MaaS bundling: A first approach towards a bundling strategy based on revealed preference data

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Abstract

Mobility as a Service bundles have attracted a high interest not only in academia but also among mobility providers. Despite an increasing body of research in the field, the question how MaaS bundles should be designed has so far been neglected. To make up for this, a stepwise bundling strategy is created. The strategy is based on four principles derived from MaaS research findings: Generate mode combinations according to measured travel data, include public transport as the core of the bundle, increase attractivity of taxi and shared modes within bundles and generate added value for the provider and the consumer. A first version of the strategy then is applied to revealed preference data. The results show that the bundles for infrequent public transport users could generate the highest share of potential buyers, especially if the public transport is combined with taxi services or bike sharing. An improved version of the strategy after evaluating the data mainly describes how to include the design dimensions “Modes”, “Metrics” and “Caps”. Especially the definition of the Caps promises to be of great value for the providers: A detailed analysis of current travel patterns of a bundle’s potential users might yield an increase in rides.

Zusammenfassung

Die Bündelung von unterschiedlichen Mobilitätsdienstleister zu «Mobilitätspaketen» hat nicht nur im akademischen Bereich, sondern auch bei den Mobilitätsanbietern grosses Interesse geweckt. Trotz zunehmender Forschung auf diesem Gebiet ist die Frage wie ein MaaS-Bündel gestaltet werden soll bisher vernachlässigt worden. Um dies auszugleichen, wird in dieser Arbeit eine schrittweise Strategie erarbeitet. Die Strategie basiert auf vier Prinzipien, die sich aus den Ergebnissen der MaaS-Forschung ableiten: Erstellung der Verkehrsmittelkombinationen anhand der gemessenen Reisedaten, Einbeziehung des öffentlichen Verkehrs als Kern des Bündels, Steigerung der Attraktivität von Taxi- und anderer «Shared Mobility» Angebote innerhalb von Bündeln und Generierung eines Mehrwerts für den Anbieter. Ein erster Ansatz der Strategie wir dann auf GPS-Trackingdaten angewendet. Die Ergebnisse zeigen, dass die Bündel für unregelmässige ÖV-Benutzer das grösste Potential haben, insbesondere wenn der ÖV mit Taxidiensten oder Bike-sharing kombiniert wird. Eine verbesserte Version der Strategie nach Auswertung der Daten beschreibt vor allem wie die Gestaltungsdimensionen "Modes", "Metrics" und "Caps" einbezogen werden können. Insbesondere die Definition der Caps-Begrenzung verspricht für die Anbieter von grossem Wert zu sein: Eine detaillierte Analyse des aktuellen Reiseverhaltens der potentiellen Nutzer einer Bündelung ermöglicht unter Umständen eine hohe Steigerung der Fahrten.

Keywords

MaaS; MaaS Bundling; Bundling Strategy; Revealed Preference Data

Preferred citation style

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1 Introduction

The objective of Mobility as a Service (MaaS) is to integrate mobility services from different operators. MaaS has not only aroused interest in academia but also among private stakeholders. Some estimate the potential to be so great that even the question has come up, who will be the "Amazon of mobility" (t3n, 2020). Especially MaaS bundling, where different modes are provided within one offer, has been subject of recent research. Various researchers published their findings about the willingness to pay for MaaS bundles and its components, most based on stated preference data (examples are Guidon et al., 2020, Ho et al., 2018, Ho et al. 2020) but also first building on revealed preference data (Reck and Axhausen, 2020). Surprisingly, there exists a deficiency of information on how the bundles shall be designed. Even though the methodology how bundles are created is missing, Reck et al. (2020) made a first step in this direction by providing fundamental design dimensions for MaaS bundles.

MaaS bundles can generally be designed to maximize additional value for consumers or providers. The creation of bundles fitting consumers current travel patterns are likely to be interesting from a consumer's perspective. Additionally, some believe it might be a tool to induce behavioral changes towards more sustainability.

The idea of this term paper is to work with several months of tracking data of a sample of Swiss residents (MOBIS project) and develop a methodology for identifying suitable bundles. As a result, a limited number of bundles for the overall population shall be developed.

2 Literature review

To have a consistent terminology, first some definitions are introduced before the relevant research gap is pointed out.

2.1 Definition of MaaS

Heikkilä (2014) introduced the term MaaS (Mobility as a Service) with the goal to integrate nowadays major trends in passenger transport (like shared e-scooters or e-bikes) into existing transport systems. She claims that passenger transportation has not witnessed the transformation of technology to more efficient operations as several industries have. Until today, many transportation researchers have offered their definition of MaaS. One of the most straightforward definition of MaaS was made by Hensher (2017). Basically, MaaS is defined as a service that combines transportation services from public and private transportation providers through a unified gateway that creates and manages the trip, which users can pay for from a single account. Guidon et al. (2020) refers to that this gateway is provided by an information and communication technology (ICT) system. The idea is to offer ICT in an integrated smartphone application and sometimes additionally on computer devices.

2.2 MaaS bundling

Bundling is a common concept in many research fields and recently intensively discussed in context to MaaS. Thereby, the users of MaaS plans can usually choose between the option to pay per trip or to subscribe to bundles of transport services. Many see MaaS bundling as a chance to create a tool for influencing mode choice. According to Reck et al. (2020), the bundle design is central to their potential of inducing behavioural change (e.g., towards a more sustainable mode-choice). Adapted from marketing literature, Reck et al. (2020) differ between mixed bundling and pure bundling in MaaS. In pure bundling the products are not sold separately but only in the bundle and in mixed bundling they are sold separately.

2.3 Research gap

Recently, the willingness to pay for single elements within MaaS bundles and consumer valuation of bundling has been studied, mainly using stated preference data (examples are Ho et al. 2018 and Guidon et al. 2020). However, it is surprising that research about how modes are optimally bundled is rare. Guidon et al. (2020) point out that bundling strategies, which have been discussed in economics since a long time, are missing for transportation. To enable comparison and a discussion about the results of stated choice experiments of MaaS bundles, Reck et al. (2020) developed the concept of behavioural master designs (Figure 1). They developed ten behavioural design dimensions along which MaaS bundles systematically vary and differ between necessary and complementary design dimensions.

Figure 1 Behavioural master design for MaaS bundles

Necessary design dimensions	Modes	Modes of transportation included in the bundle	Public transportation, carshare, (e-)bikeshare, e-scooters, taxi, car rental, ridehail
	Metrics	Way in which the mobility budget / entitlement and consumption of a mode is measured	Time-based (minutes, hours, days), distance-based (km, miles), trip-based (number of trips)
	Geography	Area of validity	Single city, multiple cities, country
	Market segment	Entity the bundle is designed for	Individuals (residents, tourists, commuters, seniors), households, employee groups
	Subscription cycle	Period of single recurrence of a subscription	Weekly, fortnightly, monthly; Calendar or rolling
Complementary design dimensions	Discounts	Type and granularity of rebate	Trip-based (20% / $5 off each trip), budget-based (subsription fee or top up $50, pay $45)
	Caps	Limit to discounted trips / entitlements depending on the metric, also referred to as budgets	Time-based (30 hours / trips up to 30 min), distance-based (30 km), trip-based (10 trips)
	Add-ons	Non-transportation services included in the bundle	Parking, coupons (e.g., shopping, accommodation, restaurants, food delivery)
	Customizability	Bundles can be pre-defined by the mobility broker or personalized by the users	NA
	Roll-over option	Transfers unused credit to the subsequent time period	NA

Source: Reck et al. (2020)

Having a concept on how to compare stated choice experiments of MaaS bundles, there is still a lack of information on how to design bundles in the first place. Therefore, the approach of this paper is to develop a methodology for identifying suitable bundles using tracking data of sample of Swiss residents, collected within the MOBIS project. The focus within this paper is limited to providers and consumers interest, the question how behavioral change towards a more sustainable behavior could be included in the bundle design is not included.

3 Data

For the present paper, mobility trajectories of 1’025 Swiss residents are used. This data come from the research project called MOBIS (2020). The MOBIS study is carried out by different Swiss universities, led by the Institute for Transport Planning and Systems at ETH Zürich.

3.1 Study context

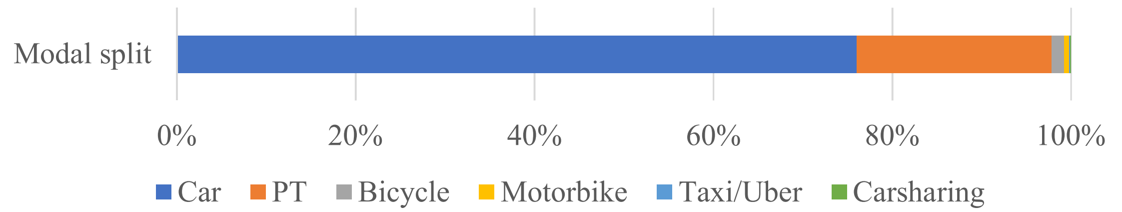
Within the MOBIS project, tracking data from participants over two months (not consistent, sometimes shorter/longer) during 2019 and 2020 has been collected. Most of the research on MaaS bundling are based on stated preference data or revealed preference not representative enough. Reck & Axhausen (2020) for example question the generalization of their research about MaaS plans since their sample is only composed of students. The MOBIS project is one of the most comprehensive studies of its kind as it includes participants distributed over most of the county and from different social backgrounds. However, the criteria for the participants that they need at least two weekdays per week either travelling by the own car or as a passenger of carsharing or taxi lead to an over proportional high share of car users.

Furthermore, it is necessary to point out that the MOBIS study did not distinguish between the different kinds of slow modes (such as shared (e-)bikes, shared e-scooters or e-bikes) and categorized all slow modes as “bicycle” except for walking, which is its own category.

3.2 Data overview

In the sample, a total of 546’772 stages are included in which the modes range from walking to airplanes. Considered for the bundling are frequently used modes. This includes the car, bicycle, taxi (or Uber; this was not differentiated), carsharing and all kinds of public transport modes. In Figure 2, the modal split is illustrated (based on distance). For comparison, the share within these modes in Switzerland corresponds to 71% for cars and 26% for public transport (BFS 2017). The difference seems reasonable keeping the condition for the participants of the study (c.f. 3.1) in mind.

Figure 2 Modal split (walking excluded)



Interesting modes to include within a bundle are shared modes like bike-sharing. The MOBIS project also includes a survey with general information about the users, e.g. whether they own a bicycle or not. Therefore, the assumption was made that each stage labelled as "bicycle" from a user not owning a bicycle was made with a shared bike. This corresponds to around 9% of all "bicycle" stages from the data.

4 Methodology

4.1 Cost allocation

To investigate a bundles potential, it is crucial to roughly estimate its cost for the users. Therefore, to enable a bundle-comparison based on cost, for each stage the cost must be calculated. The following cost estimates refer to the user's expenses.

4.1.1 Car cost and slow mode cost

Switzerland's biggest mobility club TCS (2020) estimated a cost of 0.71 CHF per kilometre for the average car in the year 2020, including all direct and indirect cost. This value is applied to calculate the costs of the stages done by cars.

For slow modes, it is assumed that stages carried out by slow modes other than bike-sharing do not generate any costs. For the bike-sharing cost, the tariffs from provider PubliBike (2020) are adapted. This includes an unlock fee of three swiss francs and an additional cost of five Rappen (one Swiss Franc corresponds to 100 Rappen) per minute. The yearly subscription is very low and therefore neglected.

4.1.2 Taxi/ Uber cost

The MOBIS study did not differ between taxi and Uber stages and assigned them into one category. Hence, from now on it is referred to the term "taxi services" to include both. Uber exists only in the bigger cities in Switzerland as of the beginning of 2020 but recently the service has been introduced to many further regions. It is assumed that Uber keeps growing and the service expands further. Therefore, both costs (for taxi and Uber) are allocated to each stage labelled as "taxi" since it seems reasonable to include a future scenario, where Uber is available all over Switzerland.

Uber

Only the cheapest option "UberX" is considered. Studying the price calculations (Uber, 2020) in Swiss cities, a relatively high difference between the eastern and the western part of Switzerland emerges. All cities east of Bern have one price composition (except Basel, they have a neglectable small difference to the others) and all the cities west of Bern (including Bern) another. To include zones where Uber does not exist yet, Switzerland is separated into two Uber zones, East and West. The separation of the two zones is made in the middle (longitude) between Bern and Basel. The tariffs are illustrated in Table 1

Table 1 Subdivision of Switzerland into two Uber tariff zones

Tariff Zone	Basic charge	Minimal Cost	Per minute	Per kilometre
East	3 CHF	6 CHF	0.31 CHF/min	1.8 CHF/km
West	4 CHF	8 CHF	0.50 CHF/min	1.7 CHF/km

Taxi

For the taxis, the cost in eight of the biggest Swiss cities are considered. Therefore, two randomly chosen taxi companies per city (Appendix A 2) are used to generate an average taxi price for each city (except for Geneva, there is the legally fixed maximum tariff used). On this basis, taxi zones are generated. As for Uber, the taxi tariff zones determine how the costs are composed. The corresponding table can be found in Appendix A 1.

4.1.3 Public transport cost

For most of the public transport (PT) stages, single ticket costs are considered. For around 2% of all PT stages where the single ticket cost is missing, a simple cost model based on the stages including the cost is built. It can be found on Appendix A 3.

The survey from the MOBIS project (c.f. 3.2) includes information about the user's PT subscription. Except for the GA (General Abonnement) and the Halbtax, the subscriptions do not include the name of the subscription nor the cost, only a basic category such as "regional pass" or "point-to-point pass". Based on this, the user's subscription with its cost is specified as in Appendix A 4. Finally, the subscription costs are added. Therefore, single ticket costs from stages within the subscription's validity area are not included to the users total cost. The subscription cost is included by scaling it down to the amount of tracked days. To double check the assumptions made for the subscriptions, the user's total PT cost including the subscription is compared to the user's total PT cost using only single tickets.

4.1.4 Carsharing cost

For carsharing, the tariffs from Switzerland's biggest provider Mobility are adapted. For simplicity it is assumed that only the basic category is used. This includes time-based cost of 2 CHF per hour and distance-based cost of 0.55 CHF per kilometre (Mobility, 2020). The subscription cost is very low and therefore neglected.

4.2 Bundling strategy

As mentioned in 2.3, there is a lack of research about how MaaS should be bundled. The concept introduced in the following provides a first approach on how bundles could be created stepwise. It does not claim to be complete nor applicable for every scenario but to offer a basis for comparison for further research. Therefore, the goal is to create a comprehensible and plausible "recipe" allowing reproduction with revealed preference data. The approach is described using the terminology of the "behavioural master design" introduced by Reck et al. (2020) and mentioned in 2.3.

4.2.1 Basic principles

Even though there is dearth of information how to bundle, a few basic principles can be derived from findings in MaaS research. Table 2 shows an overview of the hereafter introduced principles.

First, multiple researchers (Matyas & Kamargianni 2019, Ho et al. 2018, Ho et al. 2020 and Guidon et al. 2020) agree in their findings that current travel patterns match with the participants preferences for MaaS plans. It thus seems sensible to adapt bundles to current travel behaviour. Therefore, the bundle should include mode combinations characterized by the users travel behaviour. Substitution of modes for a bundle, as Reck & Axhausen (2020) did, are not part of this bundle concept. Second, Reck and Axhausen (2020) point out that PT season tickets are the core of MaaS plans for a majority due to their high usage. Therefore, the covered bundles are built around PT subscriptions, with the users' PT travel behaviour as main characteristic. Third, Guidon et al. (2020) find a tendency for negative willingness-to-pay (WTP) for taxi services and all shared modes except for carsharing (slightly positive) within bundles. Therefore, bundles shall be avoided for these modes or made more attractive by design. Within this paper the focus is on the creation of bundles, attractive designs must be found. Further, a newly introduced product (bundle) must provide added value for the consumer as well as for the provider. The added value for the consumer is mainly generated by the information and communication technology (ICT) system mentioned in 2.1 and is therefore not of financial nature. On the other hand, public transport service providers offering additional service and are therefore dependent on adding financial value compared to the status quo.

Table 2 Four principles to create a MaaS bundle strategy

Label	Principle	Based on
P1	Create mode combinations according to measured travel data	Preferences for MaaS plans = Current travel patterns
P2	Create bundle around PT	PT season ticket as core of MaaS plans
P3	Increase attractivity of taxi and shared modes	Negative WTP for taxi and shared modes within bundles
P4	Generate added value for provider	Compensate the providers for the additional effort offering MaaS

4.2.2 Behavioral master design as foundation

A consistent terminology and organized structure for the bundling strategy is achieved by using Reck et al. (2020)'s behavioral master design for MaaS bundles, presented in 2.3. Within this paper, it is waived to discuss the questions how the dimensions "Geography" and "Subscription cycle" are designed. Simply, they are set to "Switzerland" and "monthly". This is due to the amount of data: it is too small to create further geographic or temporal limitations and to keep a narrow focus on a few important dimensions. A first approach is attempted by using the dimensions “Modes”, “Metrics”, and “Caps”. This leads to the following question to include within the strategy, illustrated in Table 3.

Table 3 Relevant questions for a bundling strategy

Design dimension	Resulting question
Modes	Which are the modes included within a bundle?
Metrics	How can a mode be included within a bundle?
Caps	How is the use of the mode limited?

4.2.3 First approach of a stepwise strategy

According to the basic principles and the foundations, a first approach of a stepwise bundling strategy is developed. Thereby, five different steps are introduced.

Step one: Classify PT users

Public transport use, at the core of each bundle (principle P2), is separated into different PT user categories based on the regularity of use. The goal is to merge users which could be interested in a similar PT subscription as part of the bundle. Therefore, the users are segregated into three different categories according to their frequency of PT use (in days per week): Very frequent for users which used PT on five or more days per week, frequent for users which used PT three or four days per week and infrequent for users which used PT one or two days per week. The names of the category and the ranges are adapted from a classification of car users made by Ho et al. (2018).

Step two: Combine modes

Bundling of different public transport modes and offering them in specific subscriptions is a common concept in public transport. Therefore, to create something new, further modes are added to the categories created in step one. The share of modes in discussed in 3.2 implies that three modes are reasonable to combine with PT: Taxi services, Car Sharing and Bike-Sharing. Cars (without carsharing) and motorbikes are owned by the user and therefore cannot be part of a bundle. Further modes are not considered since it is tried to create bundles according to current travel behaviour (principle P1). To promote clear and simple interpretation of the findings about the bundles, only combinations of two modes are used for a first approach. With considerations from step one, the following combinations illustrated in Table 4 build the basis for the bundles.

Table 4 Possible bundles

Bundle	Short	PT user category	Modes
Bundle 1a	B1a	Very frequent	PT + Taxi services
Bundle 1b	B1b	Frequent	PT + Taxi services
Bundle 1c	B1c	Infrequent	PT + Taxi services
Bundle 2a	B2a	Very frequent	PT + Carsharing
Bundle 2b	B2b	Frequent	PT + Carsharing
Bundle 2c	B2c	Infrequent	PT + Carsharing
Bundle 3a	B3a	Very frequent	PT + Bicycle
Bundle 3b	B3b	Frequent	PT + Bicycle
Bundle 3c	B3c	Infrequent	PT + Bicycle

Step three: Define Metrics and Caps for second mode

From now on, the mode within the bundle which is not PT will be referred as “second mode”. After the question about which modes to include within a bundle was discussed, questions coming from the design dimensions “Metrics” and “Caps” are key to consider. The different existing PT subscriptions are usually already well defined, therefore here the focus is laid on the metrics and caps for the second mode. For a first approach, the dimensions are specified as in existing MaaS plans from provider Whim (2020) in Helsinki. Therefore, for all second modes the metrics are defined trip-based and the caps distance-based or time based respectively, seen in Table 5. Also, the quantity of the limitation for the Caps is taken over from Whim. The application to the data with these specifications shall show if the used Metrics and Caps are recommendable or if they need to be defined otherwise.

Table 5 Metrics and Caps of second mode for a first approach

Second mode	Metrics	Caps
Taxi services	Trip-based	Distance-based (5 km per trip)
Carsharing	Trip-based	Time-based (24 hours per rental)
Bike-sharing	Trip-based	Time-based (30 min per trip)

Step four: Create added value for the provider

Once the framework is built, we aim to create added value for the provider (principle P4) by polishing single elements. The term “potential user” is introduced. Potential users are travelers whose current travel behaviour include the offerings in the specific bundles. For the case of the above made assumptions, this would be the specific PT user category combined with the specific second mode and with stages within the defined caps limitation. As stated in principle P1, it is unlikely that travelers change their travel behaviour with regard to their choice of mode. For potential users already using a certain mode combination on the other hand, the assumption is made that they are willing to make slightly adaptions to their current travel behaviour within the combined modes. Based on this, a three-step model to increase the amount of stages for potential users is created (Table 6). The model is a first approach for how the analysis of tracking data can reveal the number of free rides for a bundle using trip-based metrics. The goal is to provide added value for the provider by increasing the amount of provided stages.

Table 6 Model to define the number of free rides for a bundle with trip-based Metrics

Step	Action
i.	Pick out potential users
ii.	Calculate the average number of stages per potential user within caps limitation
iii.	Round up value from step ii to the next integer = Number of free stages included in the bundle

Step five: Increase attractivity of bundles

Principle P3 urges to increase the attractivity of taxi services and shared modes within bundles. For a first approach, design dimensions "Discount" and "Roll-over Option", seen in Figure 1, are used. Therefore, for taxi service stages included within the bundle, a 10% discount is provided. For bike-sharing, a Roll-over option is integrated, allowing users to access unused credit in the next subscription cycle.

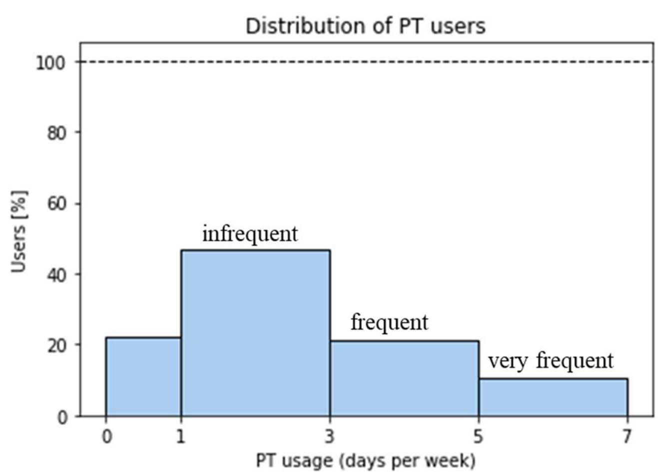
5 Application to revealed preference data

Once the strategy is defined, the data from the sample is applied to the stepwise bundling strategy. In the following the results are presented.

5.1 Step one: Classification of PT users

The 1'025 users from the sample were first categorized into public transport user categories. The public transport usage in days per week is based on an average over the whole tracking period from the users. Figure 3 shows that almost half of the users travel between one and three days per week with public transport and are therefore in the category "infrequent PT" users. The share of the "frequent PT" users and the "infrequent PT" users is remarkably lower with 20%, respective 10%. Around 20% of the users travel less than one day per week with public transport and are therefore excluded from the bundle design exercise according to specifications in 4.2.3.

Figure 3 Share of different PT categories



5.2 Step two: Combination of modes

The result of step two, the combination of the modes, was basically already done in the explanation of the approach. The evaluation of the share for the different mode combinations is shown in step three to offer a comparison of the share with and without further conditions.

5.3 Step three: Metrics and caps of the second mode

For the introduced specifications for metrics and caps, the viability must be checked. First, the share of users interested in a specific bundle is investigated by comparing tracking data with the offer within a bundle. Therefore, Table 7 shows the share of users for the different bundles. To point out the influence of the caps limitation, the share of users within the bundle is illustrated once with caps limitation and once without. It is visible that for the bundles including taxi services, the caps limitations decrease the number of potential users remarkably. For the bundles with bike-sharing, the caps yield almost to zero loss of users.

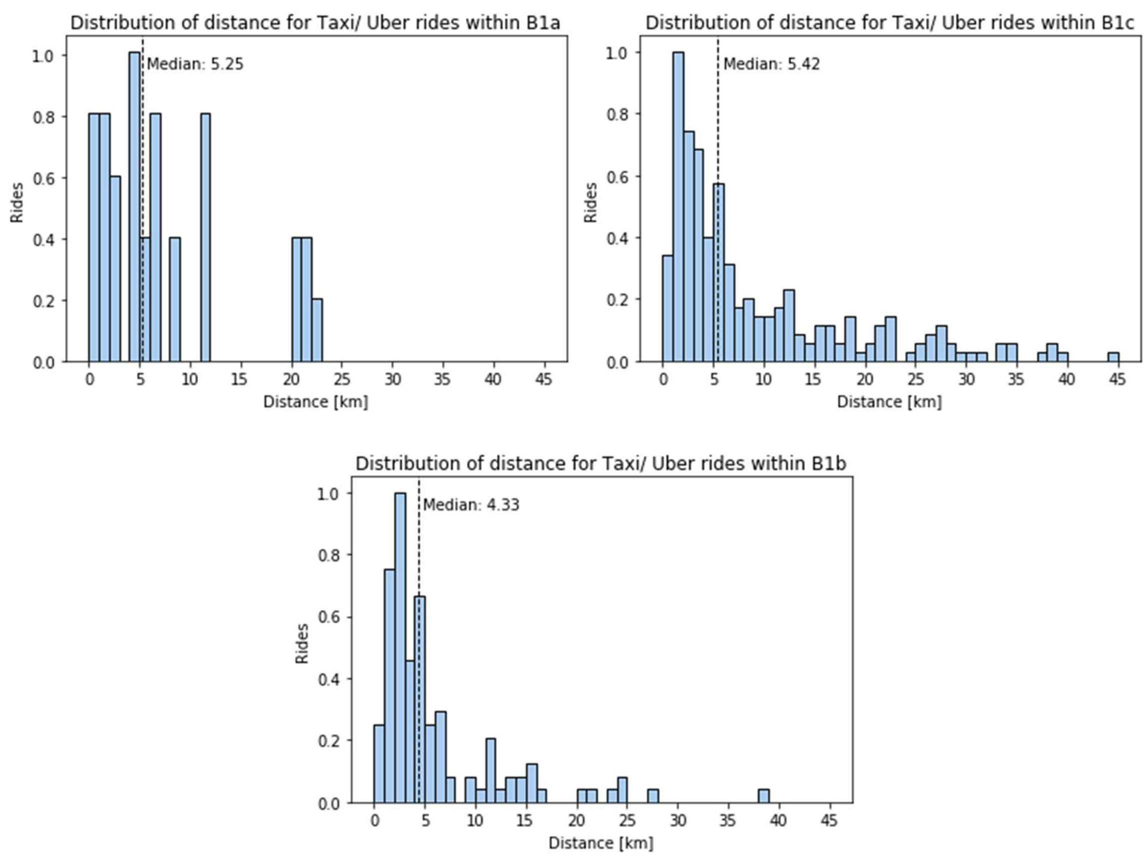
The evaluation of carsharing-data makes evident that the data from the sample is not enough to create results for the bundles. Carsharing is mostly used for round trips where the rental duration determine the cost but from the data, only stage durations are included, and rental duration cannot be determined. Therefore, carsharing is no longer considered for the results of this paper.

Table 7 Share of potential users for each bundle

Bundle	Potential users w/o limitation	Potential users	Modes	Caps
Bundle 1a	13 (1.3%)	10 (1.0%)	PT + Taxi services	Distance-based (5km)
Bundle 1b	28 (2.7%)	20 (2%)	PT + Taxi services	Distance-based (5km)
Bundle 1c	52 (5.1%)	39 (3.8%)	PT + Taxi services	Distance-based (5km)
Bundle 2a	4 (0.4%)	4 (0.4%)	PT + Carsharing	Time-based (24h)
Bundle 2b	6 (0.6%)	6 (0.6%	PT + Carsharing	Time-based (24h)
Bundle 2c	13 (1.3%)	13 (1.3%)	PT + Carsharing	Time-based (24h)
Bundle 3a	26 (2.5%)	26 (2.5%)	PT + Bicycle	Time-based (30min
Bundle 3b	48 (4.7%)	48 (4.7%)	PT + Bicycle	Time-based (30min)
Bundle 3c	68 (6.6%)	67 (6.5%)	PT + Bicycle	Time-based (30min)

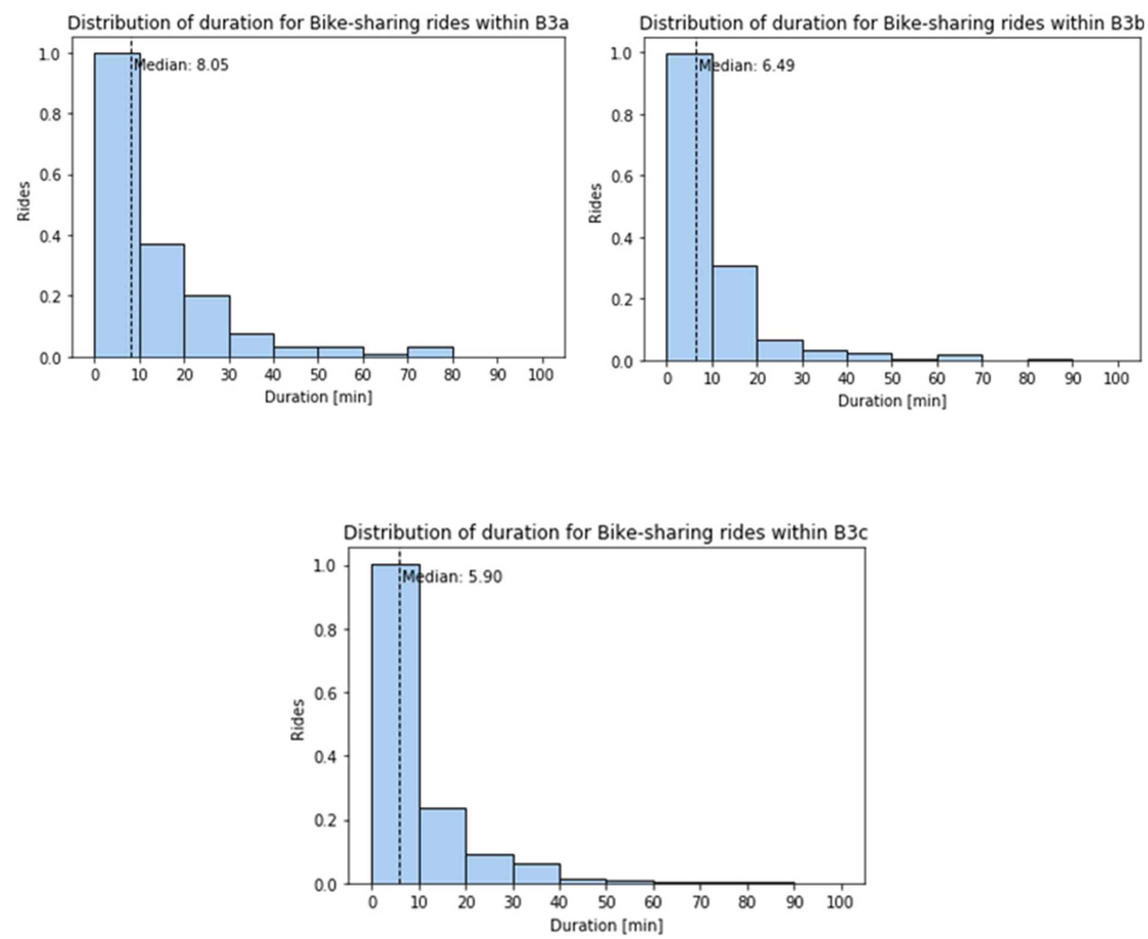
Next, the share of potential users is analyzed. The share of stages within the Caps limitation and generally the distance or time-distribution respectively is important to enable a statement for the introduced approaches. Figure 4 shows the distance distribution for taxi rides for the bundles including taxi services. Generally, the distributions look very similar except for the very frequent PT users. Their distribution is based on only a few stages and most likely that is the reason it looks so different. Hence, it is assumed that the average travelled distance is independent of the PT user category. The similar median for all categories supports this assumption. It is for all the different PT user categories around five kilometres. Therefore, around half of the rides tracked where not within the Caps limitation of five kilometres.

Figure 4 Distance distribution for taxi services for the different bundles



Likewise, Figure 5 shows the time distribution for bike-sharing for the respective bundles. The distributions again look very similar, by far the most rides for all categories were within ten minutes. The median here differs: “very frequent PT” users tend to take longer bike-sharing rides with a median of more than eight minutes, while for the others the median is around six minutes. In contrast to the taxi stages, most bike-sharing stages are within the Caps limitation. For all bundles, around 90% of the stages were shorter than 30 minutes.

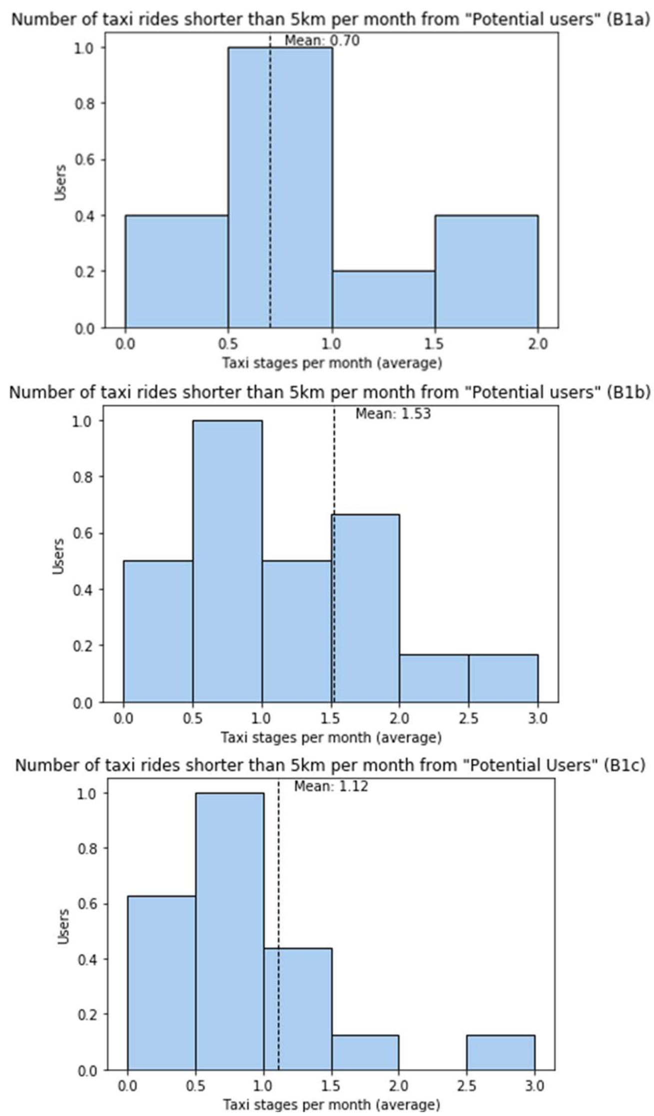
Figure 5 Time distribution for bike-sharing for the different bundles



5.4 Step four: Added value for provider

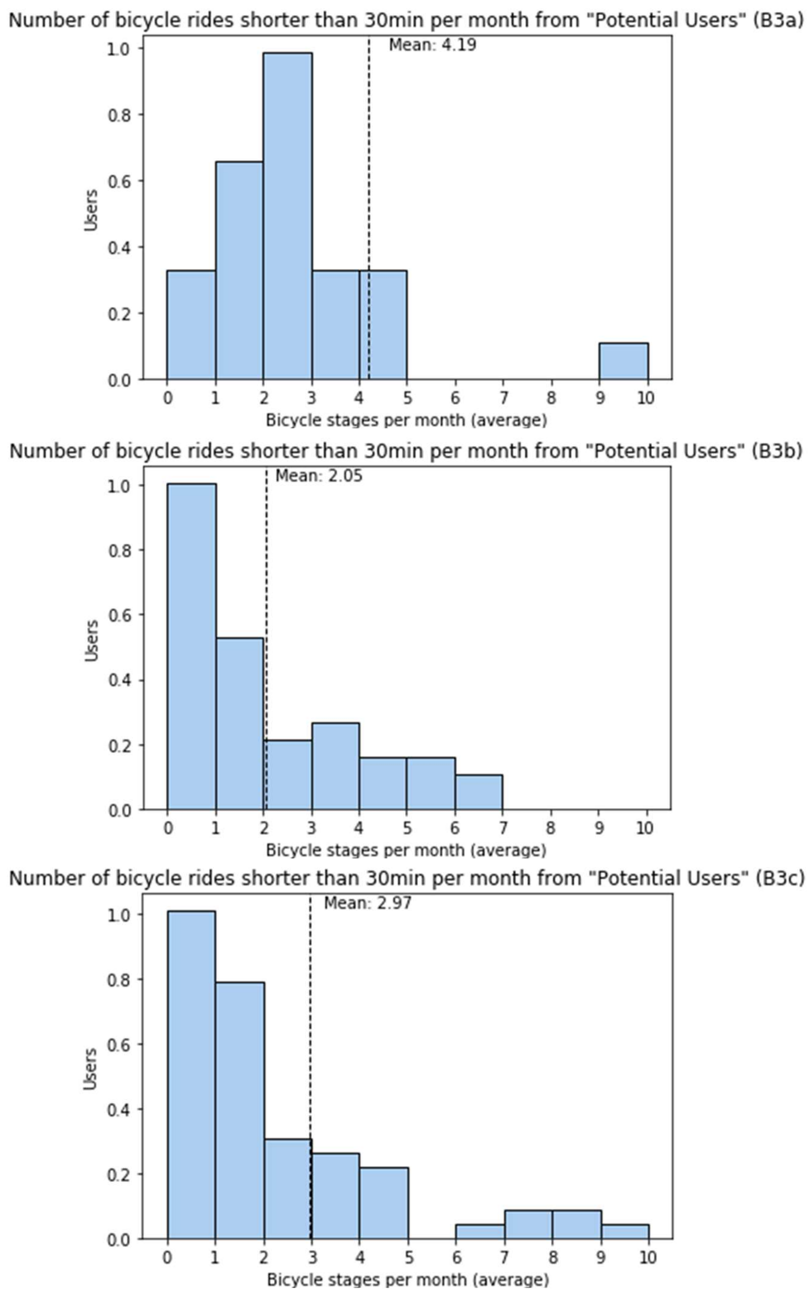
Not only the distances and the used modes of the potential users of each bundle, but also the regularity the second mode was used with was investigated. The average number of stages of the second mode per month within the Caps limitation is considered. In Figure 6, the number of rides made with taxi services per user is shown. For all bundles, most of the potential users have a little less than one taxi ride per month. In bundle 1a (illustration at top), no one has more than two taxi rides per month, in bundle 1b and 1c the most regular taxi user has a little less than three taxi rides per average month.

Figure 6 Distance distribution for taxi services for the different bundles



Likewise, the number of stages per month for each bike-sharing user is illustrated in Figure 7. Again, only the potential user's stages within the Caps limitation are considered. It can be seen that the most of the very frequent PT users (top illustration) make between two and three rides per month whereas in the other categories, most users have only one ride per month.

Figure 7 Time distribution of bicycle rides for the different bundles



The three-step model introduced in 4.2.3 to define the number of free rides to include within a bundle is applied. For the bundle 1a with the very frequent PT users illustrated at top of Figure 6, the average potential user has 0.7 taxi rides per month. Consequently, the offered bundle 1a includes one free taxi stage per month. The same is applied for bundle 1b and bundle 1c for both which then the offers includes two rides within the monthly subscription cycle. For bike-sharing, the three-step model suggests to offer five free rides within the bundle 3a since the mean value of 4.19 (Figure 7) needs to be rounded up to the next integer. For both, the bundle 3b and the bundle 3c, the free rides included within the bundle therefore is three.

With the assumption that all potential users change to the offered bundle and create only the amount of taxi or bike-sharing rides included in the bundle, an increase in rides is produced. The total amount of additional created rides and its share is illustrated in Table 8, labelled as potential. It is visible that only a small difference in travel behaviour could induce a high potential number of new rides.

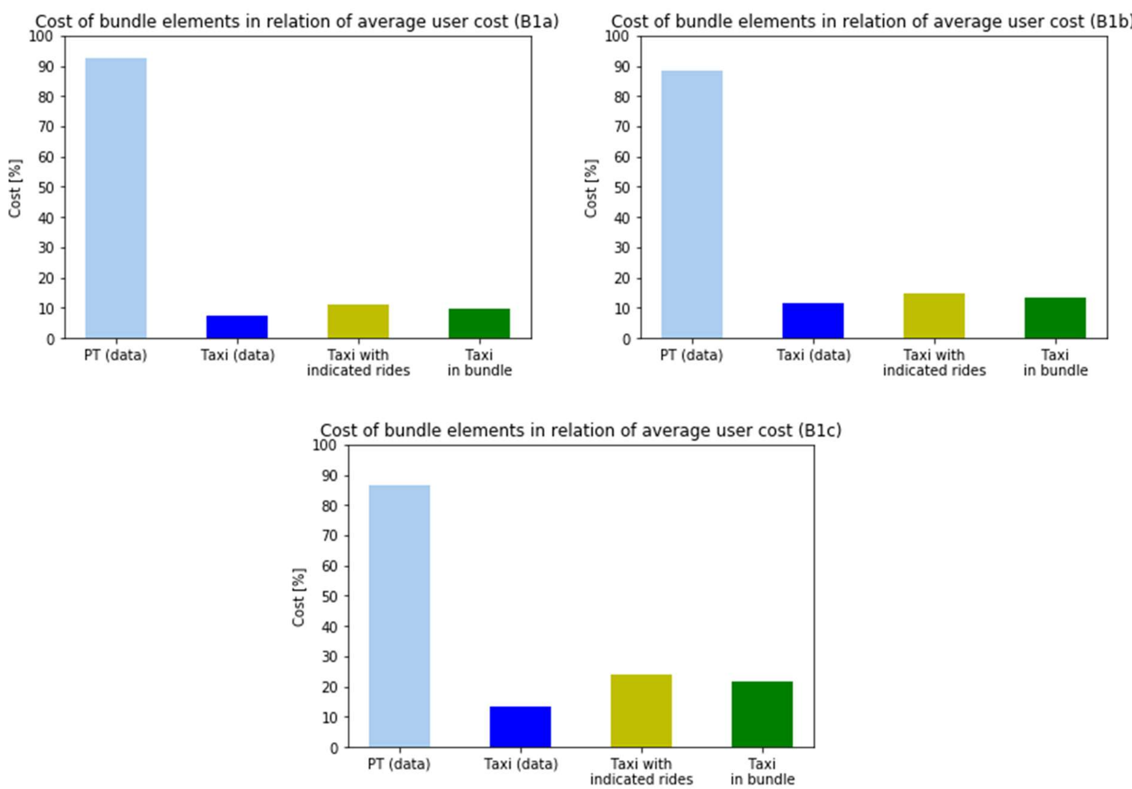
Table 8 Generated potential applying the three-step model

Bundle	Potential users (share)	Potential
Bundle B1a	1.0%	(+3 rides), 43% rise
Bundle B1b	2.0%	(+9 rides), 31% rise
Bundle B1c	3.8%	(+ 34 rides), 79% rise
Bundle B3a	2.5%	(+21 rides), 19% rise
Bundle B3b	4.7%	(+46 rides), 46% rise
Bundle B3c	6.5%	(+2 rides), 1% rise

5.5 Step five: Increased attractivity of bundles

For the step five, induced rides stated in 5.4 are included. For the taxi services, the effect of the 10% discount is pointed out. Therefore, Figure 8 is introduced, showing the average cost of the users within the bundle from the data. Additionally, the theoretical average taxi cost including induced rides from step four and the same rides with 10% discount -what correspond to the final taxi cost for the bundle - are illustrated. The average cost paid for public transport and taxi from the data results in 100%. For all three bundles including taxi services, public transport cause by far the biggest cost. Only for the infrequent PT users, a slight effect of the discount is visible since the share of taxi cost and the level of induced stages are a bit higher. It was waived to create the same illustrations using Uber cost instead of Taxi cost since the effect would be even smaller.

Figure 8 Cost of PT and taxi within the bundle



5.6 Summary of the bundles

Having all steps applied, a summary of the bundles developed including their potential costs is presented in Table 9. The public transport cost corresponds to the average cost generated by the users within the bundle. The cost of the second mode are adapted by including the induction of rides (step four) and for the taxi additionally the discount. Interestingly, the frequent PT users within the taxi bundle paid more for public transport than the very frequent PT users. Further noticeable is, that for the same amount of taxi rides, the stages made within bundle B1c are a lot cheaper than the ones made within bundle B1b. The bike-sharing bundles are generally a bit less expensive.

The included cost calculations where all made using taxi cost. By far the biggest influence on the cost has the public transport. Hence, the result would look only slightly different if Uber cost was allocated to the stages referred as taxi. On average, the stages cost about 20% less if Uber tariffs are applied instead of taxi tariffs. For the bike-sharing bundles, additionally a Roll-over option is included which cannot be expressed quantitatively. The impact of the Roll-over option can therefore only be guessed.

Table 9 Overview of the resulting bundles

Bundle	Included modes	Second mode	Potential users	Cost PT (data)	Cost second mode (adapted)	Total cost
B1a	PT + Taxi	1 free ride (5 km)	10 (1.0%)	145.40.-	15.50.-	160.90.-
B1b	PT + Taxi	2 free rides (5 km)	20 (2%)	184.70.-	28.20.-	212.90.-
B1c	PT + Taxi	2 free rides (5 km)	39 (3.8%)	78.00.-	19.40.-	97.40.-
B3a	PT + Bike-sharing	5 free rides (30 min)	26 (2.5%)	139.80.-	13.50.-	153.30.-
B3b	PT + Bike-sharing	3 free rides (30 min)	48 (4.7%)	121.30.-	7.00.-	128.30.-
B3c	PT + Bike-sharing	3 free rides (30 min)	67 (6.5%)	52.60.-	9.90.-	62.50.-

6 Concluding discussion

After developing an approach of a bundling strategy and applying it to revealed preference data, the made assumptions are critically questioned, and each step of the approach is discussed in this section. Further, adjustments in the strategy are conducted to generate a reasonable "recipe" for researchers of MaaS bundles. In the end, an outlook is presented to include additional ideas.

6.1 Review of data and general assumptions

The estimated share of users within the bundles must be interpreted with care. The composition of the participants of the study is not completely representative due to the participants condition. Captive public transport users for example are strongly underrepresented since most participants own a car. Nonetheless, the composition of the participants is especially interesting since Ho et al. (2018) point out that car non-users are less likely to purchase MaaS plans and generally frequent and very frequent car users are more likely than the average to purchase MaaS plans.

Further, the share of bundles including bike-sharing are most likely overestimated. The reason is the assumption that all stages referred to as "bicycle" carried out from non-bicycle owners are bike-sharing stages. These stages could be done by all kinds of slow modes. However, it is reasonable to assume that a substantial part of these stages was made by shared-slow modes which are very similar in their characteristics among each other. Therefore, bike-sharing can be seen as representative for all shared slow modes which would be included similarly in a bundle.

Next, the cost assumptions are reviewed. Modes that were of secondary interest within this paper are not further discussed. Mainly the public transport cost could include relatively high discrepancies compared to reality. This is because the assignment of the public transportation subscriptions in Appendix A4 is speculative and the cost of the participants subscriptions could vary a lot. For more than half of the stages, a "single ticket cost" was allocated because the user would have spent more money with the assigned subscription. Even though it is a possible scenario that users pay more with their subscription than what they would without, it seems likely that the public transport cost generally was overestimated.

6.2 Resulting adjustments to the stepwise bundle strategy

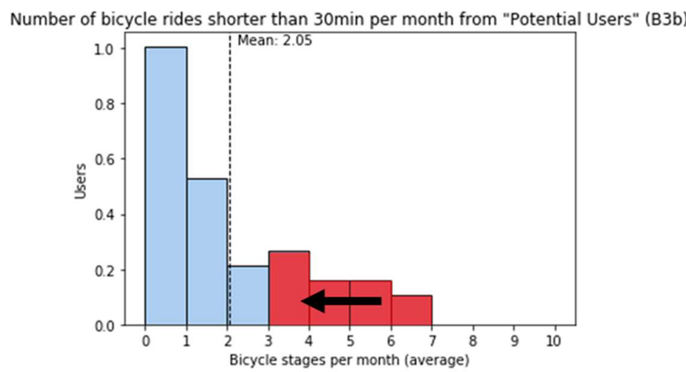
The four basic principles turned out to be a great orientation for the creation of the bundles and to help keeping the main goals in mind. It is suggested to extend the basic principles by including goals of MaaS bundling not paid attention to within this paper. One important addition would be how to adopt sustainability goals.

The subdivision into different public transport categories offers a first idea for how PT could be combined with other modes. The users from the different categories own different PT subscriptions and would therefore be difficult to unite in one bundle. Another argument for such a division are the observed differences in travel behaviour for the second mode in 5.3 and 5.4. Mainly the differences in regularity of use and duration of bike-sharing stages between the different PT categories show that very frequent PT user often generally create a higher mobility demand. Therefore, the separation in PT categories allows to provide a better customization of the offer for the users. To adapt users public transport subscription optimally into the bundle, it is conceivable to subdivide public transport even further in the first step into the different subscription options.

The chosen trip-based metrics proved to be reasonable because most of the taxi and the bike-sharing stages were within a relative similar range. Nonetheless, it would be interesting to include other metrics such as times-based or distance-based for a comparison. The caps limitations used are not fully satisfying. The five-kilometre limit for the taxi stages exclude around 50% of the potential users. Possible attempts could be to increase the distance or to use time-based caps. On the other hand, the bike-sharing limitation of 30 minutes appears feasible since it includes around 90% of all bike-sharing rides and is common practice in existing offers.

The fourth step of the strategy where additional value for the provider is created includes many open questions and interpretations. Mainly the number of free rides within a bundle was oversimplified. This concept focuses only on the average number and neglects the information, how many rides per month the individual user has used. Therefore, it assumes users to change their travel regularity according to the bundle without paying attention to how big the change would be. Additionally, it cannot be proven that this procedure would even lead to a decrease in rides. Such a scenario is conceivable, if potential users who conduct more rides than offered in a bundle switch to the bundle but others do not, as illustrated in Figure 9. For this example, three free rides would be included within the bundle according to the three-step model introduced in 4.2.3 but only users who took more than 3 rides would buy the offer.

Figure 9 Possible scenario for a decrease in rides



Nevertheless, the analysis of the potential user's data showed that a high added value could be generated by this approach. It was shown that already a slight increase in rides for single potential users can generate a high increase in total rides. Therefore, it is suggested to define how second modes are included into the bundle by first separating the potential users and then analysing their travel behaviour. It would be very interesting to know, within what regularity-range potential users are willing to adapt their travelling behaviour. This would enable systematically approaches to define how the second mode is included within the bundle.

The least well-defined step is the increase of the attractivity of the bundle. To provide discount for taxi stages within bundles seems not meaningful since it is not directly noticeable for the user when buying the respectively plan. Further it is questionable if the provider generates enough added value to offer a discount. An option could be to provide a discount for every additional ride not included within the bundle. This could be attractive for both, users and providers, if more rides are carried out but for a less expensive price. The roll-over option's effects are not measurable, and its consequences seem unpredictable. Both are conceivable, that the willingness to buy a bundle rises, but also that users are more economical with their rides and therefore generate less rides. Its effects need to be explored further, including rules and limitations how such roll-over options could be included.

Finally, all the considerations above are included to generate an updated version of the bundling strategy, presented in Table 10. Additionally, reflections about how further modes can be included and how the design dimensions “Geography” and “Subscription Cycle” could be determined are part of the suggested bundling strategy.

Table 10 Suggested bundling strategy

Step	Suggested action	Alternatives / questions
Initiation	*Set “Geography” and “Subscription Cycle”*	
Step one	*Classify PT users*	
	infrequent, frequent, very frequent	Or according to PT subscription?
Step two	*Preselection of mode combination*	
	Only two modes	
	PT + second mode	
Step three	*Determine “Metrics” & “Caps” for second mode*	
	-Metrics: Trip based	Possibly other Metrics?
	-Caps: Bike-sharing “time-based, 30min	Caps for taxi?
Step four	*Create added value for provider*	
	i. Pick out potential users	
	ii. Analyse regularity and distance /time distribution of the rides for the second mode	How generate maximal increase in rides?
Step five	*Increase attractivity of bundles*	
	Options: Add-ons, Roll-over option	
Step six	*Investigate, if addition of further modes reasonable*	
	Repeat from step two	

7 Outlook

The recently increased focus on MaaS bundles most likely will lead to further research projects about how MaaS bundles should be designed. Apart from further design strategies based on revealed preference data, it would also be interesting to move a step back and first define how MaaS bundling could be done on a more conceptional level. Therefore, it could be advisable to generate an approach based on the two main dimensions of bundling introduced by Stremersch and Tellis (2002): Bundling focus and bundling form.

Further, it is suggested to adapt an existing bundle strategy from other economical fields. For example, the creation of plans from telecommunication providers need to deal with similar questions since it is also adapted the individual users. To build a bundle analog to a telecom bundle could therefore be a valuable approach.

8 Acknowledgements

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A Appendix

A 1 Taxi tariff zones

For the cost allocation, nine taxi tariff zones are built. The zones are shown in Table 11. All stages where the midpoint of the ride is within 10 kilometres distance of a city centre are assigned to the respective taxi zone (this covers more than 80% of the taxi stages). For the rest of the stages the average costs of the eight cities is used.

Table 11 Taxi tariff zones

Tarif zone	Basic charge	Per kilometre	Per kilometre (night)
Genf	6.30 CHF	3.20 CHF/min	3.20 CHF/min
Lausanne	6.20 CHF	3.00 CHF/min	3.80 CHF/min
Bern	6.65 CHF	3.90 CHF/min	4.45 CHF/min
Basel	6.50 CHF	3.80 CHF/min	4.30 CHF/min
Luzern	6.00 CHF	3.65 CHF/min	3.65 CHF/min
Zürich	6.00 CHF	4.40 CHF/min	4.40 CHF/min
Winterthur	6.00 CHF	3.80 CHF/min	3.80 CHF/min
St. Gallen	5.25 CHF	4.05 CHF/min	4.45 CHF/min
Average	6.11 CHF	3.73 CHF/min	4.01 CHF/min

A 2 Calculation taxi costs

Stadt	x_koordinate	y_Koordinate	Art_des_Tarifs	Zuletzt_geändert	Grundgebühr	Nachts	Kilometerpreis	Nachts	Stand-/wartezeit	Nachttarif	
Genf	2500532	1117325	Maximaltarif	Oktober 2012	6.3	6.3	3.2	3.2	60 CHF/h	Kein	
			Die Unternehmen in Genf geben keine Tarife an								http://ambataxi.ch/tarif-taxi-geneve/
Lausanne	2538291	1152330	Maximaltarif	März 2011	6.2	6.2	3	3.8	54 CHF/h	Mo-Sa von 20-06, Sonntag ganztägig	
			Taxi Services		6.2	6.2	3	3.8	54 CHF/h		https://www.taxiservices.ch/clients/
			Taxi phone		6.2	6.2	3	3.8	54 CHF/h		https://www.taxiphone.ch/tarifs
			Mittelwert (ohne Maximaltarif)		6.2	6.2	3	3.8			
Bern	2600670	1199655	Maximaltarif	Januar 2018	6.8	6.8	4.1	5.5	78 CHF/h	Mo-Sa von 20-06, Sonntag ganztägig	
			Taxi Bern		6.5	6.5	3.9	4.4	69.80 CHF/h		https://taxibernn.ch/tarife/
			Nova Taxi		6.8	6.8	3.9	4.5	72 CHF/h		https://novataxi.ch/de/preise
			Mittelwert (ohne Maximaltarif)		6.65	6.65	3.9	4.45			
Basel	2611220	1267503	Maximaltarif	März 2011	6.5	6.5	3.8	4.3	70 CHF/h	Mo-Sa von 20-06, Sonntag ganztägig	
			Enzo Taxi		6.5	6.5	3.8	4.3	70 CHF/h		https://www.enzotaxi.ch/de/preise
			Taxi Zentrale		6.5	6.5	3.8	4.3	70 CHF/h		https://www.taxi-zentrale.ch/tarif-und-zahlung/
			Mittelwert (ohne Maximaltarif)		6.5	6.5	3.8	4.3			
Luzern	2665892	1211591	Maximaltarif	Januar 2015	6	6	3.8	3.8	66 CHF/h	Kein	
			24/7 Plustaxi Luzern		6	6	3.5	3.5	66 CHF/h		http://plustaxi.ch/booking/
			Taxi-Wyss		6	6	3.8	3.8	66 CHF/h		https://www.taxi-wyss.ch/taxi-luzern-preise/
			Mittelwert (ohne Maximaltarif)		6	6	3.65	3.65			
Zürich	2683354	1247353	Maximaltarif	Januar 2015	8	8	5	5	80 CHF/h	Kein	
			Tarif Taxi 24		6	6	5	5	1.33 CHF/min	Kein	https://zuerich-taxi24.ch/tarife/
			City Taxi Zürich		6	6	3.8	3.8	69 CHF/h	Kein	https://citytaxizuerich.ch/tarife-angebote/
			Mittelwert (ohne Maximaltarif)		6	6	4.4	4.4	-		
Winterthur	2697052	1261734	Maximaltarif	Oktober 2017	6	6	3.8	3.8	69 CHF/h	kein	
			Heiditaxi		6	6	3.8	3.8	69 CHF/h		https://heiditaxi.ch/portfolio-items/portfolio
			Capataxi		6	6	3.8	3.8	69 CHF/h		http://www.capataxi.ch/?gclid=EAIaIQobChMI9q6NquvT6AIVFcayCh0yFw1yEBAYASAAEgK54PD_BwE
			Mittelwert (ohne Maximaltarif)		6	6	3.8	3.8			
St. Gallen	2746284	1254335	Maximaltarif	Januar 2016	5.5	5.5	3.9	4.1	59 CHF/h	kein	
			Taxi Frosch		5.5	5.5	3.9	4.3	-		http://www.taxifrosch.ch/dienstleistungen/preise/
			1a Taxi Service 365		5	5	4.2	4.6	65 CHF/h		https://www.hr-mychauffeur24.info/442043454
			Mittelwert (ohne Maximaltarif)		5.25	5.25	4.05	4.45			

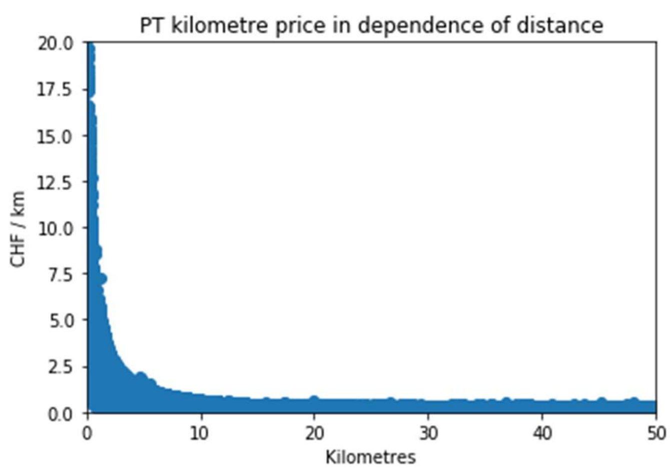
Tarife der Unternehmen höher als Maximaltarif?! Maximaltarif veraltet?

Auf sämtliche Websiten wurde zuletzt am 06.04.2020 zugegriffen

A 3 PT single ticket costs

The price per kilometre from the PT stages within the sample correlates with the total distance of the stage (Figure 10). For very short stages, the cost per kilometre is very high and gets smaller with distance. Based on the average price of the distance range, the cost per kilometre from is allocated to the PT stages without single ticket cost.

Figure 10 Distance dependent PT cost (CHF/km)



Distance	cost/km
0-500m	5.75
500-1000m	2.89
1-2km	1.44
2-5km	0.65
5-10km	0.34
> 10km	0.23

A 4 PT subscriptions

The MOBIS survey included the participants' postal code. The simple assumption was made, that user with a "regional PT pass" own a regional PT subscription from the canton they live in. The postal code for around 80% of the users was within 1000, 4000 or 8000. For the postal code 8000 (Zürich and Thurgau), it was assumed that the users own the yearly ZVV subscription for all zones, which costs 2'226 CHF (ZVV, 2020). Stages not carried out in the ZVV area were not additionally charged as a compensation for the overestimated price for the average user (most user most likely own a less expensive subscription, not valid for all ZVV areas).

For users with the postal code 1000, the PT subscription for the whole canton of Geneva was assigned. It costs 500 CHF per year (Unireso, 2020). Stages out of the tariff zones were additionally charged with single ticket costs.

The postal code 4000 includes both cantons of Basel (Basel-Stadt and Basel-Landschaft) as well as U-Abo which was assigned to the users. It costs 800 CHF per year (TNW, 2020), again additional stages not in the tariff zone were charged with single ticket costs.