3.

Table 3: "Challenging" car modal share targets for Organisation-A

Accessibility (ratio of car vs. PT journey times)	number of site users	current number of car users	modal shift targets	mode shift number
0	0	0	N/A	0
0.25	27	15	N/A	0
0.50	576	398	10%	55
0.75	290	197	17%	48
1.00	46	27	23%	10
1.25	2	1	18%	0
1.50	0	0	N/A	0
			Total	114

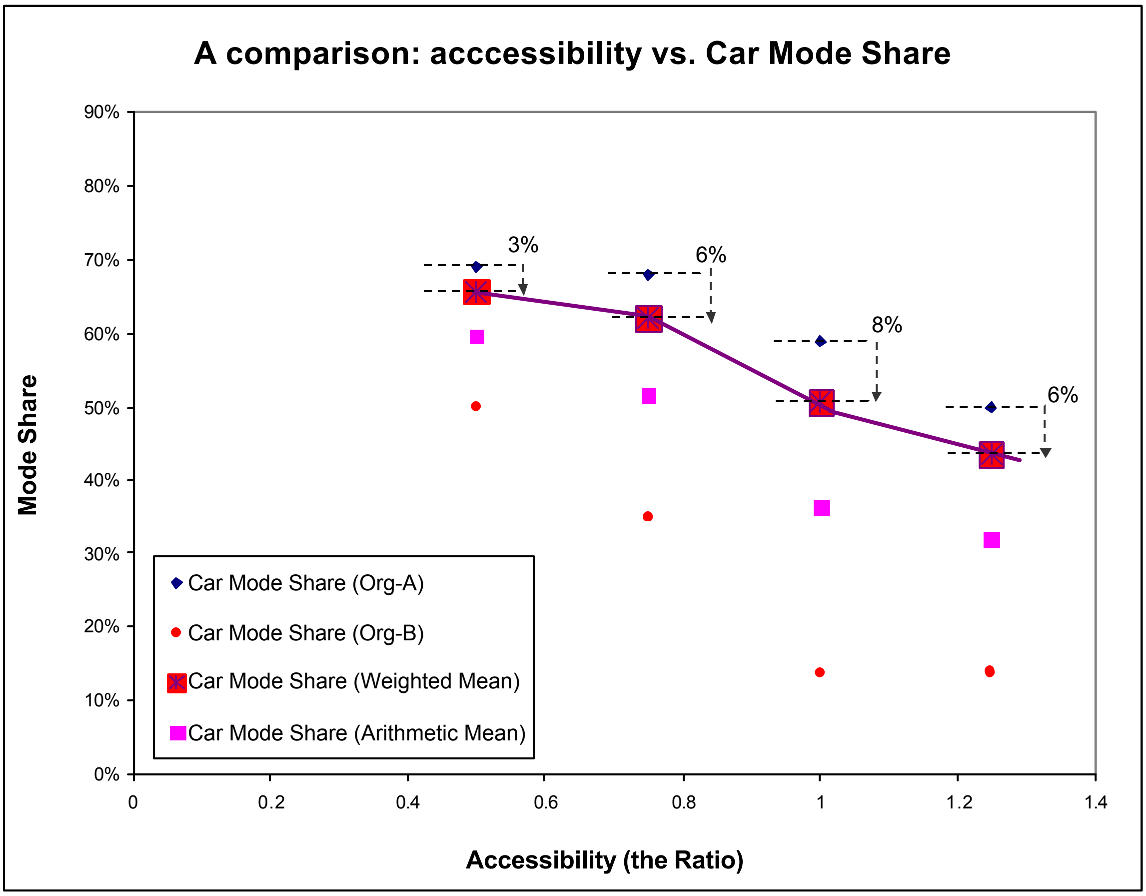

Figure 9: Modal shift target for Organisation-A set based on the "Weighted Mean" profile

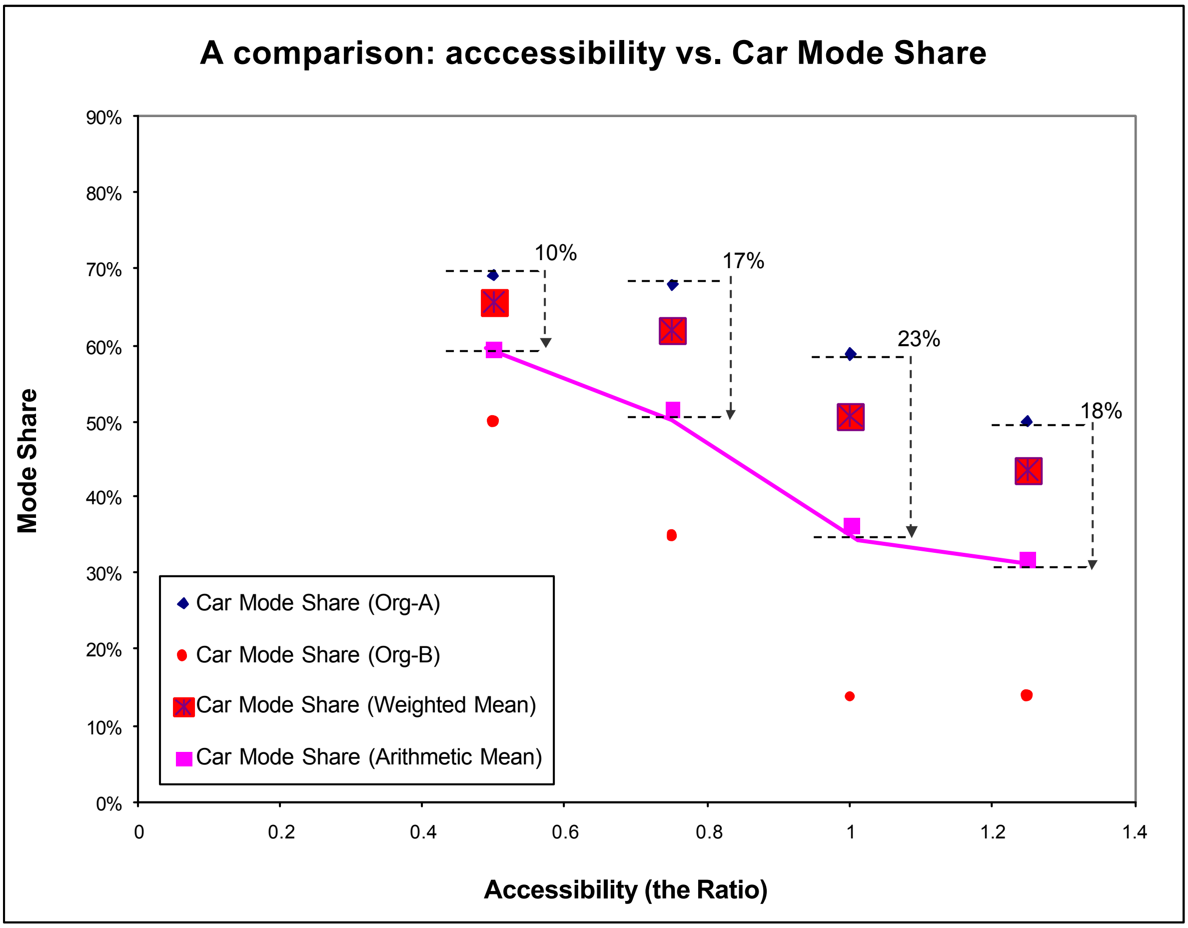

Figure 10: Modal shift target for Organisation-A set based on the "Arithmetic Mean" profile

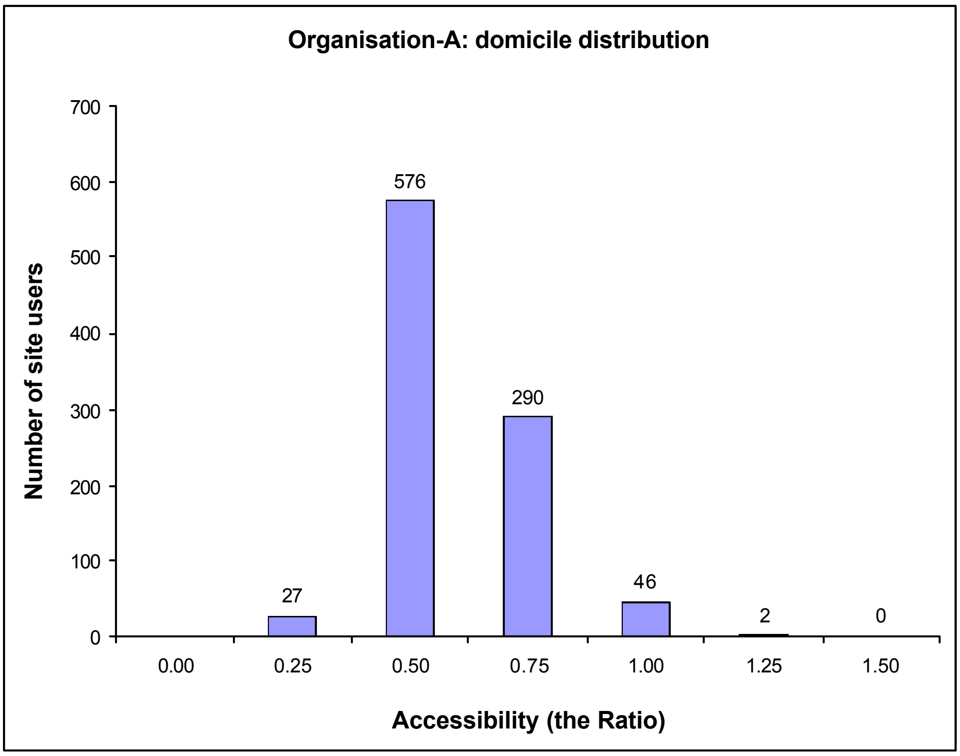

Figure 11: Domicile distribution of site users of Organisation-A

5.2.3 Implications of the car modal share targets

Two modal shift targets, namely 4% and 12% have been obtained for Organisation-A. Although the two targets represent two different views on how radical organisations should change their travel patterns, they are all derived from "mean" values. In the process of deriving the modal shift targets, the SMP method breaks down the overall modal shift targets into separate accessibility ranges, but in practice what is really of interest to all parties is the overall modal shift target. For some practitioners, the average value of the two targets, in this case 8%, might serve as an appropriate compromise.

6. CONCLUSIONS

This paper presents the Sustainable Modal Profiling (SMP) method by which a benchmarking system can be constructed to set "fair" car mode shares based on "mean" values. The SMP method uses easy-to-obtain data and separates the factor of domicile distribution from the mode share setting process. The proposed method also attempts to relate modal shift target setting to individual commuters' accessibility to public transport service. The SMP method is regarded as "fair" because it separates the effects of domicile distribution and public transport provision which are often outwith a land user's control. The targets derived through the SMP method are regarded as realistic and reasonable because they are based on "mean profile" developed from real data. Such targets are therefore believed to be more measurable and effective.

7. LIMITATION OF THE RESEARCH

Due to the limitation in resources, the current study has the following limitations that should be noted:

(1) The research assumes that accessibility is an adequate indicator to represent transport provision at different sites. The effect of other transport provision related factors such as on-site car parking restriction has NOT been taken into account in the current study.

(2) The research method assumes that the indicator of ***"the Ratio"*** can represent relative accessibility to public transport service well. This assumption is based on previous study and the observed positive relationship between the indicator and mode shares at two organisations located in Glasgow.

(3) Currently, the SMP Method relies on journey time information from Transport Direct and domicile postcode data. For speculative development where domicile postcode data are not available, and public transport provision is not yet in place, alternative data source needs to be sought. For example, the domicile distribution can be derived from trip distribution models created in the TA process, and P2PJT information can be calculated using other public transport models.

To verify the validity and applicability of the methodology proposed in this paper, further research is needed.

8. ACKNOWLEDGEMENTS

This research has been undertaken as part of JMP Consulting's role as term consultant to Transport Scotland. The author of this paper would first like to thank Transport Scotland for supporting the research. The author also would like to thank Professor Gordon Baker, John Milligan, Tim Steiner, Kelvin Clarke and David Taylor of JMP Consulting for their expert guidance and support throughout the development of this paper. The author deeply appreciates the analytical advice of Dr Debbie Ross and her direct input into the writing of the paper. I also thank Simon Bradley of JMP Consulting for proofreading the paper.

9. BIBLIOGRAPHY

Colin Buchanan and Partners (2001) *Planning for Mode Share in New Development.*

Faber Maunsell (2002) *Relationships between Accessibility and Parking for New Development*, available on TRICS CD, Version **6**.

Scottish Executive (2005a) *Planning Advice Note 75 - PAN75.*

Scottish Executive (2005b) *Transport Assessment and Implementation: A Guide.*

Notes

[1] In statistics, the Pearson product-moment correlation coefficient is a measure of the correlation of two variables *X* and *Y*, that is, a measure of the tendency of the variables to increase or decrease together. For example, if the coefficient is 0.9, then 81% (=0.9 x 0.9) of the variance of *Y* can be "accounted for" by changes in *X* and the linear relationship between *X* and *Y*.
[2] In this particular case expressed using the PTAL Index - a public transport accessibility index. The higher the index value is, the better is the public transport provision at a site.
[3] It was felt that "type of development" is a rather broadly defined characteristic that is difficult to be expressed in a numerical way.