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Option value of passenger transport

Examining the perceived value of transport options

Simon Kuster, University of St. Gallen

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Simon Kuster

University of St. Gallen
IMP-HSG, Tourism and Transport

T: +41 71 224 2612
E: simon.kuster@unisg.ch

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Abstract

Many people appreciate certain means of transport as their backup modes without necessarily using them. In environmental economics, this phenomenon of non-consumptive benefit is called *option value* and has been discussed for decades. However, in transport research, there have only been a few explorative attempts to examine the concept empirically.

This study aims at developing an instrument for the investigation of perceived option values in passenger transport. With the help of a survey tool, option valuations will be explained based on characteristics of the option mode, the travel context, and the personal context of the traveler. Furthermore, resulting valuations will be compared to market-proxies.

Subscriptions for secondary modes, purchases of second vehicles, and mobility insurances are market-based instruments that incorporate (some) option value. These backup solutions limit risk or volatility of transport costs. Therefore, under certain assumptions, the identified option values can also be compared to the valuation of financial options.

Because option values are highly context dependent, it is necessary to focus the analysis on (the inhabitants of) a specific region with its distinct transport system or options. This study proposes a methodology for the investigation of option values in passenger transportation in Switzerland for the first time.

Keywords

Option value, option price, option pricing, contingent valuation, passenger transport

1. Introduction

The availability of transport is valuable because it allows for social and economic interaction. People even appreciate certain transport means as their backup-modes without necessarily using them: Motorists value public transport as secondary option when their vehicle is unavailable; bike and bicycle riders appreciate buses as comfortable alternatives for bad weather scenarios; transit users value car sharing as backup for situations when they need to transport bulky goods. Thanks to the availability of transport alternatives, individuals can ensure their mobility.

In environmental economics, the non-consumptive benefit derived from the pure availability of a good for future use is called *option value (OV)*. Securing future access to a nature reserve, to an urban park, or a transport link provides OV. Option valuations became widely accepted in the aftermath of the Exxon Valdez oil spill in Alaska in 1989, where lawsuits required the economic quantification of environmental damage (Carson, 2012, p. 29). However, there have only been a few attempts to explore OV empirically in the field of transport economics.

Today, it is mostly unclear what drives OV in transport. This study aims at developing an instrument for the investigation of perceived OV in passenger transportation. Therefore, both existing literature as well as new approaches are explored. With the help of a survey tool, option valuations will be analyzed based on characteristics of the option mode, the travel context, and the personal context of the traveler. Furthermore, resulting valuations will be compared to market-proxies. As OV is highly context dependent, the emphasis lies on Switzerland.

2. Theory

The phenomenon of OV has been discussed by economists at least since Burton Weisbrod's (1964) seminal paper on "collective-consumption services of individual-consumption goods". Weisbrod (1964, p. 473) observed that despite their private nature, many products and services have characteristics of *public goods* – in the form of positive externalities from their production. Means of transport can for example just be used with a ticket or key (private good). However, nobody can usually be excluded from enjoying the option of a possible use in the future (at least with public or shared modes). Like a financial call option (the right to e.g. buy certain shares at a point in the future), OV stands for the *value of the possibility to access* a certain good or service in the future (at a certain price).

In the 1980s and 1990s, the theoretical discourse reached some consensus on the existence and definition of OV. Cicchetti and Freeman (1971, p. 530) were the first to define OV as the difference between *option price (OP)* and the *expected consumer surplus E(CS)*:

$$OV = OP - E(CS)$$

OP and E(CS) measure essentially the same thing, but with a different perspective in time:

- OP: Option price, represents the maximum willingness to pay (WTP) to secure a defined option (price, quantity, quality) in the future. It is therefore an *ex-ante welfare measure*. At OP, individuals are indifferent between owning and not owning the option.
- CS: Consumer surplus, represents the part of the individual's WTP that exceeds the price charged by the supplier. CS is an *ex-post welfare measure*, as it measures the benefit that the individual accrues from actual consumption or use of the good.
- E(CS): Expected CS, can also be written as $p \cdot CS$, with p for the probability of future consumption. The expected value of the (ex-post) consumer surplus thus considers the *probability* of use – but does *not* contain a measure of *risk propensity*.

Since OV is defined as the delta between ex-ante and ex-post measurement, it is not considered a distinct value-component by some authors (e.g. Smith, 1987, p. 289). OV can be seen as a kind of insurance premium for risk averse individuals: People perceive a positive OV when they (ex-ante) valuate the secured availability of a product or service (OP) higher than they valuate the probable or expected use of the good, E(CS). In other words, OV can be defined as a *risk aversion premium or bias* of risk averse people (Plummer & Hartman, 1986). Even though OV is primarily a phenomenon of perception, it can still be a considerable component of the overall value of a good (e.g. Meier & Randall, 1991).

TEV	**Main types of value**	**Subtypes**	***Examples for a public transport service***
Total Economic Value	Use values (UV)	Direct use	*Direct benefit or value of own trips with the service*
		Indirect use	*Value of reduced congestion/CO_2 thanks to the service*
		Option	***Value of opportunity for own trips with the service***
	Non-use values (NUV)	Altruist	*Value of service for others/disadvantaged people*
		Bequest	*Value of service (e.g. rail line) for future generations*
		Existence	*'Sentimental' value of a service/worth of its existence*

Table 1: Total economic value, components, and own examples (e.g. Bateman et al., 2002, p. 29; OECD, 2006, p. 87)

The OV of a good is *not* realized through consumption but exists as long as there is a chance for future use. Since even non-users of a product or service can perceive significant OV, typical customer value based frameworks (see e.g. Sheth et al., 1991) are insufficient to further investigate the concept. Instead, OV is often categorized within the framework of total economic value (TEV). TEV is a concept from cost-benefit-analysis (CBA) that allows for the inclusion of consumptive (use) as well as non-consumptive (option and non-use) values in project or service valuation (see *Table 1*). However, some authors include OV in NUV, while others regard it as a subtype of UV or even a distinct type of value. OV is heavily related to possible future use but exists without any imminent use, too.

3. Literature

Thirty years ago, Bristow et al. (1991) made the earliest known attempt to systematically develop a survey methodology for the evaluation of NUV (incl. OV) in public transport. However, the researchers were facing several methodological challenges and have not been able to isolate OV. Instead, their efforts just returned some approximations for the NUV of a local bus service. Since then, there have only been some explorative attempts to quantify option values empirically. The available studies focused on specific transport links in Great Britain, the Netherlands, and South Korea (see *Table 2*). The authors usually approached OV as part of the TEV of their investigated transport service or infrastructure (rail, bus, or road).

Authors	**Year**	**Place**	**Mode(s)**	**Surveying**	**Method**	**Disaggregation**	**Option values**
Hump. & Fowk.	2006	GBR	Rail	Phone	DCE/CVM*	Proxy attributes	GBP 2–4/hh/w
Geurs et al.	2006	NLD	Rail(s)	PC (online)	DCE	User groups	EUR 8–14/p/m
Chang	2010	KOR	Rail (type)	In-person	CVM	User groups	KRW ~15/km/h/p
Chang et al.	2012	KOR	Bus (type)	In-person	CVM	User groups	KRW ~8/km/h/p
Johnson et al.	2013	GBR	Rail (vs. bus)	Paper based	DCE	Weightings	GBP 12–26/p/y
Laird et al.	2013	GBR	Bus (network)	Paper b./PC	CVM/DCE	User gr./Weigh.	GBP 11–37/hh/y
Chang et al.	2017	KOR	Expressway	Paper based	CVM	Weightings	KRW 19 330/p/y

Table 2: Existing studies with explicit determination of option values; for explanations see following text sections. There are five more studies that addressed OV implicitly by evaluating NUV (but without isolating OV from NUV).

*Key: hh = household; p = person; w = week; m = month; y = year; km = kilometer; h = hour (headway/frequency); CVM: contingent valuation method; DCE: discrete choice experiment; *for quantification of consumer surplus (CS); GBR: Great Britain; NLD: Netherlands; KOR: South Korea; GBP: British Pounds; EUR: Euros; KRW: Korean Won*

All the previous studies applied contingent valuation methods (CVM) and/or discrete choice experiments (DCE) to evaluate the (total) economic value of a given transport link. However, as it is very challenging to find meaningful proxy attributes for the TEV components of a service (see subtypes in *Table 1*), there seems to be no advantage of DCE over CVM. Evaluating OV (and NUV) is not so much about evoking impulsive choices (as in DCE that simulate routinized transport choice) but more about individual reflection on perceived values. By focusing on specific services and a limited number of attributes (primarily the service interval), the authors reduced complexity (and generalizability) of their studies.

Approaching OV via TEV requires disaggregation. Three procedures are employed in the previous, exploratory studies, that usually focused on one specific transport link:

- Humphreys and Fowkes (2006) introduce DCE *attributes as proxies* for the different subtypes of values (e.g. altruist value via discount schemes for disadvantaged people). However, the OV of the service is not quantified directly but calculated by subtracting users' CS (retrieved via CVM) and the value of the next best alternative from the TEV.
- The procedure of *grouping respondents* by users, option users and non-users of a service is most frequently applied in literature (Chang, 2010; Chang et al., 2012; Geurs et al., 2006; Laird et al., 2013). After evaluating the TEV via CVM or DCE, the average value of strict non-users (who only hold NUV) can be subtracted from the average value of potential or seldom option users (who hold both NUV and OV) to approximate OV.
- An even simpler strategy is adopted in the most recent studies (Chang et al., 2017; Laird et al., 2013). After evaluating the TEV of a project or service via CVM or DCE, these authors just present a comprehensive list of use, option, and non-use values and ask respondents to *weight* them (e.g. by allocating 100 points to the different subtypes).

In these studies, researchers survey individuals or households with the help of phone, paper, or computer-based tools and mostly elicit OV via (hypothetical) changes of related local tax payments (see *Table 2* for obtained values). However, with advances in information technology (facilitating self-completion surveys), growing acceptance of various payment mechanisms (including subscription models), and improvements in the seamless combination of mobility modes (especially in Switzerland), the starting point of the study at hand is very different.

4. Methodology

The nature of OV makes measurements challenging. Since OV often appears to be a public good (see *Theory*), there are no reliable market transactions to base the analysis on. Principally, public goods can be valued *directly* or *indirectly* based on observed behavior on *real markets* or responses to *hypothetical markets* (Mitchell & Carson, 1989, p. 75). Previous studies on specific transport alternatives explored OV with the help of hypothetical markets via direct (CVM) or indirect (DCE) elicitation (see *Table 2*). However, this study aims at exploring the full range of possibilities to examine OV in passenger transport – in the specific Swiss context. By combining strategies for direct and indirect appraisals on both hypothetical and real markets, four approaches are conceived (see *Table 3*).

	Direct appraisal of OV	**Indirect appraisal of OV**
Obtained responses on hypothetical markets	Variant A: elicitation with open-ended CVM	Variant B: calculation via E(CS) and OP
Observed behavior on real markets	Variant D: elicitation of mobility tools (costs)	Variant C: calculation via Black-Scholes formula

Table 3: Four approaches to the appraisal of OV (for implementation of variants A, B, C, and D, see Table 4)

In the following sections, the four methodological alternatives are briefly presented and discussed. Variant A is regarded as method of choice for detailed analyses of effects of the travel context, the personal context as well as the primary and option mode on option valuation. Variant B serves as a cross-check on whether the open-ended CVM is returning reliable values. Variant C provides a financial benchmark for validation of OV based on a market proxy, and variant D allows for sense-checking of valuations based on actual spending on backups.

4.1 Variant A: direct elicitation via hypothetical market

Variant A is the most direct approach to OV. Individuals are confronted with the (hypothetical) scenario that their primary mode is not available for once. They are then asked to appraise their backup mode with a simple contingent valuation exercise. The question builds on the idea that the backup mode is only available to the individuals if they pay a dedicated base fee in advance. Participants are familiar with this payment instrument, because it exists in the Swiss transport system in the form of subscriptions, licenses, vignettes, memberships, and insurances.

By basing the open-ended question on a real trip (and retrieving the relevant attributes such as purpose, route, modality, etc., see *Table 4*), the scenario is not entirely hypothetical but very close to a (regular) travel situation of the surveyed person. This facilitates individual reflection on realistic valuations as the participant does not need to understand an artificial scenario with a range of contextual variables first. Instead, the individual can focus on the perceived value of the personal backup mode. To ensure an in-depth consideration and gain richer data, several price points are queried at once: a fair, an expensive and a too expensive price. This approach is based on a largely revised version of van Westendorp's (1976) price sensitivity meter (PSM) by Laesser and Reinhold (2010). The queried price thresholds for the monthly fee are based on the idea that they lead to different behavioral responses (cf. Laesser & Reinhold, 2010, p. 8):

- *Fair*: backup would still be used for sure
- *Expensive*: alternative backups would be considered
- *Too expensive*: alternative backup would be used (or trip not done)

Asking for several price points provides an impression of demand curves and price elasticities of demand. In addition to the absolute values, the marginal differences between the price points can be analyzed (Laesser & Reinhold, 2010, p. 10). This approach is expected to mitigate some limitations of CVM. By telling the participants, that the survey is not about the introduction of actual fees but about capturing perceived values, strategic responses are prevented.

4.2 Variant B: indirect calculation via hypothetical market

Variant B is approaching OV indirectly via OP and E(CS), which allows for calculations based on the theoretical definition of OV = OP – E(CS). It is challenging to elicit valid ex-ante (OP) and ex-post (CS) valuations without surveying individuals longitudinally over an extensive period (to eliminate e.g. seasonal effects). However, by retrieving OP and E(CS) in different sections and framings within the questionnaire, consistent values might still be returned – even within one single interrogation. Theory suggests that risk averse individuals pay (or report) OP that is systematically higher than the received (or reported) E(CS). Similar to variant A, the participants are confronted with the scenario that their preferred backup can only be used after a prior payment for access. This (hypothetical) payment takes the form of a surcharge per regular way with the primary mode and thus functions like an insurance premium per trip.

Like in variant A, individual replies are based on actual travel behavior. WTP to quantify OP is (again) captured by letting individuals reflect on a fair, expensive, or too expensive surcharge, which guarantees mobility with the backup mode (without covering the costs of the actual trip). CS is retrieved via separate question on the maximum WTP per backup trip ($WTP_{max b}$). Calculating both OP and E(CS) on a monthly basis allows for reliability checks with the results from variant A: $OV = ([WTP_{max p} - P_p] \cdot n) - ([WTP_{max b} - P_b] \cdot n \cdot E)$

- *Ex-ante*: What is the accepted surcharge per trip to have a backup option if needed? OP per month calculated with # of (planned) trips (n) and OP per trip ($\triangleq WTP_{max p} - P_p$)
- *Ex-post*: On how many trips is the backup mode expected to be used and what is its CS? E(CS) per month calculated with # of trips (n), expected use (E) and CS ($= WTP_{max b} - P_b$)

The dedicated column (variant B) in *Table 4* contains the crucial variables for this approach. However, besides comparing the resulting OV with the appraisal from variant A, the effect of all the other variables (purpose, route, modality, etc.) on OV can be analyzed separately with these results, too.

4.3 Variant C: indirect calculation via real market

Variant C is rooted in finance and provides a mathematical benchmark to further validate the retrieved values from variants A and B. The approach is based on the analogy between a call option in finance and a backup mode in transport as described by ECO Northwest (2002, p. 31). A call option entitles the owner to purchase a specific good at a specific price and volume at a point in the future. Similarly, a transport link provides residents with an option they can use at a specific price and frequency, if desired. Interestingly, the basic model on the valuation of options by Black and Scholes (1973) can (with some assumptions) be transferred to the travel context (see also *Appendix*). However, there is no known example of an actual application of this method. It is therefore suggested here as a further variant to calculate OV indirectly and offer another indication for valuation, based on the idea of real (and rational) markets.

- *S: underlying price (e.g. price per share);* here: costs per trip with primary mode
- *X: strike price (e.g. price per share at execution);* here: costs per trip with backup mode
- *σ: volatility of S (in % p.a.);* here: volatility of costs (incl. time value) of primary mode
- *t: time to expiration (% of a year);* here: frequency of option use per year

With the assumption of *standard normal distributions (N)* and a *given risk-free interest rate (r)*, the (theoretical) market value for a backup mode can easily be calculated financially. However, it is important to include the full marginal costs of both primary (S) and backup mode (X), which means that all costs incl. travel time, search time, fuel costs, road toll, parking fees, etc. need to be considered ($S_t + S_p$; $X_t + X_p$). The volatility of the primary mode (σ) can be calculated based on the regular travel time (σ_1), average delays (σ_2) and frequency of delays (σ_3). The relevant variables for the approximation of costs and volatility can be found in the specific column (variant C) in *Table 4*. A backup mode is only of value, if it is available at reasonable costs (usually a bit more costly than the primary mode) and if the volatility (of the costs) of the primary mode are sufficiently high to require this kind of hedge.

4.4 Variant D: direct elicitation via real market

Variant D is another approximation of OV via real market data, but it elicits the values directly by analyzing mobility tools purchased by the individual or household that provide it with transport backups. Such market transactions include subscriptions for secondary modes, purchases of second vehicles, as well as mobility insurances (see also *Appendix*). By limiting uncertainty (or volatility) of transport costs, such market-based offerings incorporate some OV. By querying and approximating actual expenses on transport options (see column for variant D in *Table 4*), further sense-checking of stated values from variants A and B is possible.

- *Proprietary (second) vehicles*: having a second car can be a maximum option (with its price tag – considering depreciation, etc.) that is instantly available at almost all times.
- *Sharing subscriptions (e.g. Mobility Carsharing)*: can be an attractive option that gives access to shared vehicles within a certain amount of time and at a predictable price.
- *Public transport subscription (e.g. SBB Half Fare Travelcard)*: can be a valuable option that limits the maximum volatility of transport expenses (at e.g. 50% of the full price).
- *Mobility insurance (e.g. TCS Assistance or Membership)*: can be a cheap but still reliable option – with a certain waiting time if the option (assistance) is to be called.

By retrieving the related attributes, e.g. regarding full costs of a second car (annual stand by costs, F_p via F_1 and F_2), certain approximations and sense-checks are possible (however, the value of cars can also include motives such as prestige and is therefore not purely OV).

5. Questionnaire

The objective of this study is to design a survey tool that allows for a comprehensive investigation of perceived OV in passenger transport. The suggested instrument is therefore able to incorporate different approaches to OV appraisal (A, B, C, D, see *Methodology*). Furthermore, additional variables are included to allow for a detailed understanding of OV.

Section	Variables	Variant A	Variant B	Variant C	Variant D
Travel context (normal case)	Purpose of regular trip (actual trip)				
	Frequency of regular trip (actual trip)		n (# of ways)		
	Modality				*f/g/h*
	Travel time (duration)			S_t, σ_1 (cost of t)	
	Price (primary mode)		P_p	S_p (per way)	
	Places (from _ to _)			*S_1, X_1 (km)*	
Primary mode	Quality (service/vehicle)			*S_2 (cost/km)*	
	Consumer surplus (primary mode)				
	Risk of delays			σ_3 (of n ways)	
	Average delays			σ_2 (cost of t)	
	Demand uncertainty (alternative wanted)		*p (of n ways)*		
	Substitutability (available alternatives)				
Option scenario (backup case)	Modality (main backup mode)				F/G/H/I
	Expected use (frequency)		E (of n ways)	T	
	Supply uncertainty (of backup)				
Option mode	Quality (service/vehicle)			*X_2 (cost/km)*	$F_2/G_2/H_2$
	Time to access or headway				
	Hours of operation/availability				
	Travel time (with backup)			X_t (cost of t)	
	Price (of backup)		P_b (per way)	X_p (per way)	$F_p/G_p/H_p/I_p$
Option valuation	Option value	OV (monthly)			
	Option price		OP (per way)		
Option demand	Consumer surplus (backup)		CS (per way)		
	Min. required time to access or headway				$a_{(F \leq H \leq G \leq I)}$
	Min. required hours of operation/availability				$o_{(F \leq G \leq I \leq H)}$
	User group of option mode (use in general)				$F_1/G_1/H_1$
	Purpose of option mode (use in general)				
	Attitude (towards backup mode)				
Personal context	Risk propensity		r		
	Gender				
	Year of birth				
	Education				
	Profession				
	Owned vehicles (personal/household)				*f*
	Mobility membership (Sharing scheme)				*g*
	Travelcards (SBB Half Fare Card, etc.)				*h*
	Insurance (TCS Assistance, etc.)				*i*
	Household size				
	Housing (rental/owned)				
	Household income				

Table 4: Proposed survey instrument for eliciting and analyzing OV based on relevant variables from literature

*Abbreviations and variables in the columns of variants **A**, **B**, **C**, and **D** are introduced in the section Methodology; in italics: alternative variables; **A**: none; **B**: $p \cong E$; **C**: $S_1 \cdot S_2 \cong S_p$; $X_1 \cdot X_2 \cong X_p$; **D**: $a \cap o \Rightarrow f/g/h/i \cong F_p/G_p/H_p/I_p$ (p.a.)*

The suggested questionnaire builds on actual travel behavior of the participants and starts by asking for the relevant attributes of the **travel context** (normal case) of a regular trip: *Think of a specific trip that you regularly make. It can be a way to work, school, shopping, or for leisure purposes within Switzerland. Put yourself in the specific situation and answer all the following questions for your chosen route.* The surveyed variables include purpose, frequency, modality, duration, price (perceived costs), and start-/endpoint of the trip. In the following section, the properties of the **primary mode** are collected. Therefore, the quality of the service or vehicle, the risk of delays as well as the average delays, the demand uncertainty, and the substitutability of the primary mode are queried.

In the subsequent section, the **option scenario** (backup case) is introduced: *Suppose your normally used transportation option for the specified route is not available today. There may be a one-time or temporary problem: bad weather, congestion reports and traffic disruptions, vehicle breakdown, injury, and inability to drive, license revocation, or other imponderables.* The participants are asked for their main backup mode, their expected frequency of use and the supply uncertainty of the specific transport alternative. Furthermore, characteristics of the preferred **option mode** are collected. This includes the time to access the vehicle or the headway of the service, the availability of the vehicle or the hours of operation, the travel time with the backup mode, and the price (perceived costs) of the backup per way.

The actual **option valuation** forms the core section of the survey: *Assume that your transport alternative used for the specific route is only available upon prior payment of a special fee – similar to a type of subscription, license, vignette, membership or insurance.* The OV is elicited directly via WTP for a (hypothetical) monthly base fee (quasi license or membership). With an alternative valuation question, the OP is retrieved via WTP for a (hypothetical) additional fee that needs to be paid per regular trip with the normal mode (quasi insurance premium for access to the backup mode). These questions are complemented by a section on the **option demand**, starting with CS, which is retrieved via maximum WTP per backup trip. Furthermore, minimum requirements regarding access or headway and hours of operation or availability are collected. Finally, utilization of the option mode for other than the specified route and purpose, as well as the individual attitude towards the backup mode are captured. The survey is then concluded with a section on the **personal context**, including individual risk propensity, sociodemographic variables, and mobility instruments of the individual and/or household.

6. Discussion and Outlook

The developed survey instrument aims at investigating perceived OV in passenger transport. It includes all the relevant variables (see *Table 4*) according to theoretical work on OV and based on insights from explorative work on passenger transport abroad. A detailed discussion of the underlying hypotheses is beyond the scope of this paper. However, key assumptions such as the (expected positive) relation between risk aversion and option valuation have been discussed in *Theory* and *Methodology*. It will be important to also investigate the effects of all the other variables such as trip purpose, travel time, or mode types on the option valuations – and also compare it to insights from studies on use valuations (e.g. Weis et al., 2020).

The design of the questionnaire with contingent valuation exercises and all the questions on travel context, primary mode, backup mode, and personal context have been pre-tested already. A small sample of participants with various backgrounds and travel patterns have been observed during and interviewed after the completion the survey. This procedure allowed for multiple iterations and the setup of a viable online questionnaire, which is administered via the *Unipark* web application. After validating the functionality of the instrument with a larger (student) cohort, the online survey will be distributed to a representative sample in (German speaking) Switzerland. A link to the pre-test version can be found in the *Appendix*.

Bishop (1982, p. 14) was right when he described the concept of OV as intuitively appealing but theoretically and empirically challenging. It is surprising to see that the Swiss Federal Railways (SBB) ran ads in the 1960ies that promoted the Half Fare Travelcard (Halbtax) as an option instrument for bad weather scenarios (cf. cover images of this paper). This is especially astonishing, when considering that the true option component of such offerings has never been explored. It will be interesting to see the extent to which the conceived fourfold methodological approach will be able to contribute to closing this gap. Knowing the OV of certain transport service levels is not only interesting for the conception and adjustment of payment models that incorporate some OV. Instead, it can also provide interesting insights regarding the introduction of new mobility services such as autonomous buses or last mile services that can serve as valuable backups with potentially significant option value.

Appendix

The pre-test survey (in German) can be found under the following link: *https://bit.ly/optionvalue*

Feedback from pre-testers is very welcome.

Background info on variant C (indirect calculation via real market)

Illustration of the logic and variables of the Black-Scholes model for option pricing:

Option Value: $C = S \cdot N(d_1) - X \cdot e^{-rT} \cdot N(d_2)$, with

$$d_1 = [ln(S/X) + (r+\sigma^2/2)T] / \sigma\sqrt{T} \text{ and } d_2 = [ln(S/X) + (r-\sigma^2/2)T] / \sigma\sqrt{T} = d_1 - \sigma\sqrt{T}$$

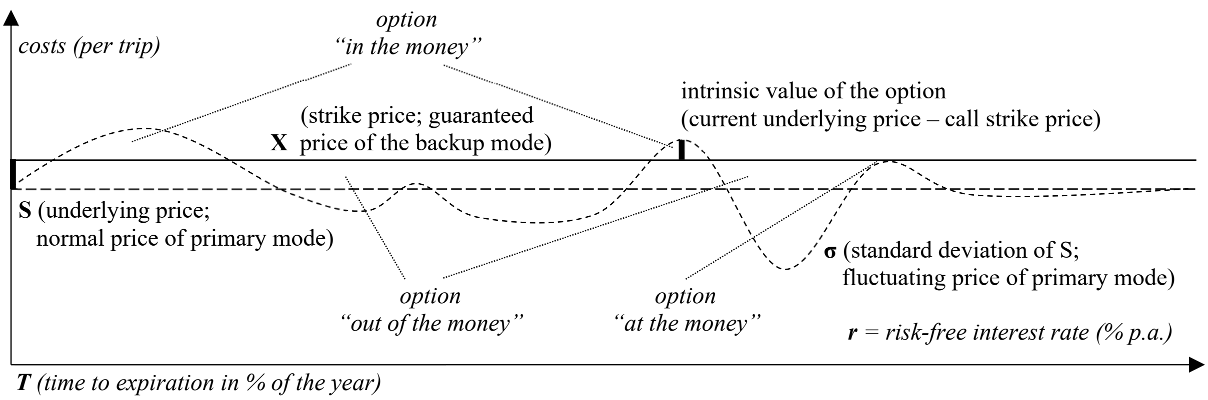

Table 5: Simplified visualization of option pricing with S (price of primary mode), X (price of backup), σ (volatility of S)

Background info on variant D (direct elicitation via real market)

Selected examples of market proxies (existing offerings with a certain option component):

Mode	***Public***	***Shared***	***Owned***
Organization	**Swiss Federal Railways**	**Mobility Carsharing**	**Touring Club Switzerland**
Offering	*Half Fare Travelcard*	*Annual Subscription*	*Annual Membership*
Annual fee	CHF 165	CHF 129	CHF 93
Price per km and hour	CHF 0.10–0.22 / km	CHF 0.55–0.95 / km + CHF 2.00–4.00 / h	CHF 0.50–0.90 / km
Note	Cost of the ticket depends on subscription, class, distance and fare zones	Cost of the ride depends on subscription, type of vehicle, distance and duration	Cost of the trip depends on the type of the own vehicle and the distance travelled
Value proposition	50% off standard fares on all Swiss Federal Railway routes and most other public transport in Switzerland; incl. further benefits/discounts	Access to >3000 cars throughout Switzerland; various rental and service models bookable (return, one-way, spontaneous); includes CHF 30 credit	365d/24h roadside assistance in Switzerland, 620 patrollers/garages, waiting time Ø 35 min, onward journey/transport guaranteed; incl. further advantages

Table 6: Examples of market offerings with option component in transport (sources: sbb.ch, mobility.ch, tcs.ch, 2021)

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