Willingness to Pay for E-Mobility Services: A Case Study from Germany

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Abstract

We analyse the relevance of and willingness to pay for services connected to operation and charging of electric vehicles. Our survey data comprises fleet manager answers from 109 German organizations, mainly small and medium-sized enterprises. The results indicate that semi-public charging infrastructure at the organizations connected to services enabling the operation of an inter-organizational charging network are relevant to most of the fleet managers. In most of the organizations willingness to pay for connected charging services is available, but only sporadic usage of inter-organizational charging activities could be observed.

1 Introduction and literature review

Electric vehicles (EV) are an important technology to reduce greenhouse gas and local air emissions as well as the dependency on fossil fuels. Yet, their market diffusion is still at low levels (IAE 2015) due to several barriers linked with this new technology (Steinhilber et al. 2013), such as a limited mobility radius or a higher recharging necessity resulting in a so-called range anxiety (Tate et al. 2008). New business models or services could diminish these concerns by proposing alternative procedures, such as mobility guarantees in case of trips that are not performable with an EV or the provision of a larger charging network (Kley et al.

2011). While business models or services[1] in the automotive industry are the subject of many papers (see e.g. Tongus and Engvall (2014) for an evaluation of business models and technology development) only some works focus on business models for EV (see Wells (2013) for a review). There are qualitative studies on business models for EV available (e.g. Bohnsack et al. (2012), Piao et al. (2014), Cherubini et al. (2015)). Furthermore, frameworks for EV business models exist (Kley et al. (2011), Stryja et al. (2015), San Roman et al. (2012)). Beyond that specific case studies are evaluated as well (Christensen et al. (2012), Illing et al. (2014), Kosub (2010)). By contrast, this paper determines the current relevance and willingness to pay (WTP) for services provided to commercial EV users. A survey targeting this issue with 109 company car pool managers, who actually procured EV within the project Get eReady, which was scientifically accompanied and partly carried out by the authors of this paper between 2013 and 2015, was performed. Findings of this case study are described in the next section before a conclusion, limitations and a brief outlook are provided.

2 Case study: Project Get eReady

2.1 Sample description and background information

The data used in this study was gathered in an online survey during the e-mobility project Get eReady. The objective of the project was to determine critical success factors for EV in organizations. Therefore, a large-scale fleet trial including 109 organizations and 327 EV was set up in order to prove whether appropriate sales activities for product service systems consisting of EV, connected charging services, charging infrastructure (EVSE[2]), consulting activities and an adequate compensation of expenses lead to an accelerated market diffusion of EV. The industry partners within the project, i. e. Bosch Software Innovations GmbH responsible for software solutions concerning connected charging services tested

[1] According to Osterwalder & Pigneur (2010), Chesbrough & Rosenbloom (2002) as well as Stryja et al. (2015) the value proposition represented by the utility that a provider offers to its customers with products and services is in the center of a business model. In this paper, we focus on services that could offer a business model. In literature, these terms are often used equivalently.
[2] Electric Vehicle Supply Equipment, i.e. charging stations

in the project, Heldele GmbH responsible for EVSE and Athlon GmbH associated to the project for EV leasing purposes, pushed the sales activities for the product service systems offered. The scientific partners, i. e. Fraunhofer ISI and KIT, supported the sales activities by fleet consulting activities as well as the contractual project integration of the participating organizations (associated with a compensation of expenses granted and the commitment to acquire the number of EV contractually specified, to install and use project specific EVSE and the project specific connected charging services). Most of the EV were registered after their contractual integration (75 %). Due to long delivery periods, the time lag between these two events was three months on average. Almost all organizations installed the project specific EVSE after becoming part of the project (about 97 %). Preconditions for project participation were, that the organizations intended to participate at least with one EV, that the organizations were allocated in Baden-Württemberg and that they still applied for the program after intensive sales conversations leading to individual recommendations concerning individual constructual, security and telecommunication requirements. The organizations participated in the project between 7 and 27 months, 16 months on average. They received a monthly compensation of expenses for participating of up to 500 Euros net per full electric vehicle (BEV) or range extended electric vehicle (REEV) and 350 Euros net per plug-in hybrid electric vehicle (PHEV) for additional costs of project specific EVSE and for the still existent economic disadvantages of EV. Overall, the resulting compensation per EV ranged between 1,200 Euros and 13,200 Euros including 19 % VAT, 8,100 Euros on average. Fleet managers[3] of all 109 participating organizations were asked to fill out two surveys with a response rate of 100 % each, i.e. all organizations participating in the project answered both questionnaires.

According to the survey results, 75 % of the participating organizations were small and medium-sized companies with up to 250 employees. The allocation of EV within the Get eReady project represents the sectors of the participating

[3] In the project Get eReady fleet managers, i. e. persons responsible for the organizations' car pools mostly involved in purchase decisions for the EV, as well as fleet EV users not involved in the EV purchase decisions, participated in the surveys. However, this article only focuses on the answers of the fleet managers.

organizations reasonably well, e. g. 36 % of the participating organizations and 35 % of the EV are allocated in the manufacturing sector (C)[4]. Comparing the EV of the Get eReady project with new commercial EV registrations in Germany shows that the manufacturing sector (C) is overrepresented by 15 percentage points (pp), information and communication (J) is overrepresented by about 11 pp and public administration (O) is overrepresented by about 9 pp. On the other hand, wholesale and trade (G) is underrepresented by 20 pp. The sector of other service activities (S) is underrepresented by about 13 pp. Despite these discrepancies, results can be considered to be representative for the current commercial EV users in Germany.

The fleet managers and decision makers in the participating organizations are on average 45 years old (SD=12), are predominantly male (about 85 %) and are well educated. About half of them have completed academic studies and about 30 % have a degree at university entrance level or a master craftsman diploma. 50 % have a technical, about 40 % a commercial background. On average, the respondents have been employed for 16 years in their organizations (SD=12) and have an experience level with fleet management activities of 10 years on average (SD=10). Half of them dedicate more than 10 hours per month to fleet management activities, 25 % four hours or less and 25 % more than 20 hours.

2.2 Relevance of different services

In a workshop with the Get eReady partners in the year 2013, a set of different services potentially relevant for EV were identified in order to ask the fleet managers and decision makers of the participating organizations about the attractiveness and relevance of these services. Based on the fleet managers' answers, the project partners agreed to consider only the relevant services in the second survey with a focus on the WTP for these services (Table 1 in the appendix). This set of services was completed by three additional services not in focus so far, but according to the authors of this study potentially relevant. These are on the one hand two alternatives of a smart charging energy service that could potentially be pro-

[4] Sectors distinguished according to NACE, Rev. 2.

vided by a Smart Charging Service Provider (SCSP) (Ensslen et al., 2014)[5] and on the other hand, the relevance and WTP of inductive EV charging as a service, which is potentially increasing the comfort level of EV charging.

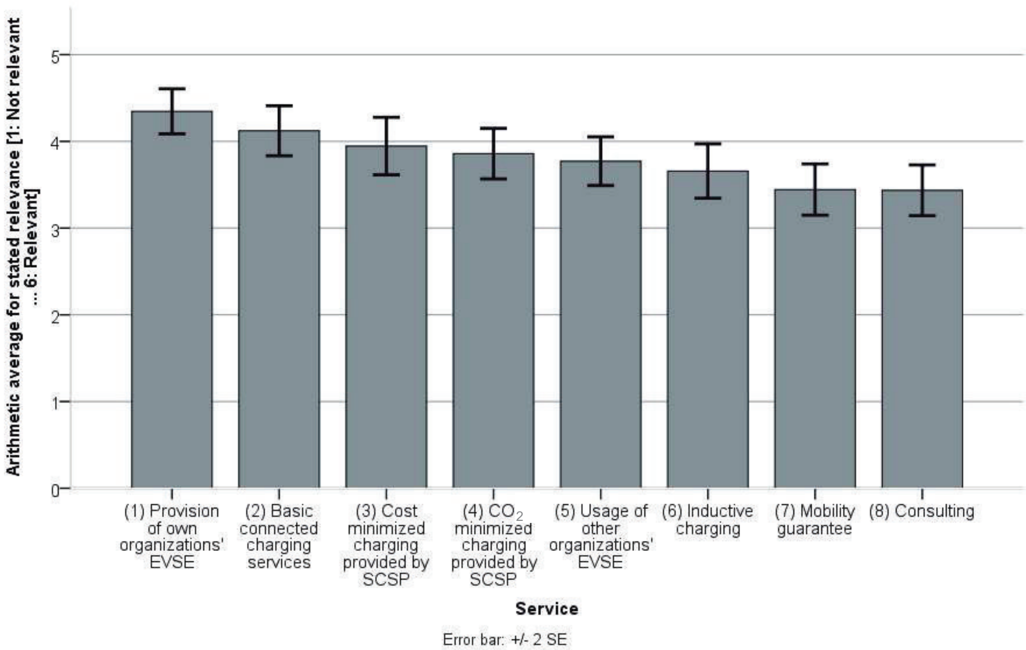

Figure 1: Relevance of e-mobility services in Get eReady[6]

Figure 1 shows the results concerning stated relevance for the services considered in the survey. The most important services are: (1) the possibility to provide the own EVSE to other organizations, (2) the basic connected charging services including a web-based map displaying charging points including information about their current availability and a reservation function as well as (3) a smart charging tariff provided by a SCSP incentivizing EV users to hand over control of the charging processes to the SCSP scheduling the charging events in a cost-minimizing manner in order to co-create value. These are also considered as comparably most relevant by the Get eReady fleet managers according to paired t-tests (cf. Table 2 in the appendix). (4) A smart charging tariff incentivizing EV users to hand over control for EV charging to a SCSP scheduling the charging

[5] This option of a new type of operator, the so-called SCSP, is contracting households and organizations and manages the charging of their EV. This operator considers the EV load shifting potentials and current price signals from electricity markets. Details about the value proposition of the SCSP are available in Ensslen et al. (2014).

[6] Scale: 1 Not relevant; 2 Predominantly not relevant; 3 Rather not relevant; 4 Rather relevant; 5 Predominantly relevant; 6 Relevant

events in a CO_2 minimizing manner and (5) the possibility to use EVSE of other organizations are somewhat less important, i.e. less important than (1). According to the respondents, (6) inductive charging, (7) mobility guarantees as well as (8) consulting activities for EV, infrastructure and car pools are least important amongst the services considered. Although some statistically significant differences between the services considered could be observed, most of them are on average considered to be rather relevant. In order to verify whether the differences observed in individuals' evaluations in the paired t-tests would also be valid if the samples were considered to be independent, additional pairwise comparisons with a one way analysis of variance were conducted ($F(7,815) = 4.763$, $p<.001$). Results of multiple comparison t-tests according to Bonferroni (cf. Table 2 in the appendix) show significant differences between services 1 and 2 and services 7 and 8 as well as between services 1 and 6. It should be remarked, that services 1 and 2 were actively tested within the project, services 6 and 7 were not. This could indicate that actually experiencing a service might contribute to an increased acceptance of a service.

2.3 WTP for different services

Two different types of services can be distinguished: E-mobility services actively tested during the Get eReady field trial (services 1, 2, 5, 8) and other e-mobility services not actively tested in the field trial (services 3, 4, 6, 7).
Table 3 in the appendix contains results for usage frequencies of the connected charging services tested within the project and Table 4 for WTP and corresponding cost assumptions. According to the results, the WTP per month and vehicle to get access to the Get eReady charging network (service fee) is higher for most of the participating organizations than the monthly costs. According to the results the participants charge the EV only scarcly at EVSE of other organizations. However, they frequently charge their EV at their own connected EVSE. The WTP for charging at own EVSE of most organizations seems as high as the current costs. Cost assumptions for all other connected charging services presented in Table 4 are higher than the WTP of most organizations.

As EV are frequently parked at the workplace for longer time periods, the control for charging EV incentivized by smart charging tariffs discussed in this study is handed over to the SCSP who is scheduling the charging events in a cost or CO_2 minimizing manner in order to co-create value.

WTP was measured with the Van Westendorp method (Reinecke et al. 2009) and is presented in Table 5 in the appendix. Using the Van Westendorp method is appropriate as this method supports to determine WTP for innovative services with unknown price conceptions as well as a so far missing competitive environment (Reinecke et al. 2009). All of these three criteria apply to the SCSP's value proposition. Furthermore, the Van Westendorp method is considered as a very efficient alternative to determine prices, that has been frequently disregarded (Reinecke et al. 2009). The method permits to determine the lower bound and the uppter bound of an acceptable price range. Furthermore, an optimal price point, which is maximizing the turnover, can be determined. Comparing the difference between the indifference price point and the optimal price point permits to derive estimates about the price sensitivities of the potential customers. Lower differences between the two price points implicate higher price sensitivities of the potential customers (Reinecke et al. 2009).

The SCSP's tariff consists of two price levels: (a) The price level for charging the EV as quickly as possible to guarantee a minimum amount of range, so that the EV could be used e.g. in cases of emergencies. (b) The price level for controlled EV charging of a SCSP who is scheduling the charging events in a cost or CO_2 minimizing manner.

The results concerning WTP for the two smart charging tariffs provided in Table 5 include complete and consistent answers from 57 fleet managers. The results indicate that the organizations' fleet managers are willing to pay somewhat less for the energy charged during the time they are handing over control of the charging process to the SCSP, if the SCSP minimizes costs (b_1), compared to a single price level state of the art reference tariff without controlled EV charging. However, the price levels for the two tariffs do not differ significantly (Table 6 in the appendix). On the other hand, they are willing to pay more compared to the reference tariff, if the charging events are scheduled by the SCSP in an environmentally friendly, i.e. in a CO_2 minimizing manner (b_2). Paired t-tests show that two of the four price curves measured differ significantly (Table 6). Furthermore, respondents are also willing to pay a premium so their EV is directly charged up to an individual minimum range threshold after it was plugged in. Paired t-tests show that significant differences could be observed in three of the four price curves measured (Table 6).

3 Conclusion, limitations and outlook

We showed that the connected charging services offered and tested within the Get eReady project are relevant to fleet managers in most of the participating organizations. However, our results seem ambiguous here: On the one hand, fleet managers state that connected charging services are relevant to them, particularly the possibility to provide their own EVSE to other organizations. On the other hand, we observe only sporadic usage of inter-organizational charging activities. Hence, the connected charging services tested within this case study may be interpreted as an "insurance" for the EV users. Furthermore, not only the e-mobility services tested within Get eReady are relevant to fleet managers, but also smart energy services, i. e. controlled EV charging by a SCSP. For this reason, we recommend to expand the existing Get eReady product service system offering by smart energy services. This would strengthen the arguments for connected charging infrastructure solutions as these form the basis for additional smart charging activities. However, the results concerning WTP for smart charging tariffs provided by a SCSP can be scrutinized as fleet managers come from organizations varying in size and internationalization. Electricity costs per kWh might vary largely between the organizations.

Future work could focus on analyzing costs and benefits of service systems consisting of EV, EVSE and corresponding services in order to provide an answer to the question whether offering suitable service systems can be supportive to EV adoption. Furthermore, acceptance in organizations for controlled EV charging in fleets should be studied more profoundly.

Acknowledgements

The research was made possible as part of the project Get eReady funded by the German Federal Ministry for Economic Affairs and Energy (FKZ 16SBW020D).

Appendix

Table 1: Services considered within the Get eReady project

<table>
<tr><th>Services considered</th><th>Average scores for services considered in the first survey for fleet managers (n ~ 40)</th><th colspan="2">Services considered in the second survey for fleet managers</th></tr>
<tr><td>Fleet consulting – Item: “Trips which are outside the range of EV can be distributed amongst conventional vehicles”</td><td>5.3</td><td>x</td><td rowspan="7">Results cf. Figure 1</td></tr>
<tr><td>Sharing of own organizations’ EVSE over platform – Item: “My organization would offer EV charging possibilities on the premises to other organizations against payment.”</td><td>4.6</td><td>x</td></tr>
<tr><td>Usage of other organizations’ EVSE over platform – Item: “For my organization it would be attractive to have the possibility to use EV charging possibilities of other organizations against payment.”</td><td>4.3</td><td>x</td></tr>
<tr><td>Display of current EVSE availability – Item: “Frequently access to publicly accessible charging points is not possible because these are occupied by (conventional) vehicles.”</td><td>3.9</td><td>x</td></tr>
<tr><td>Web-based map displaying charging points – Item: “It is difficult to find out where publicly accessible charging points are allocated.”</td><td>3.7</td><td>x</td></tr>
<tr><td>A EVSE reservation function – Item: “Frequently publicly accessible charging points are occupied by other EV.”</td><td>3.5</td><td>x</td></tr>
<tr><td>Mobility guarantees (rental car option) – Item: “Trips that cannot by made with EV due to their range limitations could be substituted by free of charge rental cars.”</td><td>3.3</td><td>x</td></tr>
<tr><td>Using advertisement space on the EVSE for own advertisements – Item: “For our organization it would be attractive to place advertisements on our charging station.”</td><td>3.1</td><td colspan="2" rowspan="6">Representatives of the Get eReady project partners considered these services not to be relevant for further analyses during a workshop in the end of the year 2014.</td></tr>
<tr><td>Mobility guarantee (train travel option) – Item: “Trips that cannot by made with EV due to their range limitations could be substituted by free of charge train trips.”</td><td>2.5</td></tr>
<tr><td>Leasing of advertcement space on the own EVSE to other organizations – Item: “For our organization it would be interesting from a financial point of view to rent advertisement space on the charging point out.”</td><td>2.3</td></tr>
<tr><td>Sharing of the own organizations’ EV over a platform – Item: “For my organization it would be attractive to rent fleet vehicles of our organization to other organizations.”</td><td>2.0</td></tr>
<tr><td>Usage of EV from other organizations over a platform – Item: “For my organization it would be attractive to use fleet vehicles of other organizations against payment.”</td><td>2.0</td></tr>
<tr><td>Separate registration and billing of private and business trips – Item: “For us it is a problem that business and private trips can not be registered in a way that separate billing is possible.”</td><td>1.6</td></tr>
<tr><td>Billing of charging events</td><td colspan="3" rowspan="5">Representatives of of the Get eReady project partners considered these services not to be relevant for further analyses during a workshop in the end of the year 2013.</td></tr>
<tr><td>Roaming</td></tr>
<tr><td>Authorized repair shops</td></tr>
<tr><td>Breakdown- and maintenance service</td></tr>
<tr><td>EV specific add-on for fleet management systems</td></tr>
</table>

Annotation concerning the measurement scale for the items on the services considered:
1 Not applicable at all; 2 Predominantly not applicable; 3 Rather not applicable; 4 Rather applicable; 5 Predominantly applicable; 6 Completely appicable

Table 2: Paired samples t-test results and Post Hoc ANOVA results (in brackets) for different services

	Provision of own organizations' EVSE (1)	Basic connected charging services (2)	Cost optimal smart charging tariff provided by SCSP (3)	CO_2 optimized charging provided by SCSP (4)	Usage of charging infrastructure of other organizations (5)	Inductive charging (6)	Mobility guarantee (7)
Basic connected charging services (2)	n.s. (n.s.)						
Cost minimized charging provided by SCSP (3)	n.s. (n.s.)	n.s. (n.s.)					
CO_2 minimized charging provided by SCSP (4)	** (n.s.)	n.s. (n.s.)	n.s. (n.s.)				
Usage of charging infrastructure of other organizations (5)	*** (n.s.)	** (n.s.)	n.s. (n.s.)	n.s. (n.s.)			
Inductive charging (6)	** (*)	** (n.s.)	n.s. (n.s.)	n.s. (n.s.)	n.s. (n.s.)		
Mobility guarantee (7)	*** (***)	*** (*)	* (n.s.)	* (n.s.)	* (n.s.)	n.s. (n.s.)	
Consulting (8)	*** (***)	*** (*)	** (n.s.)	* (n.s.)	* (n.s.)	n.s. (n.s.)	n.s. (n.s.)

Annotation: *p<.05, **p<.01, ***p<.001, n.s.: not significant

Table 3: Usage frequency of connected charging services

Service	N		Number of charging hours / usages per month				Percentiles		
	Valid	Missing	Mean	Std. Deviation	Min	Max	25	50	75
Reservations	82	27	2.00	6.90	0	50	0	0	1
Charging at the own EVSE	81	28	64.47	90.51	0	600	15	32	80
Charging of others at the own organizations' EVSE within a regional charging network (Get eReady)	73	36	1.74	6.42	0	50	0	0	0
Charging of others at the own organizations' EVSE within a supra-regional charging network (Hubject)	74	35	1.24	6.16	0	50	0	0	0
Charging at other organizations' EVSE within a regional charging network (Get eReady)	76	33	3.45	10.41	0	60	0	0	1
Charging at other organizations' EVSE within a supra-regional charging network (Hubject)	78	31	4.42	18.38	0	120	0	0	0

Table 4: WTP for e-mobility services

Service	Pricing model (payment frequency and object)	Cost assumptions	N		WTP / Expected refund [in Euros]						
									Percentiles		
			Valid	Missing	Mean	SD	Min	Max	25	50	75
Activation fee	One time per organization	248.65	89	20	102.18	145.09	0	1000	10	50	135
EVSE maintenance	Monthly per EVSE	54.20	89	20	19.38	21.61	0	100	5	10	25
M2M	Monthly per EVSE	15.00	95	14	1.85	2.24	1	15	1	1	2
Service fee	Monthly per EV	2.45	87	22	8.52	13.6	0	100	2	5	10
Reservation	Pay per use	1.00	76	33	1.08	1.80	0	10	0	0.50	1
Charging at the own EVSE[7]	Pay per charging hour	0.95 (≤ 3.3 kW) 0.85 (> 3.3 kW)	58	51	0.93	1.25	0	5	0	0.5	2
Regional provision of EVSE (in Get eReady)[8]	Credit per charging hour	1.00 (≤ 3.3 kW) 3.10 (> 3.3 kW)	52	57	1.65	1.56	0	6	1	1	2.75
Supra-regional provision of EVSE (in Hubject)	Credit per charging hour	n. a.	55	54	1.82	1.95	0	10	0	1	3
Usage of EVSE of other organizations within a regional charging network (Get eReady)[9]	Pay per charging hour	1.95 (≤ 3.3 kW) 3.95 (> 3.3 kW)	57	52	2	1.74	0	6	1	2	3
Usage of EVSE of other organizations within a supra-regional charging network (Hubject)	Pay per charging hour	n. a.	57	52	1.82	1.71	0	6	0	2	3
Mobility guarantee (free usage of a rental car at 20 days per year)	Pay per EV per year	n. a.	86	23	98.6	190.45	0	1200	0	22.5	100
Consulting	One time payment per organization	1,000	86	23	70.88	121.17	0	500	0	0	100
Inductive charging	One time payment per EV	n. a.	84	25	309.89	686.77	0	5000	0	22.5	437.50

Table 5: WTP for smart charging tariffs of a SCSP (n=57)

	Optimal price point	Indifference price point	Point of marginal cheapness	Point of marginal expensiveness
Reference tariff with a single price level	2.65 €	3.55 €	1.30 €	5.00 €
First price level: Direct charing so the minum range threshold is reached as quickly as possible.	2.95 €	3.80 €	1.70 €	5.90 €
Second price level: SCSP controls the charging processes in cost minimizing manner.	2.60 €	3.15 €	1.40 €	4.95 €
Second price level: SCSP controls the charging processes in an environmentally friendly, CO_2 minimizing manner.	3.25 €	3.85 €	1.70 €	5.25 €

[7] Excluded outlier: 1 respondent with WTP of 85 Euros per charging hour
[8] Excluded outlier: 1 respondent expecting credit of 95 Euros per charging hour
[9] Excluded outlier: 1 respondent with WTP of 395 Euros per charging hour

Table 6: Differences between WTP for the two price level smart charging tariffs of a SCSP controlling charging events of EV and a state of the art single price level reference tariff without controlled charging

Pairwise comparisons	**WTP compared**	**Paired differences**				
		Mean	**SE**	**t**	**df**	**Sig. (2-tailed)**
Reference tariff **vs.** (a) First price level with direct charing so the minum range threshold is reached as quickly as possible	Too expensive	-0.59	0.26	-2.25	49	**0.029**
	Expensive	-0.50	0.22	-2.28	49	**0.027**
	Cheap	-0.28	0.13	-2.08	49	**0.042**
	Too cheap	-0.12	0.07	-1.65	49	0.106
Reference tariff **vs.** (b_1) Second price level with SCSP controlling the charging processes in cost minimizing manner	Too expensive	0.20	0.30	0.67	47	0.507
	Expensive	0.18	0.25	0.73	47	0.469
	Cheap	0.06	0.15	0.37	47	0.711
	Too cheap	0.07	0.07	1.05	47	0.300
Reference tariff **vs.** (b_2) Second price level with SCSP controlling the charging processes in CO_2 minimizing manner	Too expensive	-0.64	0.37	-1.72	48	0.091
	Expensive	-0.45	0.28	-1.61	48	0.114
	Cheap	-0.53	0.20	-2.68	48	**0.010**
	Too cheap	-0.32	0.15	-2.17	48	**0.035**

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