The choice of workplace and residential location in Germany

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Abstract

Workplace and residential location influence many other behavioural choices of travellers as they define the marginal cost of further travel and the distances involved. The *German Value of Time (VOT) Study* includes revealed and stated preference data in a long-term choice context. The alternatives in the choice situations include travel related variables and in addition a description of the work and residence of the respondents itself. This paper shows and compares the results of an in-depth analysis of long-term decision behaviour with travel as an element and presents both values of time and travel time elasticities from this choice context.

Keywords

Value of time, *German VOT Study*, long-term choices, workplace location choice, residential location choice

1 Introduction

Microeconomic 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 DeSerpa (1971). As a result the value of time has been a subject of analysis for the past five decades. The current state of practice draws largely upon past British, Dutch and Scandinavian studies ((Wardman, 1998); (Abrantes and Wardman, 2011)) which over time moved from revealed preference (RP) data, where estimates are derived from the actual choices made by travellers, to a growing reliance on personalized stated choice (SC) experiments, where travellers are typically required to make choices between hypothetical situations. The values of time are estimated using suitably formulated discrete choice models of travel behaviour, especially of route and mode choices.

Most value of time studies consider short term decisions framing experiments around a situation where respondents are presented with variations to travel time and cost of different modes or routes. The questions arises if the focus on short term decisions is the most appropriate? Can for example a commuter vary much of his daily commute in the short run or is it perhaps more reasonable that changes in commutes occur because of longer term decisions that people make such as where to work or where to live? (Beck et al., 2016).

Workplace and residential location influence many other behavioural choices of travellers as they define the marginal cost of further travel and the distances involved. Therefore the focus of several more recent empirical studies shifted to understand and explain everyday travel behaviour as a routine activity changing due to key events such as residential relocation or workplace decisions. A recently published article by Müggenburg et al. (2015) reviews the theoretical framework and the most important studies investigating mobility behaviour in a long-term choice context. (Schirmer et al., 2014) give a comprehensive overview of residential location choice literature and show that travel time, commuting and employment changes are significant determinants of choices.

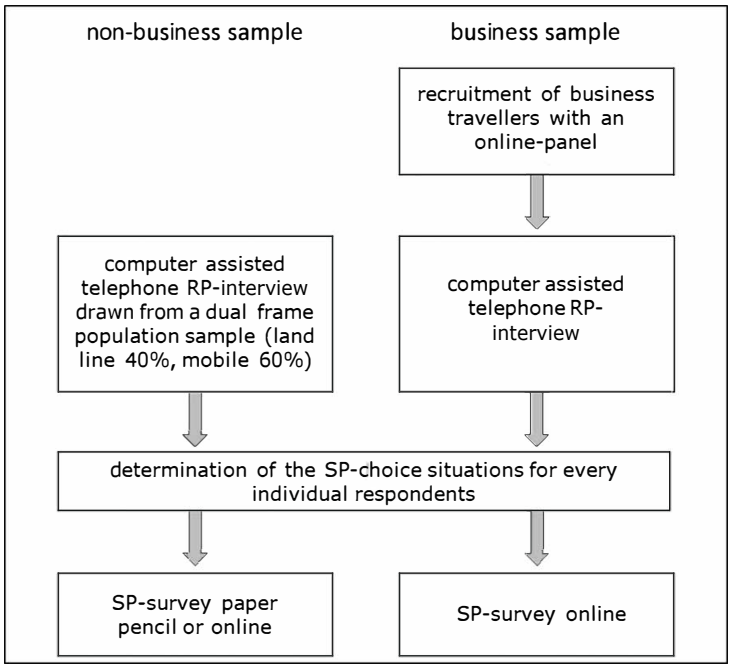
Trading workplace or residential location, however, represents a long term choice; it is a decision that is not made easily and cannot be changed quickly. In this paper, we examine value of time measures in this specific choice context. The paper makes use of a combined revealed and stated stated preference experiment conducted in Germany in 2012. The alternatives in the choice situations include travel related variables and in addition a description and variation of work and residence attributes of the respondents. The respondents were asked to make trade-offs between this transport and workplace or residence related attributes.

The remainder of this paper is structured as follows; the next section outlines the survey and is followed by methods used to examine long-term workplace and residential location choices made by respondents; Section 4 outlines the results of the modelling before presenting the final discussion and outlook in section 5.

2 Survey description

In 2012 the Federal Ministry for Transport and Digital Infrastructures (BMVI) assigned the German VOT study - a project on the first official estimation of values of time (VOT) and values of reliability (VOR) for personal business and non-business travel in Germany (Axhausen et al., 2015). Having initiated several projects the BMVI intends to update the overall methodology of the Federal Transport Plan, its medium- to long-term investment strategy for the countrys transport infrastructure. This also includes the cost-benefit analysis (CBA), which is used to evaluate the effects of hundreds of German infrastructure projects.

Figure 1: Process of the study



The current state of practice of evaluating travel time savings and reliability draws upon prior British, Dutch and Scandinavian studies Wardman (1998); Abrantes and Wardman (2011) which over time moved from revealed preference (RP) data to a growing reliance on personalized stated choice (SP) experiments. The values are estimated by using suitably formulated discrete

choice models of travel behavior. Swiss studies had further developed international practice by employing more complex SP experiments including multiple modes and multiple elements of the generalized costs of travel in a series of overlapping choice contexts (Axhausen et al., 2004, 2008; Weis et al., 2012; Fröhlich et al., 2013). The design of the German VOT study builds on the experience of those studies in Switzerland. A more detailed description of the survey design, survey process and response behavior of the German VOT study can be found in (Ehreke et al., 2014) and (Axhausen et al., 2015).

Table 1: Types of questionnaires non-business sample

from RP-survey		*assigned SP-games*				
refer-ence	mode	mode choice	route choice	reliability	long-term	Nr.
trip daily trip	walk	walk / put / car	–	–	workplace	1
	walk	walk / put / car	–	–	residential	2
	bike	bike / put / car	–	–	residential	3
	bike	bike / put / car	–	–	workplace	4
	put	bike / put / car	–	put type 1	workplace	5
	put	–	put	put type 2	residential	6
	car	walk / put / car	–	car type 1	residential	7
	car	–	car	car type 2	workplace	8
long distance	put	bus / put / car	–	put type 3	workplace	9
	put	–	put	put type 1	residential	10
	car	bus / put / car	–	car type 3	residential	11
	car	–	car	car type 1	workplace	12
	put	put / car / plane	–	put type 2	workplace	13
	put	–	put	put type 3	residential	14
	car	put / car / plane	–	car type 2	residential	15
	car	–	car	car type 3	workplace	16
	plane	put / car / plane	–	plane type 1	workplace	17
	plane	put / car / plane	–	plane type 2	residential	18

In line with international practice the data collection process of the *German VOT study* adopted a two stage approach: in a first step the respondents reported about their current trips - RP (revealed preference). Then the information about the non-chosen options was added and a reference trip randomly selected. In a second step the hypothetical choice situations - the SP (stated preference) experiments - were constructed around it. Figure 1 shows the data collection

process. The population-based non-business sample was drawn from a dual frame of land line and mobile numbers (60% and 40%). It was incrementally controlled over the survey period so as to ensure the spatial quotas in terms of the German federal states. The non-business sample included both experiments with a short-term horizon (route, mode, route and reliability time), as well as a long-term choice context (work place and residential location). The business sample however did not include long-term experiments. In total 18 different types questionnaires where conducted and based on the reference randomly distributed to the respondents (Table 1).

2.1 Workplace long-term choice task

In the workplace games we presented choices via an labeled choice experiment where respondents were asked to choose between their current workplace and an alternative workplace that varied in commute times, commute costs, salary and other workplace attributes. The attributes and their variation can be found in Table 2. An example of this choice task is shown in Figure 2. A respondent received eight long-term choice tasks in total.

Table 2: attributes workplace experiments

RP attribute	*unit*	*SP variation*	*alternative*	
(current altenative)		*(new alternative)*	*current*	*new*
car commute time	(min)	–30%, –10%, +20%	x	x
car commute cost	(€/month)	–20%, +10%, +30%	x	x
public transport commute time	(min)	–30%, –10%, +20%	x	x
public transport commute cost	(€/month)	–20%, +10%, +30%	x	x
salary before tax	(€/month)	–10%, +/–0%, +10%	x	x
staff managed	(number)	–50%, +20%, +100%	x	x
budget managed	(million €/year)	–50%, +20%, +100%	x	x
change of industry needed	(yes/no)	no, yes	no	x
change of company needed	(yes/no)	no, yes	no	x

Figure 2: Example of workplace choice task

	Curent	New
car commute time	0:13 h	0:09 h
car commute cost	58 € / month	34 € / month
pt commute time	0:43 h	0:36 h
pt commute cost	54 € / month	32 € / month
salary (before tax)	1600 € / month	1760 € / month
staff managed	4 employees	23 employees
budget managed	1,0 Mio. € / year	0,7 Mio. € / year
change industry	no	no
change company	no	yes
Choice:	☐	☐

2.2 Residential location long-term choice task

The residential location games were similar to the workplace ones but with residential attributes. Despite the travel cost and time of commute trips by car or public transport the same is shown and varied for trips to the nearest shopping location. The residential attributes regard the appearance and location of the dwelling. All attributes and their variation can be found in Table 3. An example of this choice task is shown in Figure 3.

Figure 3: Example of residential location choice task

	Current	New
type of dwelling	apartment	house
size	120 m^2	132 m^2
standard	old	renovated
exterior	none	garden
rent / mortgage	540 € / month	600 € / month
area	rural	rural
car travel time:		
commute	0:12 h	0:08 h
shopping	0:15 h	0:13 h
car travel costs:		
commute	56 € / month	43 € / month
shopping	21 € / month	19 € / month
pt travel time:		
commute	0:36 h	0:32 h
shopping	0:15 h	0:18 h
pt travel costs:		
commute	59 € / month	54 € / month
shopping	19 € / month	24 € / month
Choice:	☐	☐

Table 3: attributes residential location experiments

RP attribute (current altenative)	*unit*	*SP variation (new alternative)*	*alternative*	
			current	*new*
type	(house/apartment)	house,apartment	x	x
size	(m^2)	–20%, +10%, +30%	x	x
standard	(new/renovated/old)	new, renovated, old	x	x
exterior	(none/garden/balcony)	none, garden, balcony	x	x
rent/mortgage	(€/month)	–20%, +10%, +30%	x	x
area	(urban/suburban/rural)	urban, suburban, rural	x	x
car travel time:				
- commute	(min)	–30%, –10%, +20%	x	x
- shopping	(min)	–30%, –10%, +20%	x	x
car travel costs:				
- commute	(€/month)	–20%, +10%, +30%	x	x
- shopping	(€/month)	–20%, +10%, +30%	x	x
pt travel time:				
- commute	(min)	–30%, –10%, +20%	x	x
- shopping	(min)	–30%, –10%, +20%	x	x
pt travel costs:				
- commute	(€/month)	–20%, +10%, +30%	x	x
- shopping	(€/month)	–20%, +10%, +30%	x	x

3 Methodology

The non-linearities of distance and travel time in the short term experiments were tested with a set of formulations, including the elasticity continuous interaction terms and various non-linear attribute specific transforms. In the end, the best results were obtained with the following formulation (Axhausen et al., 2015):

$$U_i = \Sigma_j ... (\beta_{i,j} * x_{i,j} + \alpha_{i,j} * \ln(x_{i,j} + \gamma_{i,j})) * \left(\frac{z_j}{\mu(z_j)}\right)^{\lambda_{ijz_j}} ... \quad (1)$$

Where U_i is the utility of the alternative $i = 1, ..., n$, x_{ij} is the attribute j of alternative i, $(\beta, \alpha, \gamma)_{ij}$ are parameters associated with $x_{i,j}$, $\lambda_{i,j,z_{i,j}}$ is the elasticity of the sensitivity to attribute j for alternative i with respect to attribute z_j and $\mu(z_j)$ is the mean of attribute z_j. The continuous interaction terms vary across attributes Mackie et al. (2003). For travel time and cost income

indexed as z_j was used divided by the sample mean value to normalize the values to cover the income elasticity effect. For all other attributes, travel time as was used, allowing sensitivities to change depending on travel time. For attribute specific non-linearity, a combined linear and logarithmic approach was used, with the additional positive offset term to handle attribute values close to zero. The model specification differs from the Swiss value of time study where the distance elasticity of the VOT is obtained directly from the model parameters Axhausen et al. (2008).

For the long-term choice experiments yet a much simpler linear approach was used because different problems occurred which had/have to be dealt with. The preliminary utility function has the simple form:

$$U_i = \sum_j \beta_{i,j} \cdot x_{i,j} \tag{2}$$

Where U_i is the utility of the alternative $i = 1, ..., n$, x_{ij} is the attribute j of alternative i and $\beta_{i,j}$ is the linear parameter for the valuation of $x_{i,j}$. The Logit-formula of the probability of choosing one alternative is:

$$P_i = \frac{e^{U_i}}{\sum_j e^{U_j}} \tag{3}$$

Two different models - one for workplace choice and one for residential location choice - were estimated. The results are described in the next section.

4 Preliminary results

Workplace models

Table 4 shows some descriptive statistics about the workplace attributes. Overall, a large majority of situations resulted in keeping the current workplace. The distributions of travel times, costs and salary are similar for the current and new locations. However, the changes in number of managed employees and budget are biased towards more responsibility. There are as many choice situations that require changing industry sector (*resp.* company) as situations that do not.

Table 4: Descriptive analyses workplace attributes

attribute	*unit*	*level*	*current*	*new*
n = 9504				
choice	overall (%)		6749 (71.0)	2755 (29.0)
car commute time	(mean (sd))		26.15 (37.67)	24.49 (36.62)
car commute cost	(mean (sd))		95.41 (100.68)	84.90 (90.94)
pt commute time	(mean (sd))		46.74 (79.93)	44.24 (78.35)
pt commute cost	(mean (sd))		114.43 (256.66)	105.45 (237.32)
salary before tax	(mean (sd))		2734.39 (1356.64)	2732.38 (1361.76)
staff managed	(mean (sd))		9.68 (70.93)	23.94 (103.33)
budget managed	(mean (sd))		1.217m (1.223m)	1.671m (1.619m)
change of industry needed	overall (%)	no	9504 (100)	4991 (52.5)
	overall (%)	yes	0 (0)	4513 (47.5)
change of company needed	overall (%)	no	9504 (100)	4499 (47.3)
	overall (%)	yes	0 (0)	5005 (52.7)

Table 5 shows the values of the parameters for the model of change of workplace. The parameters give more insight into the inertia observed above: the constants indicate that everything else equal, individuals prefer not to change workplace; but also that changing company or industry sector are both negatively valued. Increasing travel time has, expectedly, a negative influence whereat the effect of car travel time is much stronger.

Surprisingly, however, travel cost is not significantly different from 0 and was removed from the model. Even with different model formulations the parameter never turned out to be significantly different from 0. This leads to the conclusion that in our survey travel cost did not have an influence on the decision between the current and a new job. This could be due to survey design and rather small variation in travel time compared to a salary increase or decrease. Another explanation could be that in contrast to travel time travel costs in Germany are subsidized by the government through tax reduction so that the variation of cost in the survey may not make a difference to the respondents at all.

Salary has a positive influence, even more when the respondents can choose a salary increase. Being responsible for staff or budget has also no significant influence. Salary and travel time seem to be more important predictors than the characteristics of the work itself.

Table 5: Results of the model for workplace change

LL: -4968.027

Estimates:

	est	se	trat_0	trat_1	robse	robtrat_0	robtrat_1
ASC_current	1.5481	0.0468	33.05	11.70	0.0711	21.77	7.71
ASC_new	1.0000	NA	NA	NA	NA	NA	NA
beta_car_tt	-0.0179	0.0027	-6.69	-379.66	0.0038	-4.77	-270.57
beta_put_tt	-0.0026	0.0013	-2.06	-788.07	0.0014	-1.84	-704.60
beta_salary_less	0.0051	0.0003	16.66	-3228.37	0.0005	10.50	-2034.00
beta_salary_more	0.0093	0.0005	18.33	-1958.33	0.0007	12.50	-1335.14
beta_industry	-0.4871	0.0502	-9.70	-29.63	0.0576	-8.45	-25.80
beta_company	-0.2939	0.0498	-5.90	-25.98	0.0504	-5.83	-25.67

Residential location models

Table 6 shows some descriptive statistics about the residence location attributes. Here also, a vast majority of the choices result in keeping the current residence. In the current state, houses and apartments are equally represented, whereas the new situation contains more apartments. The new situation also contains more “new” apartments and less “renovated”. Characteristics of the commute remain equivalent in the two situations. Due to a mistake conducting the SP choice experiments the times for car and public transport travel times with the purpose shopping are identical.

Table 6: Descriptive analyses residence location attributes

attribute	*unit*	*level*	*current*	*new*
n = 8634				
choice	overall (%)		7229 (83.7)	1405 (16.3)
rent/mortgage	(mean (sd))		258.03 (335.58)	263.68 (344.70)
type	overall (%)	house	4457 (51.6)	3312 (38.4)
	overall (%)	apartment	4177 (48.4)	5322 (61.6)
size	(mean (sd))		132.47 (155.39)	124.98 (149.72)
standard	overall (%)	new	1881 (21.8)	2647 (30.7)
	overall (%)	renovated	4988 (57.8)	4333 (50.2)
	overall (%)	old	1765 (20.4)	1654 (19.2)
exterior	overall (%)	none	530 (6.1)	2011 (23.3)
	overall (%)	balcony	4509 (52.2)	2940 (34.1)
	overall (%)	garden	3595 (41.6)	3683 (42.7)
area	overall (%)	urban	4024 (46.6)	3729 (43.2)
	overall (%)	suburban	2202 (25.5)	2116 (24.5)
	overall (%)	rural	2408 (27.9)	2789 (32.3)
car travel time:				
- commute	(mean (sd))		13.33 (25.18)	12.53 (23.76)
- shopping	(mean (sd))		10.63 (14.44)	10.14 (14.11)
car travel cost:				
- commute	(mean (sd))		47.99 (79.47)	50.97 (86.71)
-shopping	(mean (sd))		17.33 (21.73)	18.65 (24.11)
pt travel time:				
- commute	(mean (sd))		23.06 (61.29)	21.68 (57.82)
- shopping	(mean (sd))		10.63 (14.44)	9.88 (13.74)
pt travel cost:				
-commute	(mean (sd))		41.89 (76.64)	44.45 (82.79)
-shopping	(mean (sd))		14.82 (14.38)	16.00 (15.88)

Table 7 shows the results of the model for residential location change. The inertia is again and even stronger visible in the constants. Travel time has a negative effect. In contrast to the workplace experiments the signs for travel time and cost are as expected and the parameter estimates are significant. The signs for size and rent are expected. As for the characteristics of the dwelling, houses with garden recently built are preferred. The residential area was not significantly different from 0.

Table 7: Results of the model for residence location change

LL: -3179.661
Estimates:

	est	se	trat_0	trat_1	robse	robtrat_0	robtrat_1
ASC_current	2.5373	0.0351	72.34	43.83	0.0524	48.44	29.35
ASC_new	1.0000	NA	NA	NA	NA	NA	NA
beta_tt	-0.0100	0.0020	-5.01	-504.21	0.0021	-4.68	-470.78
beta_tc	-0.0110	0.0015	-7.49	-685.73	0.0019	-5.81	-532.21
beta_size	0.0213	0.0021	10.19	-468.50	0.0029	7.39	-339.77
beta_rent	-0.0078	0.0008	-9.83	-1275.90	0.0008	-9.16	-1188.29
beta_type_app	-0.2699	0.0254	-10.61	-49.93	0.0359	-7.51	-35.35
beta_std_new	0.6591	0.0694	9.49	-4.91	0.0991	6.65	-3.44
beta_std_ren	0.1791	0.0300	5.97	-27.38	0.0435	4.12	-18.87
beta_ex_bal	0.5447	0.0744	7.32	-6.12	0.1007	5.41	-4.52
beta_ex_gar	0.5571	0.0368	15.16	-12.05	0.0504	11.05	-8.78

5 Discussion and outlook

In this paper, the objective was to estimate models for long term choice situations. We examined choices derived from willingness to pay style questions where trade-offs between time, cost and other long term choice attributes were made by the respondents. Overall, we have shown that values of time differ between short-term and long-term decisions.

Firstly, both long-term choice contexts show that the respondents above all prefer to remain in their current situation rather than changing the workplace or their residential situation. In the workplace games this can also be seen by the negative influence of changing the industry or company.

Secondly, it can be stated that travel time and cost are less valued in the long term choice context as other attributes become more important. Especially in the workplace context this can be seen by the insignificance of travel cost compared to a salary increase. While the survey design and rather small variation in travel time could explain this insignificance it could also be that the variation of cost made no difference at all due to Federal tax reduction for commuting travel cost in Germany.

The preliminary evidence from this study into values of time in the long term clearly indicates that the values differ to short term values. This paper represents the first attempt to analyze long term decisions, but there is much research that needs to be conducted. Future research needs explore a more complex utility function and compare short and long therm values directly. Additionally, it would be interesting to analyze the data such that short-term and long-term decisions can be modeled jointly.

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