Experiences from the German value of time (VOT) and value of reliability (VOR) study

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Abstract

Germany's Federal Ministry of Transport and Digital Infrastructure (BMVI) is currently preparing the 2015 Federal Transport Investment Plan (BVWP). As part of this, it is updating the overall methodology including the cost-benefit analysis (CBA), which is used to evaluate the effects of hundreds of German infrastructure projects. The paper presents the survey of the first official estimation of the values of time (VOT) and values of reliability (VOR) for personal and business travel for Germany. The VOTs will replace a set of existing values, which were based on values from BVWP'92. The VORs were estimated for the first time, as they are not incorporated in the standard appraisal yet. This paper gives inside on the survey design, reports experiences made in the field phase and analyses the response behaviour of the participants. It shows that a rich dataset has been collected which builds the basis for further modelling.

Keywords

Value of time, value of reliability, revealed preference, stated preference, non-business travel, business travel, response behaviour, non-traders

Preferred citation style

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1. Introduction

The German Federal Ministry of Transport and Digital Infrastructure (BMVI) is currently preparing the 2015 Federal Transport Investment Plan (BVWP), its medium to long-term investment strategy for the country's transport infrastructure serving longer distance travel (Bundesministrium für Verkehr und digitale Infrastruktur 2014). As part of compiling the new BVWP, the BMVI is updating and modernizing the overall methodology of its central evaluation tool: the cost-benefit analysis. For hundreds of infrastructure projects the effects of transport policies and investments are evaluated with individual CBAs. An on-going project is focusing on the CBA, while as such and a second is estimating and recommending values of travel time (VOT) and reliability (VOR) for personal and business travel. While the new VOTs will replace a set of existing values which were based on values from BVWP'92 and had not been verified independently since then, the VOR will be estimated for the first time as they are not incorporated in the standard appraisal yet (Bundesregierung 2003). On this account a research team around the IVT of the ETH Zurich is estimating the valuation for VOT and VOR for the BMVI (Axhausen et al 2014), which is also the basis of this paper.

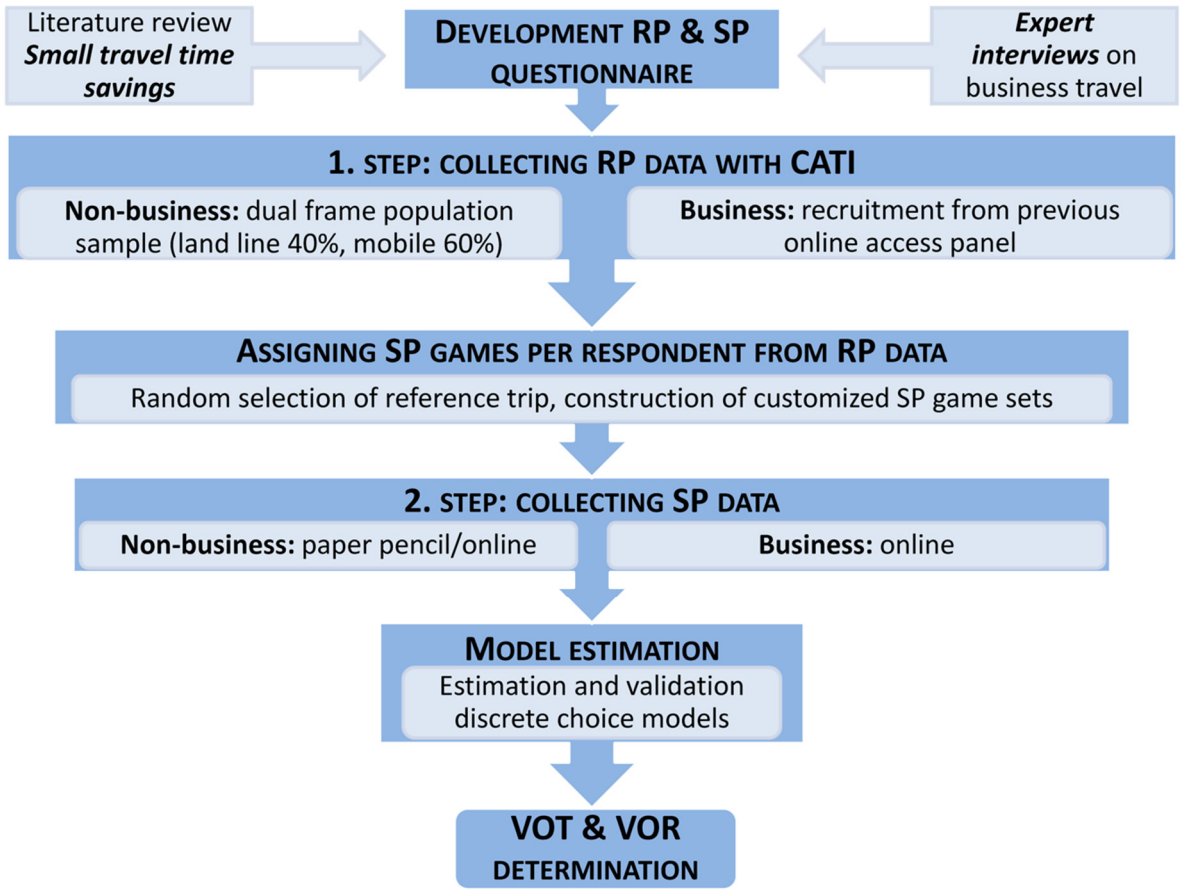
Often travel time savings have the largest share in gains on the utility side of CBAs (Mackie et al. 2001). Micro-economic models of time allocation have been used to derive the valuations of technologically constrained time use since the work of Becker (1965), Beesley (1965) and De Serpa (1971), where the main focus is on the value of travel time. The current state of practice draws largely upon past British, Dutch and Scandinavian studies (Wardman, 1998; Abrantes and Wardman, 2011) which in time moved from revealed preference (RP) data to a growing reliance on personalized stated preference (SP) experiments to estimate the VOT and VOR by using suitably formulated discrete choice models of travel behaviour, especially of route and mode choice. The individualized stated choice survey is the established approach (e.g. Small 2012). The design of the present study builds on the experience of studies in Switzerland (Axhausen et al., 2004 and 2008; Weis et al., 2012; Fröhlich et al., 2012), which had further developed international practise by employing more complex stated choice experiments including multiple modes and multiple elements of the generalised costs of travel in a series of overlapping choice contexts. This paper presents the design of the German VOT study in detail. Further it will report experiences made during the study's field work and analyse the response behaviour of the participants.

2. Study design

After the pre-test in May the two-step survey was carried out in six subsequent waves from July to September 2012. On the basis of the revealed preference (RP) data collected, a stated choice (SC) questionnaire was designed in a second step. The SP experiments include mode choice, route choice and reliability experiments. In order to allow the process for cross-checking of the results, the approach was further expanded to include long term choice contexts, which also involve travel as an element (residential and work place location choice). The BVWP requires estimates for both private and business travel. As business travel is concentrated in a small share of the population, it was necessary to recruit a complementary

sample in addition to a population based (non-business) sample to obtain a large enough number of cases. Figure 1 shows the protocol of the study.

Figure 1: Protocol of the study



Furthermore business travellers are sometimes not free to choose the mode or even the route of their travel due to company policy and thereby invalidate the SP experiments. This was checked beforehand by conducting a small-scale qualitative interview survey. 24 decision makers had been recruited to cover the main regions of Germany as well the range of firm sizes. The result was that many firms indeed had policies in place but employee's constraints are often more of a higher general order than a direct regulation by the decision makers and they were free to choose their routes and in the vast majority also the mode of travel, allowing for the continuation of the SP study without having to fear a major bias in the results.

The population based non-business sample was drawn from a dual frame of land-line and mobile numbers (60% and 40%) to ensure that the growing share of mobile only persons are included. It was incrementally controlled over the survey period so as to ensure the spatial quotas in terms of the German federal states. This is based on an ITMS-Double frame and recommended by recent German market research studies (ADM 2012). The additional sample of business travellers was recruited with an online access panel.

In line with international practice in a first step data on recent trips performed by the respondents was collected. The RP trips are obtained as the three trips to the workplace, the most important shopping and/or leisure destinations. Also information on the last long-distance trip over 100 km distance was collected, where, if the latter was ground-based, data on the most recent air trip was also collected. The rationale behind the approach is based on the observation that the bulk of a person's everyday travel is to a very small number of destinations (Schönfelder and Axhausen, 2010), so that a good range within a relatively short computer assisted telephone interview (CATI) can be achieved. Business travellers reported their last three business trips. The CATI geocoded the destinations and the route using Trip Tracer (DDS GmbH, 2013). The trip information was complemented with the usual socio-demographic information and information about mobility tools. The reference trip of a respondent was chosen randomly but aiming at an overall share of about one third long-distance trips and two-thirds daily trips, so the reference trip was selected with a bias to longer trips given their rarity and the interest of the BVWP in intercity travel. This selection was corrected in the analysis through a reweighting to match the distance-purpose distribution observed in the most recent German national travel diary survey (MID 2008, see Follmer et al., 2010). In the business sample the most recent trip became the reference.

The SP experiments were constructed around the reference trip. Information about the non-chosen options were added. The non-chosen alternatives and their attributes were based on information from a number of resources. Door-to-door travel times from a MATSim[1] implementation based on the average travel times reported by Tom-Tom Stats® and a NavTeq® – network for Germany. The travel times on public transport were obtained from relevant websites.

Respondents received three different SP experiments in the general case, and two if the reference trip was a business trip. Each type of SP experiment contained 8 situations where the respondent had to choose between three modes or two route alternatives, workplace or residential alternatives. The modes offered were walking, cycling, car, local public transport (PT) and the various long distance public transport modes: train, air and the newly deregulated coach option. By that time the lack of familiarity with the coach as a scheduled long-distance alternative resulted in unreliable estimates and no results for the coach option will be reported. In total, respondents were offered between 16 and 24 choice situations. The SP questionnaires included additional attitudinal questions. Both samples received the SP experiments within a maximum of two weeks of having participated in the CATI. The business trip sample responded via a web-based survey system. The non-business sample could respond in a paper-and-pencil form or as well in a web-based survey.

Table 1 shows the allocation of the 18 different SP experiments for the non-business sample. The design of the business sample was basically the same only without the long-term experiments residential and work place location choice.

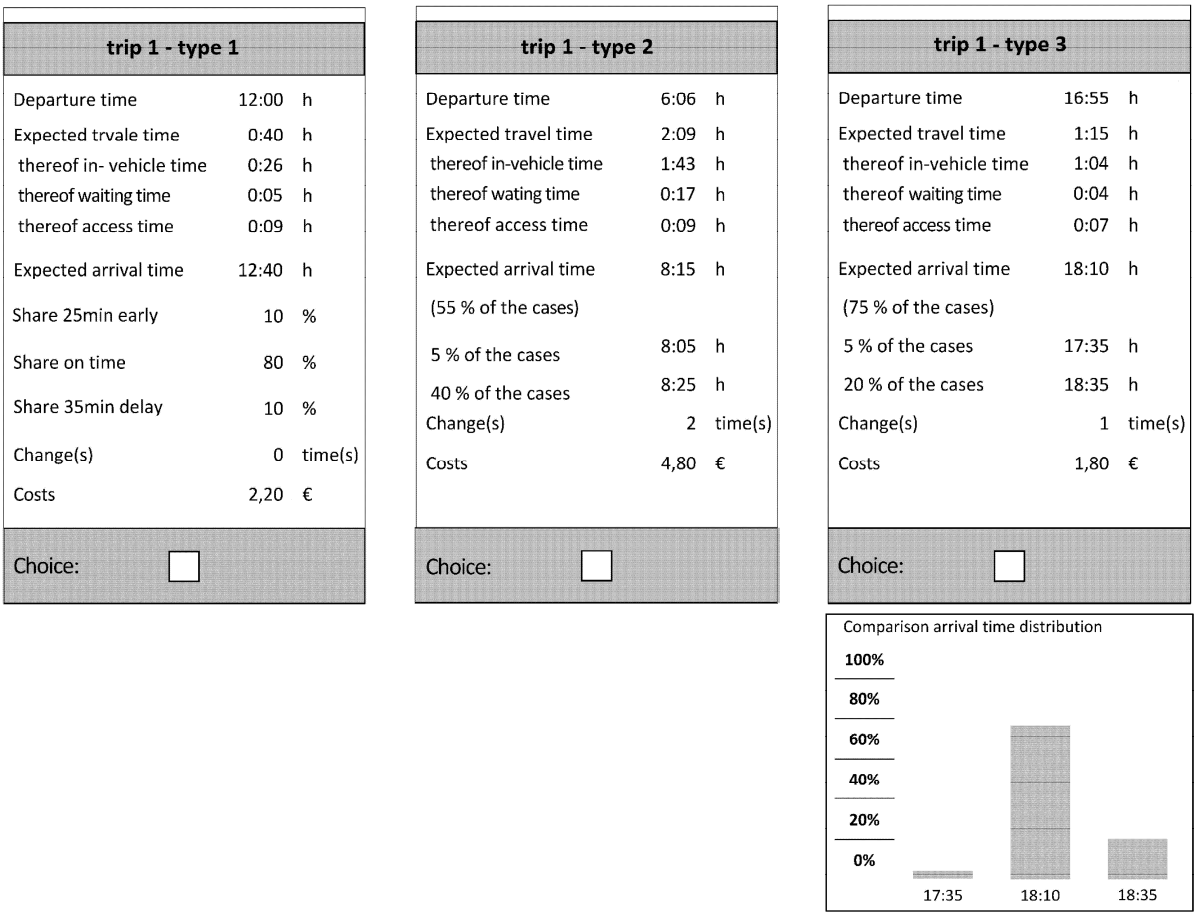
[1] Multi-Agent Transport Simulation, see www.matsim.org.

Table 1: Allocation of the SP experiments (non-business sample)

From RP		SP experiments allocated				
Reference trip	Reported mode	Mode choice	Route choice	Route – departure time (reliability)	Long term	Nr.
Daily travel	Walk	Walk/ PT / Car	-	-	Work place	1
	Walk	Walk/ PT / Car	-	-	Home location	2
	Bicycle	Bicycle / PT / Car	-	-	Home location	3
	Bicycle	Bicycle / PT / Car	-	-	Work place	4
	PT	Bicycle / PT / Car	-	PT type 1	Work place	5
	PT	-	PT	PT type 2	Home location	6
	Car	Walk/ PT / Car	-	Car type 1	Home location	7
	Car	-	Car	Car type 2	Work place	8
Long-distance	PT	Coach / PT / Car	-	PT type 3	Work place	9
	PT	-	PT	PT type 1	Home location	10
	Car	Coach / PT / Car	-	Car type 3	Home location	11
	Car	-	Car	Car type 1	Work place	12
	PT	PT / Car / Air	-	PT type 2	Work place	13
	PT	-	PT	PT type 3	Home location	14
	Car	PT / Car / Air	-	Car type 2	Home location	15
	Car	-	Car	Car type 3	Work place	16
	Air	PT / Car / Air	-	Air type 1	Work place	17
	Air	PT / Car / Air	-	Air type 2	Home location	18

The reliability experiment was formulated as route-departure time choice with an indication of travel time variability. Three formats of different complexity were tested, but each allowing to estimate the mean-variance model of scheduling. All three formats were retained after the pre-test, as it indicated no clear preference between them in spite of their growing complexity. Figure 2 shows the three different presentation types of reliability using the example of public transport whereas each column represents one type of experiment.

Figure 2: The three different types of reliability presentation



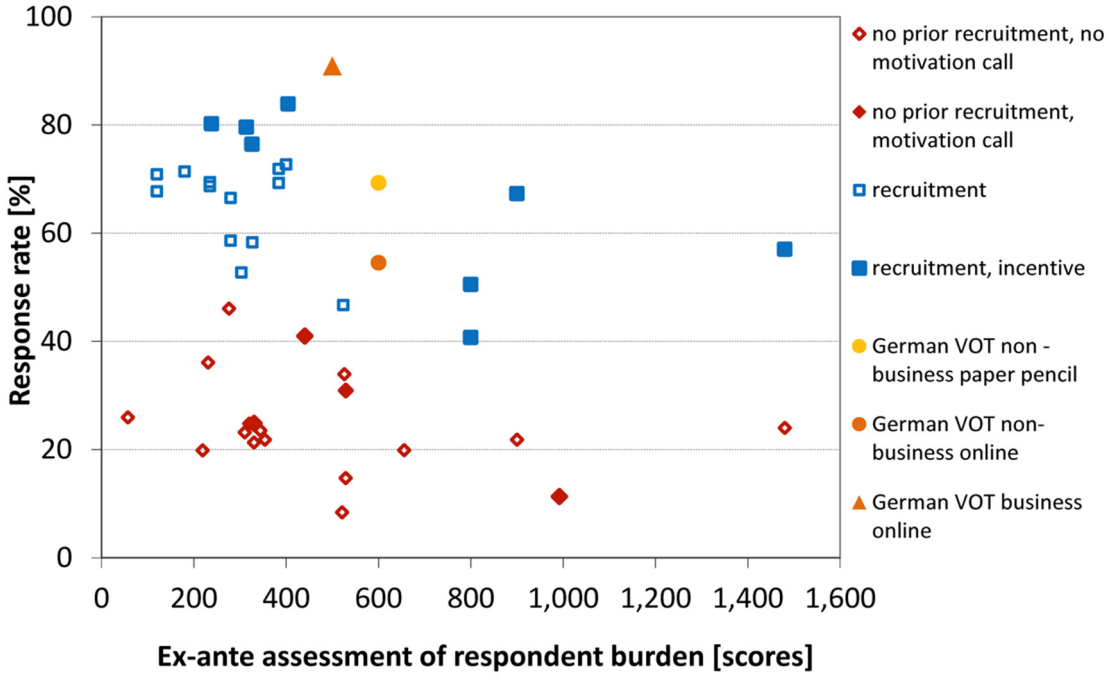
The travel time reliability was varied by providing different congestion probability and average congestion times (delay) for automobile travel and by providing the probability of delays (in minutes) from scheduled arrival time for public transport travel (delays were a percentage of the specified tolerance from the RP survey). Furthermore the mode choice experiments included the share of delayed arrivals and the route choice experiments the share of trips delayed.

3. Response behaviour

Before sending out the SP game sets of the first wave the expected response rates for the paper-pencil and online non-business and business sample were predicted following Axhausen and Weis (2010) and compared to other surveys already conducted at the IVT (see Figure 3). All

three actual rates settled in the expected range. Finally the response behaviour was even better than the IVT Swiss value of time experiences.

Figure 3: Response burden and AAPOR response rates



A recruitment rate of over 30% for the CATI interview and 75% completion rate for the first phases and response rates of 73% and 93% for the second phases in spite of the complexity of the instruments indicate a strong interest in the topic.

In the RP survey almost 4,000 persons completed the questionnaire providing socio-demographic characteristics and information on recent trips. The data was controlled so that there was a sufficiently large sample of responses for all trip purposes.

Including the pre-test data about 2'300 non-commercial and 790 commercial-trip respondents completed the full questionnaire including all SP games provided to them. Hence the sample contains almost 64,500 choice observations. Figure 3, and Table 2 show that the response rate of the commercial study is overall higher than in the non-commercial study as participants were recruited in a business market research online panel.

Table 3 gives an overview about the distribution of the number of fully completed choice sets by sort of the experiment and sample. Beside the overall numbers between the business and non-business sample the completed experiments are distributed more or less evenly as the reliability experiments are also route choice games the total number is even higher than the mode choice sets. Nevertheless sufficient data for all five types of SP experiments was collected.

Table 2: Response behaviour of the samples in the main study

	non-business sample	business travel sample
Contacts	9,491	1,112
Completed computer assisted telephone interview (CATI) (RP)	3,151 (33.2%)	848 (76.3%)
Indicated willingness to participate written SP experiments	2,965	--
Indicated willingness to participate online SP experiments	186	848
Completed written SP experiments	2,187 (73.8%)	--
Completed online SP experiments	98 (52.7%)	786 (92.7%)

Table 3: Number of completed SP games by type of experiment

	non-business			business			total		
experiment	**SPs**	**Pers.***	**response in %**	**SPs**	**Pers.***	**response in %**	**SPs**	**Pers.***	**response in %**
mode choice	12,339	1,631	67.6	3,439	431	90.8	15,778	2,062	71.3
route choice	5,796	748	71.4	3,258	408	91.1	9,054	1,156	77.4
reliability	14,536	1,938	68.3	6,695	839	90.9	21,231	2,777	73.9
workplace	9,584	1,225	70.6	--	--	90.8	9,584	1,225	74.3
residence	8,682	1,159	66.9	--	--	91.1	8,682	1,159	72.1
total	50,937	6,701	68.3	13,392	1,678	90.9	64,329	8,379	73.2

* max. 3 SP experiments per person

Figure 4: Response by sample, medium and wave

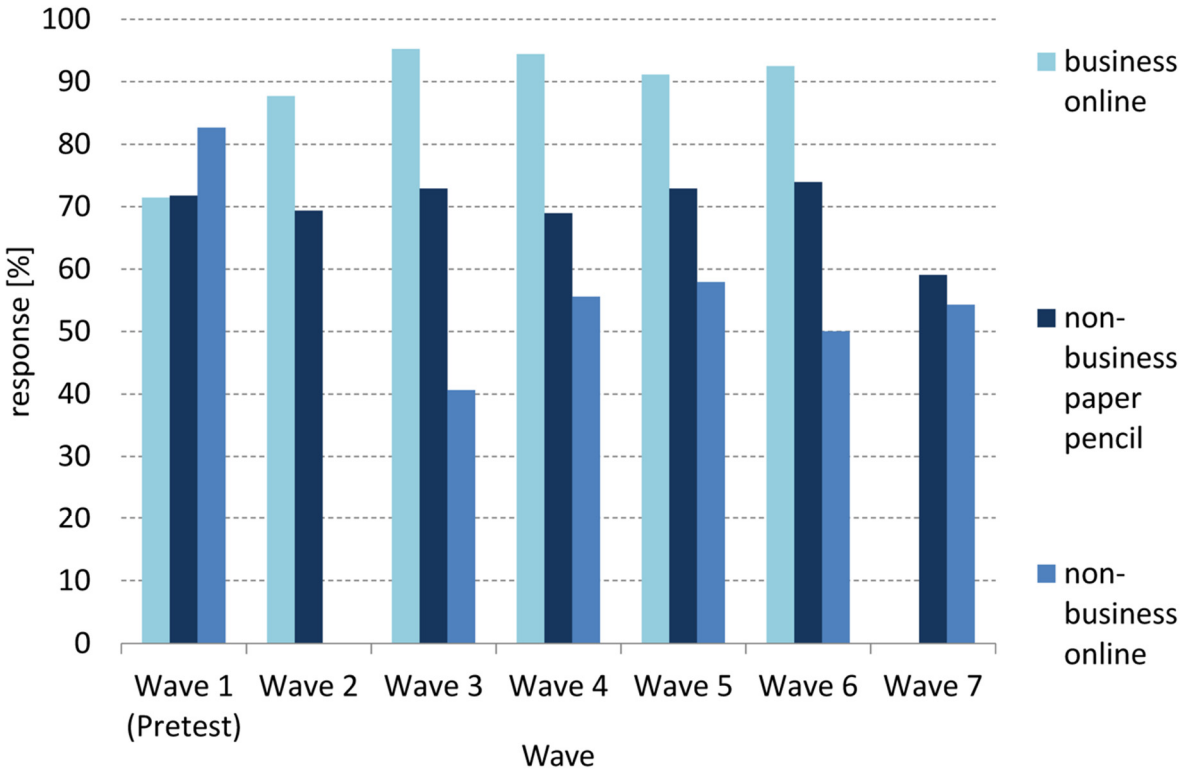
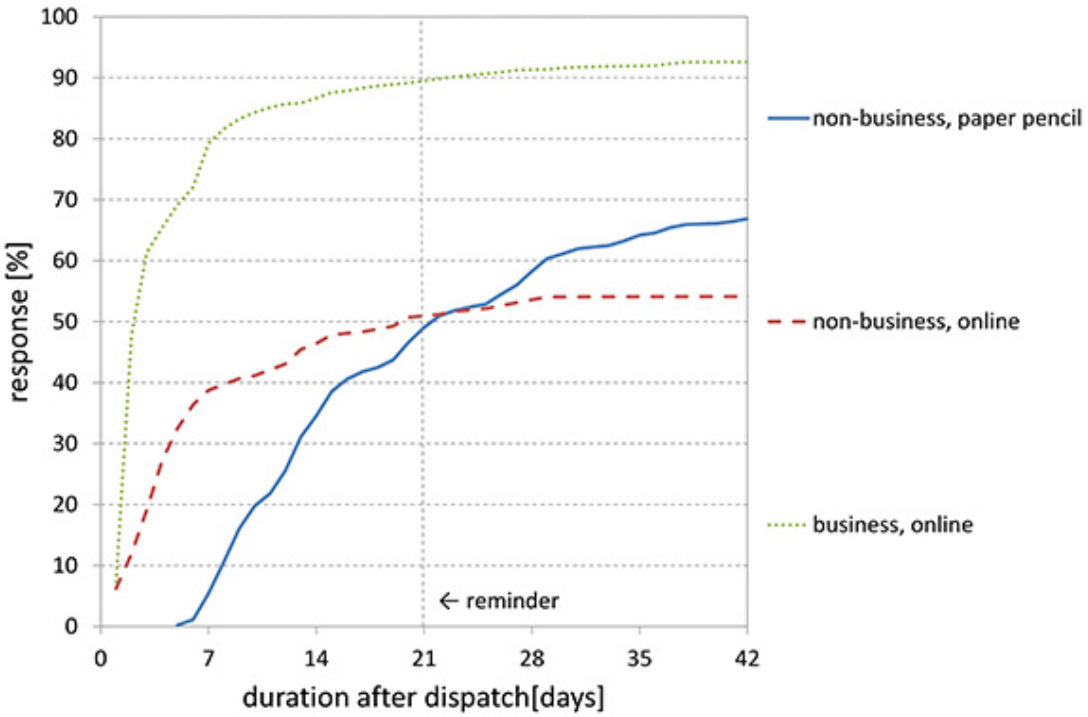


Figure 4 shows the response rates of the single waves by sample and medium. As mentioned above respondents in the business sample have an overall higher response rate (except in the pre-test). The aimed-for number of participants in the business study was already reached after wave six so that in the seventh wave only non-business SP game sets were send out. In the non-business survey respondents were free to choose between completing the questionnaire online or as paper-and-pencil. From almost 3200 respondents who indicated their willingness to participate in the SP experiments only 5.6% or 186 person in total chose to complete the questionnaire online. Hence the response rate of the online non-business sample varies more than the other samples' rates as it is total number is much smaller. In any case the response rates in that sample were the lowest.

To complete the full online SP questionnaire respondents in the business sample needed between 1.3 and 43.8 and on average 9.4 minutes. Participants in the non-business survey needed more time, taking between 5.1 and 58 and on average 17 minutes to fill in the survey questionnaire. Nevertheless the absolute number of respondents of the non-business online SP survey is about ten times smaller than the absolute number of participants in the business online access panel.

Figure 5: SP response time in days

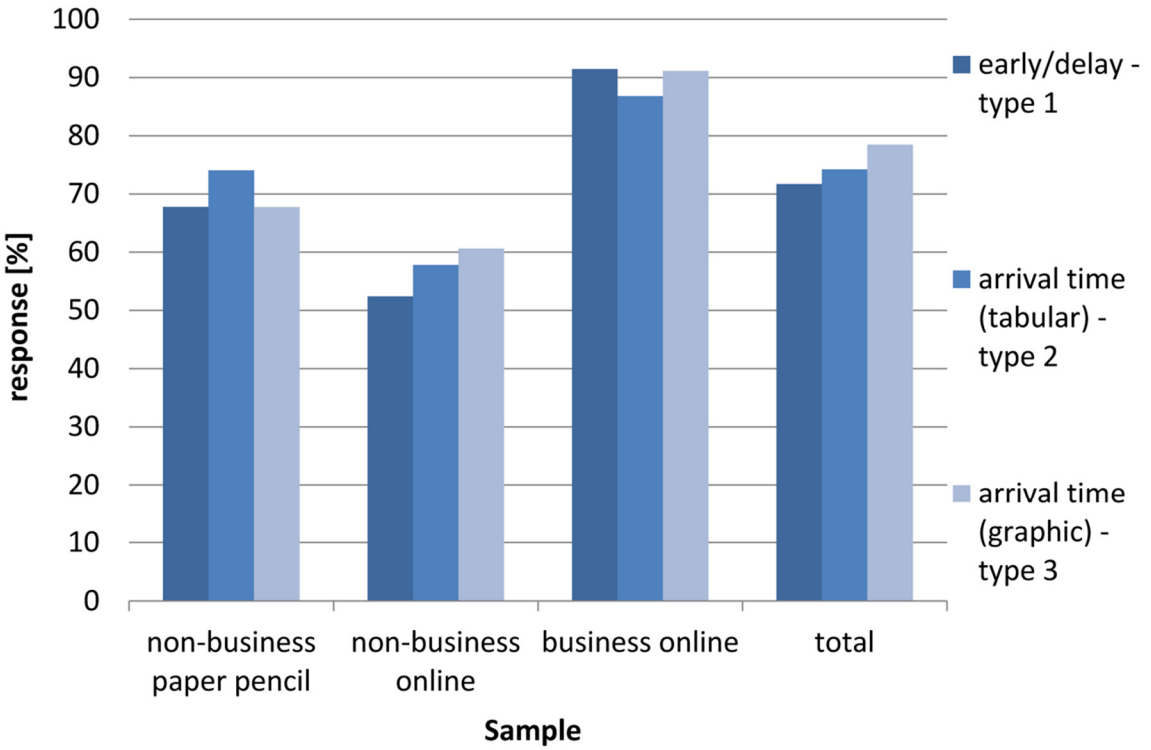


Within two weeks after participating in the CATI respondents received the SP games and the overall time it took them to send back the questionnaires was recorded. Those who did not answer within 21 days after the send-out received a reminder by that time. Figure 5 shows that the reminder had only little impact in the two online-surveys but did so in the paper pencil one.

Responses to the two online samples were faster than in the paper pencil survey. Over half of the respondents of the online business sample answered within two days. After one week 80% of respondents had already completed the SP games. The reminder had almost no effect as responses did not increase after it was send out. In the non-business sample half of the respondents took a maximum of 4 days to answer the SPs. Most of the respondents (80%) answered within 14 days. The reminder increased responses by about 2%.

Sending questionnaire by post and back takes more time in general than answering an online survey. First completed SP arrived after 5 days and half of the questionnaires were send back within two weeks. The reminder sent after 21 days motivated an increase between 15% and 20% additional responses after an additional time interval of about four days. 80% of the questionnaires arrived within 28 days. So it took the respondent almost the twice the time to complete the written questionnaire however not including the additional time by sending it through post. The last questionnaire arrived after 151 days.

Figure 6: Response by presentation of reliability

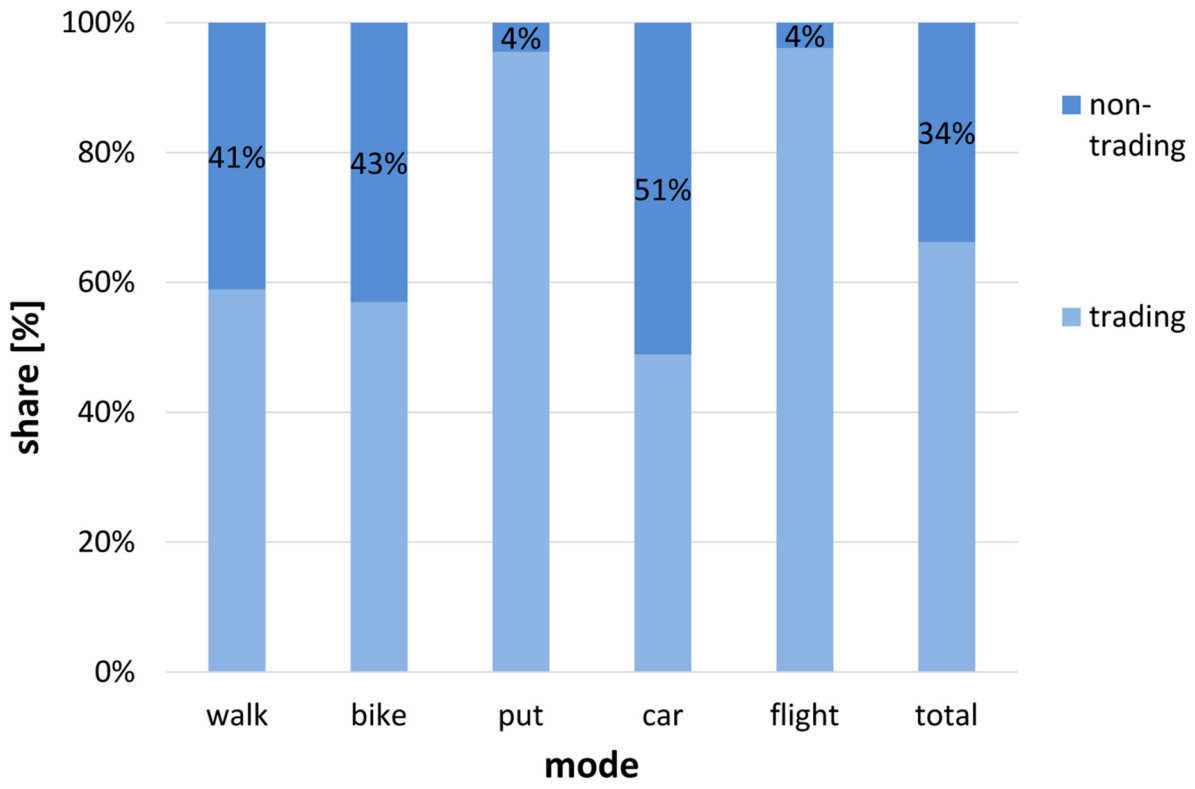


Besides experience from the pre-test the main study confirmed that all three types of reliability presentation obtained equally high response rates (see Figure 6). Between the presentation types no clear pattern is recognizable. In the written paper pencil non business survey the reliability presentation type 2 got the most responses whereas respondents in the non-business online survey responded best to type three presentation of reliability. Type one turned out to gain most responses in the online business survey whereas in total the difference between type 3 and type one is about 6%. If one has to decide between the different presentation types it seems reasonable to prefer a graphical presentation of reliability so that it easier for respondents to understand the experiment.

Non-traders in a stated preference survey are respondents, who always chooses the same alternative across their choice sets regardless of the available alternatives' attributes. This may have several reasons, one of which is the presence of extreme preference in the context of utility maximisation. Other reasons could be picking the same alternative for every situation in order to reduce boredom or the misunderstanding of the questions. In the German VOT study in total 34% of the respondents never varied their choices in the mode choice experiments (see Figure 7). Differentiated by mode it can be seen that that share of non-traders is higher for car user and persons of the non-motorised transport whereas public transport user are more willing to vary their choices. Non-trading does not necessarily imply inconsistent responses. Hence, the relevant variables, such as trip distance and purpose and the availability of mobility tools were included in the modelling process rather than excluding non-traders.

In the long-term workplace choice experiment the share of non-traders was at about 43% from which 14 % were always choosing the new workplace. In the residential location choice experiment the share of non-trader was a bit higher with 51% whereas only a share of 7 % always choose the new residence alternative. Overall the share of non-traders was in the expected range. In the route choice and reliability experiments the focus trip was randomly varied so we could not be distinguished between non-chosen and chosen alternative.

Figure 7: Non-traders mode choice experiment



Another important issues for a survey is item non-response, which means that respondents do not answer to a particular unit among the questions. In social sciences these are often sensitive private information like income or education. The German VOT study showed only minor problems with item non-response, most of the missing value were less 3%. Only the questions about education and children living in the household had a share of missing values higher than 15%, but where more or less covered by other questions, for example as the number of persons living in a household or the profession of the respondents (less than 1% missing values). However, the variable household income which was essential for later modelling and usually is also one of the more sensitive questions showed an item non-response rate of only 2.5%. All other variables in the survey not shown in Table 4 had item non-response rates less than 2 %.

Table 4: Item non-response over 2%

	don't know	don't say	missing or zero	total	share
graduate yes/no	302	2	1,881	2,185	50.9 %
# children < 14	0	0	838	838	19.5 %
# children < 18	0	0	837	837	19.5 %
education	3	8	668	679	15.8 %
household income	0	0	107	107	2.5%

4. Conclusions

In the German VOT study new survey methods were applied for estimating new values of time and for the first time values of reliability to support the Federal Transport Plan 2015. This first official estimation required special accuracy in the data collection process. Using a combined RP and SP survey reflects the state of the art of transport research.

This paper presented the experiences made during data collection and preparation for further model estimations. It was shown that the collected data set comprehends rich information with a promising amount of cases suitable for the calculation of short as well as long-term willingness to pay values. Each type of SP experiment includes enough cases to estimate single models per experiment as well as a joint model with all short-term games. The response rates were in the expected range, although especially the business online sample exceeded expectations. All forms of reliability presentation gained similar response rates and could be used in further surveys, although it seems to be easier for respondents to understand the experiment with a graphical display. Non-traders were in the expected range. The item non-response was very low for most of the variables.

Of course there is always room for improvement. Especially new approaches in the valuation of business travel time savings demand more attributes for adequate estimation as travel time can be used for i.e. working (see Hensher 1977). Nevertheless this has been the first official value of time and reliability study in Germany. The values should be updated on a regular basis with every new BVWP but at least with every second. Additionally the methods and approaches should be developed further with every new estimation.

5. Acknowledgements

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