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To cite this article: Adam Ungvarai 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **603** 042091

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Modal Split – Different Approaches to a Common Term

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Abstract. The modal split, also known as modal share or mode choice, is a common and widespread indicator in transportation engineering to evaluate transportation behaviour. In brief, the modal split shows the percentage of travellers using a particular mode of transport compared to the ratio of all trips made. For example a higher modal split number of bicycle users indicates a more sustainable city. But when going deeper into the analysis, it turns out that surprising variations in the definition emerge, each with a more or less different meaning. But even if definitions would be crystal clear, the measuring practice makes it almost impossible to regard certain mathematical numbers as the one and only result. However, scientific research still uses it as an indicator. Crucial exact conclusions and result may be drawn from modal split numbers. As the origins date back to the 1960's, how can this indicator still work? How can it still be the best method to calculate trends in transportation? Isn't there nowadays a better indicator nowadays? It turns out there is not. Modal split is still the best evaluation method in measuring quality of some regions transportation system. In this article I try a theoretical approach to this term, and also point out practical issues. I give a short overview of the history of modal split, and finally focus on examples based on real cases to explain where problematic approaches can occur.

1. Introduction

The term modal split is a common one in traffic engineering. To some extent it reads as the usage proportion of each transportation mode, for example by car, on foot, or theoretically even on horseback. If we count the volumes of each mode, and compare them to each other, we get a very valuable ratio, the modal split. This property varies from city to city, and is applied to evaluate current conditions or development in transportation.

But at a closer look one can notice several contradictions. The exact calculation of volume on each mode can be made in different ways. Definitions are conflicting. Sometimes a volume results in a fraction of a number. What if one mode is simply left out? What causes the problems and how to understand the differences will be discussed in this paper.

In 2017 a BSc thesis carried out a study of transportation behavior in Debrecen where modal split was also estimated [1]. Since 2018 it is a part of the homework for all students of the civil engineering course at the University of Debrecen to calculate modal split values. Out of the arising questions, it turns out that this term is by far not enough studied, and no exact convention is available for several important questions. On the other hand, if one makes an overview of the modal split archives of Budapest for the last decades, it can be seen that there are also serious contradictions, although a base trend is undoubtedly noticeable.



A lot of these questions seem to be theoretical, but if a particular question arises, some answer is to be given. The real behavior does not change if we define it another way, yet the volume we read out will be different. Unexpected variations are possible. In this paper an attempt is made to evaluate the interesting points.

2. A brief history

The first time mention of the so-called modal split goes back to the United States in the 1950s, when transportation became a serious issue there. Increased traffic demand and traffic jams which followed motivated several cities to intend researches, and to start thinking about transportation as science. The first famous instances are the Detroit Metropolitan Area Traffic Study – far away the acropolis of car industry that time - and the Chicago Area Transportation study [2,3]. One outcome of this era were first theories about traffic forecasting, traffic models, which try to foresee traffic volumes in future. The very classic transportation demand model used there – still a rudimentary nowadays – is the four-step-model. [4] The third stage of modelling is called modal split.

In this modelling step a previously calculated amount of trips between an origin and a destination is broken up into parts belonging to different transport modes. The step is usually being implemented by certain assumptions given in functions. Therefore modal split simply used to mean the ratio of motorised individual traffic to public transport, between a traffic origin of the model, and a destination. No complex choices, which are fashionable nowadays, have been considered.

Since that time the term has grown out of the transportation models. Modal split turned out to be a very good descriptive value in evaluation of any transportation environment. First only used for one origin area in the transportation model, this rate can be easily related to a whole city or even urban area. With such a descriptive and cumulative value, settlement developments can be evaluated. It became a practice to analyse modal split values independent of any transportation demand model for some particular task.

3. The case of Budapest modal splits

The transportation habits in the Hungarian capital city have changed a lot during the last decades. A steady trend can be studied from cheap public transport in the socialist era towards ownership of cars and motorised transport. Although this trend is nowadays slowing down and several official statements enforce the development of attractive public transport services, the values still trend for car usage.

Searching for modal split data related to this phenomenon, results are contradicting. It seems that some values are changing random wise. Some outtakes from the last years are illustrated on figure 1.

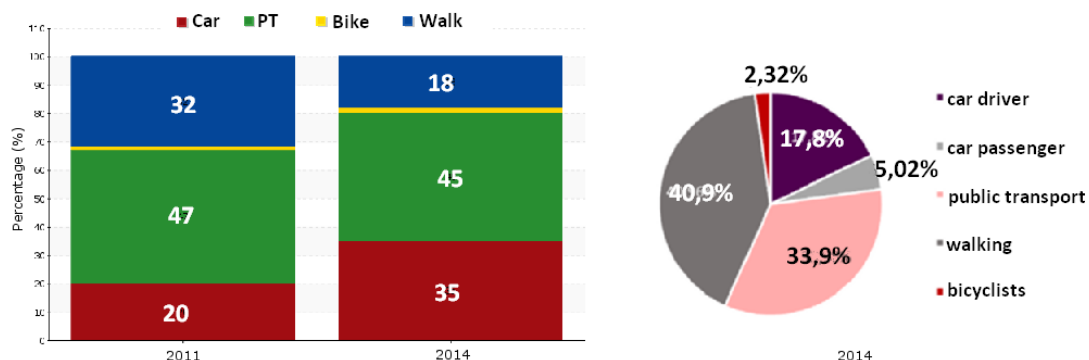


Figure 1. Available modal split values of Budapest (a) The EPOMM modal split tool [5]
(b) Flow project – BKK data [6]

It is simply unlikely that walking went back from 32 to 18 and then grow again to 41 percent within just 3 years. Or abnormally public transport reads 47, 45 and 33 percent. This example gives an excellent view that basing on these data sets no evidence can be made. The reason seems to be that all

these values originate from other surveys. No background methods and boundary conditions are clear, but the data sets are still set side by side.

By involving older data, the result would be similarly contradicting. Although the shift from public transport to motorised transport could be read out definitely. No secondary data, like pedestrians and bicyclists would really fit. With these detailed data, which are just moving around some percent in Budapest's case, and have been only studied in the recent times, one has to be even more careful.

The lesson learned is: Basing just on raw results, where no background methodology is known, detailed conclusions or short-term-evidences cannot be made.

4. The case of definitions

When looking for an exact definition of modal split, various versions can be found. A selection of the variants is listed below. The modal split

- is the division of traffic performance of the various transport methods [7]
- is the participation of a given transport carrier on the whole market [8]
- is the choice of transport method – the split up of the traffic on more traffic modes in case of choice possibility [9]
- provides information about the real composition of traffic [10]
- is an important criterion for validating mobility behavior of society [11]
- is the distribution of the transport volume on the different carriers [12]
- is the percentage of travelers using a particular type of transportation or number of trips using said type [13]

The listed variants do not only differ in formulation. In what units do we measure “participation”? How to handle feeder trips, which only connect some other carriers? How to handle intermodal¹ travels? What if the term travel² and trip³ are mixed? [14] And the most important question: how to deal with walking? All travels on world somehow surely contain at least a small amount of walking. How to deal with the short walking trips and how to handle long walking travels?

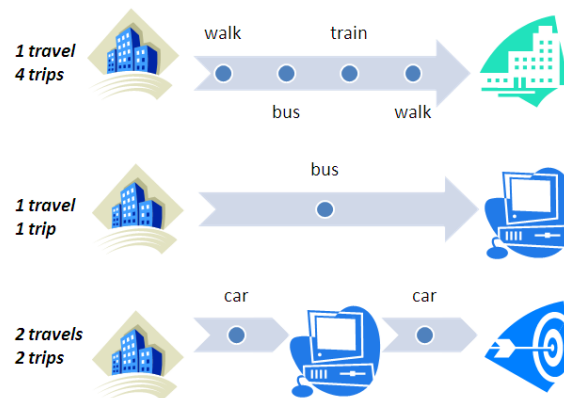


Figure 2. The distinction of travel and trip

For the modal split two major definition versions are applicable: the bimodal split and the multimodal split [16]

- The bimodal split just compares public to motorized individual transport. Stated for example as “60-40”. This variant was rather used in former times, when sophisticated transportation was equal to car usage. The mentioned Chicago and Detroit studies both use

¹ The seamless combination of more transport modes [15]

² Travel: one complete journey from origin to destination [14], also see figure 2.

³ Trip: used for any fraction of a travel, eg. section of one mode between mode changes [14], also see figure 2.

only bimodal split. In this case, usually all other modes are simply left out, and the calculation base is just the sum of cars and public transport. Nowadays considered as outdated, bimodal applications still need to be handled with care. Sometimes misunderstood just the motorized individual traffic is compared to all others together, thus used as one mode against all others.

- The multimodal split, where all mentionable transport modes are taken into account. Correctly, residual small modes should be mentioned always as “others”. For example e-rollers, alternative vehicles may play still a negligible role today. Theoretically, the calculation base is to be modified if any mode is left out.

At this point it is important to mention a common parallel term: the ratio of transportation performance, or kilometer performance which is referred to distance, instead of trip numbers. This term is also widespread and applications may be all volume based quantities. In this paper I do not go into detail, just about the modal split.

An impressive example of contradictions is a switch between languages in Wikipedia. The English page defines the modes of transport fully different from the Hungarian one. The Hungarian version defines human powered methods definitely not as transportation mode. [17, 18] Both pages are referred by some kind of native enthusiast collective; this rather shows that even definitions necessary for modal split are understood differently in each region.

Sometimes questionnaires just refer to the main mode of transport used for trips to work. In most cases the main mode is relatively easy to obtain even for any laic user. The benefit is the very easiness. The issue is, that out of this question we won't get real modal split, just an approximation and just of commuting to work. As young modern users tend towards multimodal transport⁴, this method becomes more and more questionable. Application of this variant also leads to arising problems in statements of more detailed surveys.

5. The case of traffic surveys in Debrecen

5.1. The 2017 survey of a bachelor thesis work

In 2017 a traffic survey was performed within the framework of a bachelor thesis by Bianka Kasza, the author of this article was the supervisor. This survey not only focused on actual traffic conditions, but also on peoples' motivations and behaviour. The results flow into the thesis work called “Sustainable traffic suggestions for the city of Debrecen”. [1]

The survey was based on an online questionnaire. This was filled out by over 1000 people, which by far outperformed our expectations. Although the questionnaire did not reach official representativeness, several filter methods have been applied and the results have been corrected to the actual population of Debrecen. The answers were filtered by hand to pick out doubled, unrealistic, or any suspicious ones. After this step the extreme upper and the lower ends of the result array have been cut off. Finally, the results of each social class have been corrected to the real proportions of the city provided by the Central Statistical Office (KSH) of Hungary.

Regarding the questions, we laid out 3 groups: social classification, traffic behaviour, ideology and future view of sustainability. The questions regarding traffic were detailed. We wanted to know, beside traffic data, how people's ideology is correlated to traffic behaviour, and how progressive is the vision of citizens on sustainability.

⁴ The possibility of choice among more transport modes

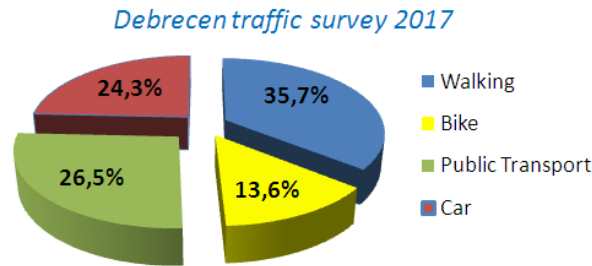


Figure 3. Normalised modal split values for Debrecen [1]

Without going into the mentioned exhaustive detail questionnaire now, the composition of the modal split made several issues. Questions asked usage data for every transport mode, and were also focusing on variations during daily routine. Therefore the load on each carrier had to be normalised, as some people have a much higher mobility than others. The question of walking made also serious trouble. Peoples sight, what is to be understood as walking, differs. Some take a severe walk to a bus stop as walking, other just as reaching the bus. The results of the normalised modal split can be seen on figure 3.

During this research we found that the modal split of Debrecen is quite similar to that of Vienna [1, 19]. This is very surprising, as the traffic conditions of the two cities are very different. Not just because of the size of the city, but because of deteriorated road conditions and old vehicles on rural bus lines in and around Debrecen. Bicyclists ride usually poor vehicles; e-bikes are very rare. Despite this, the modal split shows similar results, as seen in figure 4. The share of bike users is even higher than in Vienna.

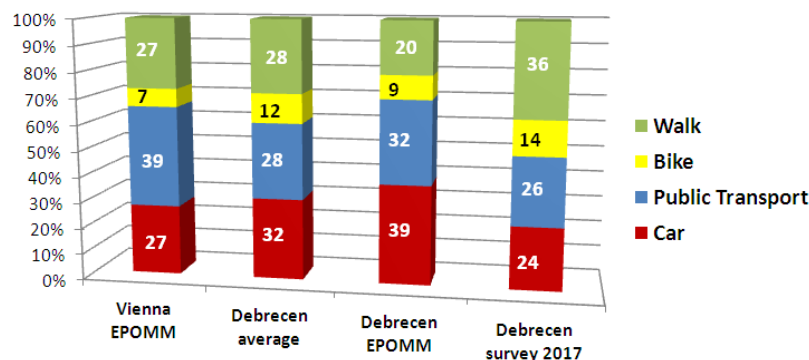


Figure 4. Modal split of Vienna compared to Debrecen [19, 20, 1]

As a result of this discovery, we had to think about the reasons. The modal split is not detecting two circumstances:

- The progression of the values. Maybe one city has a developing public transport, the other has a rather shrinking one, but in only one modal split result this is not expressed.
- The quality of a value. In one case the bicyclist quota is a forced one. The majority of those who ride a bicycle in Debrecen cannot afford anything else, but would do so immediately, if the circumstances would change. In Vienna lot of people could afford a car, but choose to ride a bike, due to a healthier lifestyle. Economically driven bicyclists are a time bomb for traffic planning. They dream of car ownership, or at least their children do so. Immediately when they can afford it, they will change to a car. And modal split is making no difference between economically forced and convinced sustainable users.

5.2. Study works of civil engineering students

As part of study work, students of the civil engineering course on the University of Debrecen have to make traffic documentation of their own life. Several conclusions are to be done: kilometer distances, energy consumption, travel types and also modal split values. Here the boundary is a group of people and results will be a kind of personal modal split for a specified time frame.

The arising questions of second-year students were surprising. Several detail problems arise, lot of them so deep, that it made trouble to answer them. This resulted of three reasons:

- The students elaborated the task so intensive, as no responder in a questionnaire will. Even short trips were analysed and changing between vehicles was considered in detail. On the other hand some tried to skimp the work and this lead to similar difficult questions.
- Multimodal trips always made problems. Definitions never care about how much to go into detail. A reoccurring question was how small and medium walks are to be calculated.
- Stopovers or turn backs in travels sometimes can be hard to manage. Nowadays due to mobile phone culture trips can be modified occasionally due to a phone call.

As a lesson learned, an appropriate definition is once again very important, due to common vision and formulated that way that also intermodal trips can be handled. Also, a threshold to walking may be defined, that short walking sections are solved consequently. Below what distance is walking to be left out?

Matulin et.al. made studies about the modal split and dealt with the problem about intermodality [14]. According to his point of view the number of trips should be determinant. If more transport modes are used during one travel, each of these will be one trip. And modal split should be calculated on a basis of the total number of trips.

In this approach the discrepancy is that a person with multiple intermodal trips has a much bigger weight than a person with just an ordinary travel. This leads to further inconsistency if walks at mode changes are involved. Then we get a bigger and bigger weight for the same journey, although no more travel is made. Only such an evaluation makes sense where this is not affecting the overall result at all.

6. The reasons for contradiction

Summarising the possible reasons for contradiction, they can be classified into 4 main groups:

a. *The lack of definitions*

Often, the basic definitions already make trouble. The term and its principles should be clear defined to match later results.

b. *Unknown boundary conditions and methodology*

Together with a final value, the boundary conditions and exact surveying methodology should be mentioned. As surveys show big variations, so the results will. To register detailed progression, completely the same survey needs to be repeated.

c. *The exactitude of the measured quantity*

Even the basic quantity shows variation. Weather it is influencing the value and people's behaviour may change overnight. The more precise information we want, the more contradictions will arise. Also, during a questionnaire, a respondent may give inconsequent answers.

d. *Walking*

Surprisingly, walking is not seen by everybody as a transport mode, as it uses no external equipment. Furthermore, every travel starts and ends up in some walking, which leads to contradictions. Skipping this may modify the end result to a big extent.

In the authors sight solving problem group A and D is possible and would vitally improve all contradictions. With a successful improvement, effects of group B and C could be significantly reduced.

7. The proposed definition

To sum up, the modal split should be defined so that it can be implemented to utmost traffic surveys data sets. If we focus on decision points, this seems to be the best solution at all, as almost no gaps in the definition can occur.

The modal split within a given boundary of space, time or set of persons should be defined as the percentage of travels fulfilled by a given mode of transport. If a travel consists of more trips or steps, the number of decisions should be determinant.

When implemented, the case of a mode change should use broken up weights smaller than 1, and each part (trip) should represent an equal fraction. One decision (how to solve a travel from an origin A to a destination B) should always make out the whole weight of 1. If this decision is fulfilled by more carriers (trips), these should be equal fractions of 1. The distance travelled should not be weighted, but extremely small distances have to be left out, like ones that can occur usually only by walking.

A threshold to walking needs to be defined as well: under what distance is walking to be neglected. A length of some hundred meters seems to be appropriate for European circumstances; but it is for sure varying among different cultures. A short walk, as for change of vehicles at intermodal stations or from a house to a near bus stop should not be classified as trip. Everything longer should, like the bus stop is already seriously far away, or the car parking could only be solved some streets away. In this way, a jump to the closest supermarket by foot is already an independent travel, and does not fall into the issue of threshold.

To define any boundaries keeps vital: In this perception also some group of people's modal split can be interpreted.

8. Conclusion and summary

It can be stated: within the framework of accurate definitions there is a theoretical value of modal split available for a given boundary. The number of trips in a city amounts to a definite number each day and there is a definite number of passengers using public transport. However this theoretical number cannot be made out precisely, just estimated as a stochastic variable. Being punctilious certainly will not meet our expectations, as numbers surely change overnight.

The only thing to be done consequently is to extrapolate data; the base data are by all means to be measured with the same technique.

In this paper I made an overview of the contradictions about the term modal split. Despite dealing with it seems easy, during an intensive research with a questionnaire of diversified questions or any detailed work, a lot of problems can occur. I made a proposal for a definition which can make work easier and clear in outcome, which also works for any intermodal case or diffuse dataset. I presented the origins of contradictions and pointed out possible ways to avoid them.

The modal split is still the best indicator for measuring transport behavior, despite all difficulties in defining or approximating it. As modal split is measuring an active choice of the users, this quantity still represents the people's behavior, and not the circumstances, neither the result. Users do not choose exactly aware of kilometers, emissions, or effects on environment. They choose mostly based on travel time, cost, or personal habits, and this number is exactly reflecting this mixture.

The modal split is definitely measuring behavior of people and a common perception of travelers. It is connected to local circumstances, mostly to the traffic system of the region. But it is definitely not measuring environmental protection or carbon dioxide emissions, neither distances travelled.

Acknowledgment

A special gratitude goes to Bianka Kasza. Her participation in the student research program and later her bachelor thesis was a remarkable work, and a big shift on my interest for modal split. Guiding her intelligent work was a pleasant experience. The author also grateful to Gyula Dávid, for revising the English text and giving helpful advises.

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