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Benefit-Cost Analysis with Local Residents' Stated Preference Information: A Study of Non-Motorized Transport Investments in Pune, India

Hua Wang, Ke Fang, and Yuyan Shi

Abstract

One of the major difficulties in doing benefit-cost analyses of a development project is to estimate a total economic value of the project benefits, which are usually multi-dimensional and include goods and services that are not traded in the market, and challenges also arise in aggregating the values of different benefits, which may not be mutually exclusive. This paper presents an analysis of a non-motorized transport project in Pune, India, which uses the contingent valuation method to estimate the total value of the project benefits across beneficiaries. A sample of the project beneficiaries are presented with a detailed description of the project and then are asked to vote on whether such a project should be undertaken given different specifications of costs to their households. A function of willingness-to-pay for the project is then derived from the survey answers and the key determinants are found to include household income, distance to the project streets, current use of the transportation modes, future use of the project streets, predicted impacts of the project, and level of trust in the government. The total willingness-to-pay of the local residents is found to be smaller than the total cost of an initial design of the project. Heteroskedasticity is also found to present in the willingness-to-pay models.

KEYWORDS: benefit-cost analysis, transport project, contingent valuation

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1. Introduction

One of the major difficulties in doing benefit-cost analyses of development projects is to estimate the total value of the project benefits, which are usually multi-dimensional and include goods and services that are not traded in the market. Take a non-motorized transport (NMT) project, for example. The major benefits may include improving travel convenience and safety, reducing congestion and saving time, improving environmental quality, and reducing driving cost. Most of the benefits, however, are nonmarket goods and cannot be easily valued. Even if an economic value can be obtained for each of the project benefits, the final aggregation may still face a number of issues such as double counting.

One potential solution to estimating a total economic value of a development project is to use the contingent valuation (CV) method, for which a survey can be designed and implemented to collect preference information of the project beneficiaries and a total value of the project in monetary terms can be inferred. As the utility level of a respondent should be affected by the various aspects of the multi-dimensional benefits associated with a project, a CV survey can be so designed that a respondent is required to consider a total value of the benefits of the project for his/her family. After 50 years of research in the area of non-market valuation, the CV method has been developed from its initial controversial stage to a legitimate and most popular valuation approach (Smith, 2004), given that a number of requirements on survey design and execution are satisfied.

The CV method has been successfully developed and applied in the area of environmental economics, but has not been well tested in the area of transportation. As a big part of the benefits of a transport project, such as time saving, improvement in environmental quality and public health, increased land value, etc., is not generally traded in the market, no such information on market demand or competitive market prices are readily available, especially in the developing countries. Therefore, the use of the CV method can be very important for benefit-cost analyses of transport projects in the developing world.

This paper reports a CV study of a NMT project in Pune, India. In 2008, it was proposed to have the World Bank finance a NMT project in Pune under India's Sustainable Urban Transport Program (SUTP), which aimed to improve the road conditions for the pedestrians and cyclists. A CV survey was developed and applied to the potential beneficiaries of the project[1], and an internal validity

[1] The survey was applied to the original version of the project proposal, dated as of December, 2008. The final version of the project design has been changed significantly after the survey was conducted. Among other changes, the new design employed asphalt rather than concrete to significantly reduce the cost.

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test on the willingness-to-pay (WTP) estimation was conducted. The study also tested the heteroskedasticity assumption in modeling the WTPs which has been mostly neglected in previous CV studies.

The paper is organized as follows. In the following section, we briefly review the existing literature on the CV method from various threads, especially the applications of the CV method in the transportation sector and the evolution of heteroskedasticity treatment in recent years. In section 3, we introduce the policy context, including the goal and the proposed activities of the Pune NMT project as well as the potential benefits this project may generate. The survey design and implementation, the WTP elicitation strategy and the descriptive statistics of the major questions in the questionnaire are summarized in section 4. In section 5, we present our analytical framework that accommodates heteroskedasticity assumption in WTP estimation using the augmented payment card (APC) elicitation strategy. The estimation results are also shown in this section. Discussions and conclusions are provided in section 6 and 7 of this paper.

2. Literature Review

The contingent valuation (CV) method is principally developed in the area of environmental economics. However, it has been gradually adopted in the transport sector over the last decade. Feitelson et al. (1996) examined the effects of aircraft noise following an airport expansion by using the open-ended (OE) CV approach. Verhoef et al. (1997) asked the respondents the minimum time gains they required for a certain road process, the answers to which implied a maximum WTP for the time gains. Painter et al. (2002) employed the OE CV strategy to measure the economic value of a regional rural transit that had both user and nonuser values. Also with an OE value elicitation strategy, Walton et al. (2004) found that the motorists were willing to pay for an improved fuel efficiency and a reduced interior vehicle noise from the road surface pavement, but the reduction in vehicle stopping distance resulting from the project was not valued by the motorists. However, there has been little consideration given to valuing the total benefit of a transport project as the one presented in this paper. In the meantime, despite the increasing volume of transportation literature in contingent valuation, WTP has been obtained from fairly simple elicitation strategies such as open ended (OE) and dichotomous choice (DC) questions, and homogeneous variance is the common assumption for such estimates.

A few previous studies have attempted to either accommodate heteroskedasticity in the error terms, or employed more advanced elicitation techniques that acknowledge individual uncertainties. Carlsson and Olof (2000) found that the estimated marginal effects of WTP for an improved air quality were quite robust to the homoskedasticity assumption, based on OE elicitation

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questions. Using a split-sample design, Afroz et al. (2005) investigated the convergent validity of different CV strategies including OE, DC, and payment card (PC). The results suggested that the WTP values for an air quality improvement did not differ significantly across the different strategies. Lanford (1994) detected the presence of overdispersion of un-observables which may lead to biased parameter estimates or overestimated significance levels in DC models. Cameron et al. (2002) found that the dispersion of error terms varied systematically with elicitation strategies including OE, DC, PC, and multiple bounded discrete choice (MBDC) strategies, based on the results from a split-sample design. Violation of the homoskedasticity assumption does not result in biased or inconsistent coefficient estimates in OE ordinary linear square models, but it may cause the variance of the coefficients to be underestimated. Thus a weighted least square regression is often used to correct heteroskedasticity in such models in order to judge the true relationship of significance. The one-bid DC models that fail to represent the heterogeneity in variance, however, may yield substantial biases or inconsistencies in coefficient estimates as well as WTP estimates (Halvorsen and Soelensminde, 1998). Horowitz (1993) argued that if a specified distribution function is qualitatively different from the true data generation process, i.e., the error dispersion is not drawn from the same distribution, the biases in coefficient estimates based on maximum likelihood estimation procedures could be substantial. Their findings are consistent with that of another study by Gourieroux and Trognon (1984) which indicates that the estimations of discrete choice models are quite sensitive to the distribution assumptions of the error terms.

The concept that an individual's valuation for good or services is best viewed as a random variable associated with a distribution or a range of possible values rather than a single point value has been gradually accepted in the community of CV research (Welsh and Bishop, 1993; Welsh and Poe, 1998; Wang, 1997; Wang and Whittington, 2005). The concern of respondents' WTP uncertainty has led to the more advanced elicitation techniques that allow respondents explicitly state their choice uncertainties or increase the number of bids offered to respondents so as to enhance the information about WTP qualitatively or quantitatively (Wang and Whittington, 2005). The representative examples of such development are the MBDC strategy and the stochastic payment card approach. In the recently developed MBDC questions, respondents are shown a number of different possible prices, and instead of asking them to simply accept or reject each of these prices, the respondents are asked to select one of several pre-established possibilities, such as Definitely Not, Probably Not, Not Sure, Probably Yes, Definitely Yes, that the respondent would accept the price. This approach has been suggested to yield more meaningful results and better match with the hypothetical nature of the survey (Wang and He, 2010).

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Although the recent improvements in CV questionnaires have to some extent accommodated the uncertain nature of respondents' WTPs, most of such studies assumed the variance of WTP distribution to be homoskedastic with only a few exceptions (Alberini et al, 1997; Wang and Whittington, 2005). For example, Welsh and Poe (1998) adapted the "return potential" format and employed the MBDC strategy that asked respondents to express both the choice and the voting certainty for the referendum at each bid value. They found MBDC questions significantly reduced confidence intervals around the estimated WTP mean. However, as pointed out by Wang and He (2010), the underlying assumption in Welsh and Poe (1998) model was that all respondents shared similar distributions, and the heterogeneity in WTP variance was not considered. Alberini et al (2003) built upon the random valuation threshold model of Wang (1997) to model WTP thresholds be functions of respondent characteristics. While the heterogeneity in thresholds was acknowledged, the variance estimated in their model was still based on homoskedasticity assumptions. Alberini et al (1997) also noticed the heteroskedasticity possibility with their double-bounded DC strategies and modeled the WTP distance to price bids to capture the heterogeneity in variance. Although the results were mixed depending on the model specifications, the assumption of heteroskedasticity was not rejected. As will be described in more detail below, this study incorporates a heteroskedastic variance in the WTP estimations.

3. NMT Project in Pune

Pune, located near the west coast of India, is the eighth largest metropolitan city in the country. According to the 2001 Census, Pune has about 244 square kilometers of municipal land area and the population density is about 10,400 per square kilometer (World Bank, 2008). The area in the center of the city is much more densely populated. The main driver of the economy of Pune is the auto industry and its educational, research and development institutions.

Pune is historically known for its use of bicycles. While the usage of the bicycle has been gradually coming down over recent years with increasing urban sprawl and rising income levels, it still composes a major component of Pune transportation due to the significant slum population and student population. Walking and cycling currently constitute approximately 33-35% of the total trips in Pune (World Bank, 2008).

The current transport infrastructure in Pune, however, does not adequately meet the needs of NMT mode. It is characterized by traffic congestion with a rapid increase in private car and two-wheeler ownership; narrow, poorly maintained, unpaved and limited road networks; scarcity of parking spaces; motorized and non-motorized transport modes sharing roadways; inadequate

roadway accommodation for buses and NMT; lack of traffic signals, poor traffic control and management; increasing traffic accident risks especially among pedestrians and cyclists; overcrowded, non-accessible and inefficient public transport; alarming levels of pollution and noise associated with transportation; lack of transport infrastructure specifically designed for pedestrians and cyclists.

The Pune NMT project is a component of India Sustainable Urban Transport Program (SUTP), which was proposed to be financed by the World Bank. It is a comprehensive transportation infrastructure construction program including various physical investments in public transport, intelligent transport system technology applications, and investments in technical assistance and capacity building. The component NMT was specifically designed to improve the pedestrian and cycling infrastructure of the feeder roads along the two pilot Bus Rapid Transit (BRT) corridors - first running south on the Mumbai-Bangalore National Highway for a length of 5.6 km and the other running east along the Pune-Sholapur highway for a length of 8.2 km.

The key objectives of the NMT project include: facilitating the integration between BRTS and non-motorized transport; improving safety and a comfortable environment for non-motorized transport; using the "raised crosswalk" concept and underpasses for both pedestrians and cyclists to connect important BRT stations and non-motorized transport clientele; and formulating an integrated solution in the form of a network for non-motorized transport. The total length of the feeder roads which are to be renovated is 41.5 kms, with 23.8 kms in the vicinity of BRTS1 (Satara Road) and 17.7 kms on BRTS2 (Sholapur Road). The average width of the feeder roads is 20 meters. The construction includes footpaths, cycle tracks, cycle stands, underpasses, and trees, etc. The width of the footpaths and cycle tracks are 2 meters each. The construction should be completed in about one year after the project is approved, and the quality will last for at least 10 years.

This project aims to provide better access to urban activity centers for pedestrians and cyclists and make the roads a safer place for them to travel. Separate lanes for cyclists and pedestrians, wide roads, leveled pavements free of debris and other materials will make walking and cycling attractive alternatives to using motorized vehicles. Visual signs in the form of road markings would be put up and distinctive paving materials would be used. The facilities which are created specifically for pedestrians and cyclists would also make motor vehicle users conscious of the rights and privileges of the pedestrians and cyclists on the road. A more equitable distribution of road space would be sought for motorized and non-motorized traffic. The whole project will be enthusiastically promoted to encourage citizens to use the facilities created for them.[2]

[2] World Bank (2008) provides more details about the project.

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4. Survey Design, Implementation and Summary Statistics

4.1 Survey design and administration

A CV survey was conducted in Pune in March and April, 2009, to provide data for estimating the total value of the potential multi-dimensional benefits that the NMT project could bring to the residents in Pune. Prior to the main survey, two focus groups and 116 pretests were carefully conducted to enhance the understanding of Pune transportation situations and to improve the wording of the questionnaire and the visual aids. The survey was carried out by ten professional enumerators in a specialized survey company in Pune, and the survey enumerators were trained by one of the authors of this paper. Face-to-face interview was chosen as opposed to telephone interview to reduce selection bias, besides being a more effective technique for explaining the CV scenario to the respondents and gauging if respondents have understood the scenario they are being asked to evaluate. The target respondents were heads of those households who can make decisions on behalf of the entire families and are situated within the project area, which are defined as potential beneficiaries. The sample area covered seven wards of Pune (Tilak Road; Sahakar Nagar; Bibvewadi; Hadapsar; Vishrambaughwada/ Kasba Peth; Bhavani Peth, and Dhole Patil Road) that are neighboring the project sites. The total number of households located in the seven wards was estimated to be 234,689, or roughly 1.17 million individuals. A number of starting addresses in each ward were randomly selected first, and following the right hand rule, households neighboring the starting addresses were all selected to participate in the interview. A total of 1512 household heads were finally interviewed.

Table 1 gives the details of sample selection and interview. Except Dhole Patil, which had a high refusal rate, the response rates of all other six wards were quite high (>=70%).

The final survey questionnaire consists of four sections: (A) Urban development & transport. Questions were asked about the current socio-economic conditions in Pune, the issues and problems of the city, the level of satisfactions with the current transport system; (B) Bus Rapid Transit (BRT) System. This section covered the current household usage of public transport and BRTs, the difficulties in access to BRTS, the awareness of and the experience in BRTs; (C) NMT project and WTP elicitation. This key component provided the respondents with the background, feature and benefits of the project, and elicited individual information on their WTP preferences; (D) Follow-up questions about WTP and about individual and household demographic characteristics.

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Table 1: Sampling Details

Wards	Ward population*	Number of starting address used	Households contacted	Heads of Households not available	Households refused interview	Successful interview (% of household heads contacted)
Vishrambaughwada / Kasba Peth	209044	59	526	171	77	278 (78.3%)
Bhavani Peth	197547	52	502	193	69	240 (73.3%)
Hadapsar	188244	53	431	123	69	239 (77.6%)
Tilak Road	162041	39	319	121	24	174 (87.8%)
Bibvewadi	154516	52	385	86	33	266 (88.9%)
Dhole Patil	143483	40	704	322	212	170 (44.5%)
Sahakar Nagar	118568	35	301	111	45	145 (76.3%)
Total	1173443 (100%)	330	3168	1127	529	1512(74.1%)

*Ward population source: www.janwani.org

During the survey, visual aids were presented to facilitate the communication between the enumerators and the respondents (**Appendix 2**). A map shows the scale and location of the project and highlights the project streets and the feeder roads proposed to be renovated. A set of pictures of the streets after improvement helps explain the aims and the benefits of the project. A set of pictures of the current streets helps the respondents ponder over the road and traffic conditions in the city. The respondents can have a better understanding of the changes that the project can bring to them by comparing the two sets of pictures.

4.2 WTP elicitation

Before answering the questions on WTP for NMT road renovations, the respondents were provided with a detailed description of the key goals and objectives of the project, the background and rationale for the CV scenario, the potential payment vehicle, which is part of the electricity bill, and the possible impacts of the project on their households in the near future (**Appendix 1**). The project activities were reiterated to stress the fact that the project would bring about an improvement over the current situation. It was ensured that the respondents were reasonably familiar with the major concerns associated with the project and therefore able to consider these thoughtfully in a personal context.

In the questionnaire, the respondents were told that in order to complete this project, it is necessary to invest large sums for which the Government will require new sources of financing. The respondents were told that "Given that the PMC (the government) cannot cover all the cost for improving the transport

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situation in Pune, it is only reasonable that some additional fees be collected from households like yours. Every effort will be made to ensure the fees collected be solely used for this project. The purpose of the survey is to determine how strongly the citizens like you will support this transportation project which may introduce some cost to the household." The respondents were also told that "if the total fee collected from the households like yours is enough for the project, the project will be implemented and will be implemented properly. If the fee collected is not enough, this project will have to be cancelled." The respondents were told that once this project passes a referendum, a special urban construction fee, which will be solely used for the project, will be charged to the household through the electricity bill (or other utility bills if no electricity bills).

The respondents were then asked to think of their income and other necessary expenditures of the household in the future on food, clothes, transport, and entertainment, etc. before they select their WTP answers in the augmented payment card. The respondents were told that all potential costs to a household were listed, from 0 to a very large number that nobody would like to pay. For each cost, the respondents were asked to give an answer. The cost is the total payment that the household would have to make for this project, but can be made monthly in the next two years, or 24 times. Respondents were reminded that there was no right or wrong answer and only an honest answer from the respondent was wanted. To minimize the starting point bias, the enumerator did not necessarily begin at the price of zero on the payment card and proceed sequentially. In an attempt to help the enumerator select the starting point in the augmented PC, the respondents, in an earlier question, were asked to state their average monthly electricity bill. As the electricity bill is a fairly good indicator of the standard of living of the household, it was decided to take 30 % of the household electricity bill as the starting cost point at which the enumerators could begin the PC questions. The enumerators then moved forwards or backwards as the case needed. Such a design to a large extent minimized the potential protest bids, excess zeros or implausibly bid bids.

Three versions of augmented payment cards (APC) were designed in the survey. Rather than being asked to pick up a value in the payment card to reflect their maximum WTP as with a traditional payment card approach, in Version A of this survey, the respondents had two options, 'Yes' and 'No,' to respond to each of the prices in the payment card. In Version B, the respondents had 3 options, 'Yes', 'Not Sure' and 'No'. In Version C, the respondents had five options to respond to their WTP questions, 'Definitely Yes', 'Probably Yes', 'Not Sure', 'Probably No' and 'Definitely No'. All three versions consisted of an identical series of 24 prices ranging from 0 to 1000 Indian Rupees per month. The respondents were randomly assigned with one of the three augmented payment cards across the entire sample. The survey statistics shows, however, that only 4%

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of the respondents assigned to Version B ever chose the option of "Not Sure", and that only 8% of the respondents assigned to Version C circled "Probably Yes", "Not Sure" or "Probably No" as their answers; all of the rest respondents in version B and C gave 'yes' and 'no' answers with certainty. Therefore, in the final analysis, the answers from all three versions are combined together into a single format where a lower bound and an upper bound of an individual's WTP are utilized for the WTP estimation. Table 2 gives the standard augmented payment card design that the study employed.

Table 2: Payment Card Design

Total in Rs (for 2 years)	0 (free)	240	480	720	1200	1680	1920	2400
Monthly	0 (free)	10	20	30	50	70	80	100
Yes	1	1	1	1	1	1	1	1
No	2	2	2	2	2	2	2	2
Total in Rs (for 2 years)	3600	4800	7200	9600	12000	14400	16800	19200
Monthly	150	200	300	400	500	600	700	800
Yes	1	1	1	1	1	1	1	1
No	2	2	2	2	2	2	2	2
Total in Rs (for 2 years)	24000	36000	48000	72000	120000	168000	192000	240000
Monthly	1000	1500	2000	3000	5000	7000	8000	10000
Yes	1	1	1	1	1	1	1	1
No	2	2	2	2	2	2	2	2

4.3 Descriptive Statistics

Table 3 summarizes the statistics of the major variables for the total of 1512 respondents. These variables were grouped into 6 broad categories: (1) individual and household demographic characteristics; (2) household economic status; (3) current use of transportation system; (4) perceptions about the proposed project; (5) project impacts; and (6) personal uncertainties.

The survey statistics show that 83% of the respondents were male. The average age of the respondents was 43 years old. 92% of the respondents reported Hindu as their religion; 89% were married. Approximately one third of the respondents had undergraduate education or higher; very few of them currently inactive in labor force (6%). The average household size was 4 persons. On average it takes 14.6 minutes of walk from home to the nearest roads to be renovated.

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Table 3: Descriptive Statistics of Major Variables

Variable	Description	Mean	Std
(1) Individual and household demographic characteristics			
Male	Gender (male=1, female=0)	.82	.37
Age	Age	43.3	12.5
Hindu	Religion (Hindu=1, other=0)	.92	.26
married	Marital status (married=1, other status=0)	.89	.30
highedu	Education category (undergraduate or higher including vocational=1, secondary or below=0)	.36	.48
Notinlf	Labor force status (not in labor force=1, in labor force=0)	.06	.23
Hhsize	Household size	4.6	2.0
distancetime	Home walking distance (minutes) to the nearest road to be renovated	14.6	10.8
(2) Household economic status			
hhincome	Household monthly income in thousands Rupees	9.6	6.8
electricbill	Household monthly electricity bill divided by household monthly income	5.3%	5.0%
travelexpense	Household monthly transportation cost divided by household monthly income	11.0%	8.4%
(3) Household current use of transportation system			
transportimport	Think transportation is one of the three most important problems in Pune (yes=1, no=0)	.47	.49
modewheeler	Current most frequent transportation mode in household (two-wheeler=1, other=0)	.55	.49
BRTuse	Household members used BRT in last month (yes=1, no=0)	.77	.42
(4) Perception about proposed project			
roadworse	Current road condition around home compared to the pictures shown to the respondent (worse=1, better or same=0)	.33	.47
projectuseful	Think project is generally useful to the household (yes=1, no or not sure=0)	.77	.41
PMCgoodjob	Think Pune Municipal Corporation (PMC) can do a good job in project operation (definitely yes or to some extent yes=1, definitely no or to some extent no or neutral=0)	.29	.45

Table 3: Descriptive Statistics of Major Variables *(continued)*

Variable	Description	Mean	Std
(5) Project impact and use			
environmentimpact	Think project will have positive impacts on environment (yes, significant impact=1, no impact or maybe some impact=0)	.17	.38
incomeimpact	Think household income will increase as a result of road renovation in two years (yes=1, no or not sure=0)	.10	.31
streetsafe	Think roads will be safer after renovation (yes, a lot safer=1, no or only a little bit safer or not sure =0)	.15	.35
healthimprove	Think people's health will be improved as people use renovated roads (yes, significantly=1, no or very marginal improvement or not sure=0)	.31	.46
futurewalkcycle	Household member will walk or cycle on renovated road in future (yes=1, no=0)	.54	.49
futurevehicle	Household member will drive on renovated roads in future (yes=1, no=0)	.87	.32
futurebus	Household member will take bus on renovated roads in future (yes=1, no=0)	.71	.45
morepeople	Think more people will walk on roads after renovation (definitely yes or probably yes=1, no or not sure=0)	.73	.43
(6) Personal uncertainty			
notsureuse	Respondent was not sure which activity the household members would use the renovated roads the most (not sure=1, sure=0)	.28	.45
notsureincome	Respondent was not sure whether the household income will increase in future (not sure=1, sure=0)	.18	.38

The average monthly income of the households that participated in the survey was approximately 9.58 thousand Rupees[3] (equivalent to 192 US dollars). The electricity bill accounted for about 5% of the total household income, and 11% of the income was spent on transportation associated activities.

On matters pertaining to transportation, 47% of the respondents viewed transportation as one of the top three most important problems that Pune needs to urgently address, while the top transport related issues were road congestion,

[3] One India Rupee equals to roughly 0.02 US Dollar.

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maintenance and safety. According to the respondents, the most favorable option for reducing traffic congestion and transport related air pollution was to improve public transportation and have stricter enforcement of vehicle emission limits. 99% of the respondents said that improving the current transport of the city was important or very important. 73% of the respondents had family members who used public transport last month and most of them said it was not easy to access to the public transport system. Over a half of the households reported two-wheeler vehicles as the most frequently used transportation mode, and 70% of the families used two-wheelers in last two months. Almost all of the respondents were aware of the BRTS in PUNE and 77% of them had family members who used the BRTS last month in various ways. But most of them (73%) were not satisfied with their experiences in using the BRTS. 62% of the respondents thought the BRTS were very useful or somewhat useful, and 76% agreed that it would be a good idea for Pune to construct more BRTS type of roads.

33% of the respondents said the roads around their homes were worse than the average roads in Pune shown in the pictures (**Appendix 2**). For 41% of the respondents, they witnessed some accidents in the NMT project affected streets in the past 3 months. 77% of the respondents thought the project was useful to their families and 90% said the project would be very important or somewhat important to their families. Only about 30% of the respondents asserted that PMC could do a good job in managing the implementation of the project. People's confidence in money collection feasibility was not very high either: only 11% stated that PMC would not have problem at all to collect money and another 39% believed there would be some problem but it was still possible.

Various perceived impacts of the proposed NMT project were explored in the survey. 17% of the respondents said that the project would have significant positive impacts on city environment, 15% said the streets would be a lot safer after renovation, and a third of them thought people's health would be significantly improved as people would walk or cycle on the renovated roads more. The direct income effect of the NMT project is deemed marginal: only 10% stated their household incomes would be increased as a result of road construction. A majority of the households stated that they would use renovated streets in various ways including walking, cycling, driving or taking bus.

All of the above 5 broad categories of major variables can be viewed as potential determinants of the WTP for the project and were included in the maximum likelihood function for WTP estimation. To estimate WTP standard variance (σ), a unique set of variables revealing personal perceptions on uncertainties was also included. We hypothesized that the dispersion of an individual's WTP increases with his/her uncertainties in the specified commodity and in the expectation on purchase capabilities in the future. Two indicators were therefore generated to represent the personal degrees of uncertainty: how certain a

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respondent knew how to use the roads after construction, and how certain a respondent was about his/her household income in the future. Concerning the degree of certainty that respondents had with respect to the future use of the roads after construction, the statistics shows that 28% of the respondents were not sure about which activity the household would use the roads the most. A smaller proportion (18%) of the respondents was uncertain regarding the income growth in the future.

5. Analytical Framework and Estimation Results

5.1 Analytical Framework

As described above, with this APC approach, each of the respondents in the sample has a lower payment value for which an answer of "yes" is recorded and an upper payment value for which an answer of "no" is recorded. A modeling strategy for such a double-bounded WTP data can be built upon the double bounded dichotomous choice model introduced by Hanemann et al. (1991) and the traditional payment card model developed by Mitchell and Carson (1981). This new elicitation strategy can produce a more efficient estimation of WTP because this approach not only elicits individual preferences along with a lengthy list of bids, as the traditional payment card approach does, but also narrows an individual's WTP range down to a narrower and more accurate bid interval, similar to a bidding game.

Assume that the indirect utility of an individual i depends on the usage of the constructed NMT road and other explanatory variables. Let q^1 and q^0 represent the utility levels associated with and without the NMT project, y is income, $W*$ is the amount of money an individual is willing to pay, X represents the vector of socioeconomic characteristics or other factors that may affect WTP. The WTP that equates the two indirect utility functions under the initial condition without the project and under the improved situation with the project can be written as:

$$v[(q^1, y - W*, X, \varepsilon)] = v[(q^0, y, X, \varepsilon)] \quad (1)$$

where ε represents the uncertain factors which are not reflected in y, q, W.

Solving for the equation, we have, W* = $WTP(q^1, q^0, y, X, \varepsilon)$. Suppose that each individual has his or her own willingness-to-pay W_i* ,and that W_i* follows some form of a cumulative distribution function F(t). Although we do not directly observe W_i* from the payment card responses, we know W_i* for individual i lies somewhere between W_{iL} and W_{iU}, where W_{iL} is the lower bound

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that individual i would vote for, and W_{iU} the upper bound that individual i would not vote for. Thus the probability of individual i's WTP falling between the interval $[W_{iL}, W_{iU}]$ is

$$\Pr(W_{iL} \le W^*_i \le W_{iU}) = F(W_{iU}) - F(W_{iL}) \tag{2}$$

With a specific distribution function assumption for F(t), such as a normal distribution, the WTP mean (μ_i) and standard variance (σ_i) for an individual can be estimated by maximizing the following log likelihood function:

$$LogL = \sum_{i=1}^{n} \log[\Phi(\frac{W_{iU} - \mu_i}{\sigma_i}) - \Phi(\frac{W_{iL} - \mu_i}{\sigma_i})] \tag{3}$$

Both μ_i and σ_i can be functions of personal characteristics and other variables, and linear functions of them can be specified as the following:

$$\begin{aligned} \mu_i &= \beta_0 + x_i'\beta_1 + \gamma_i \\ \sigma_i &= \delta_0 + z_i'\delta_1 + \nu_i \end{aligned} \tag{4}$$

where x_i and z_i include individual and household characteristics and other WTP determinants, and the error terms γ_i and ν_i in the two equations can be assumed to have means of zero and be normally distributed. By substituting the two equations in (4) into the likelihood model (3), the WTP determinants can be estimated[4].

The alternative homoskedasticity model, as used in almost all of the previous studies, assumes that all respondents share the same σ. The hypothesis of equality between the estimated maximum likelihood functions under heteroskedastic assumption and homoskedastic assumption can be formally tested by using the likelihood ratio (LR) test:

$$LR = -2\ln(\frac{ll_{\text{hom}o}}{ll_{hetero}}) \sim \chi^2(df_{\text{hom}o} - df_{hetero}) \tag{5}$$

Where $ll_{\text{hom}o}$ and ll_{hetero} are the log likelihood estimates associated with the homoskedastistic model and the heteroskedastic model, respectively. The second difference in these log likelihoods follows a chi-square distribution with ($df_{\text{hom}o}$ - df_{hetero}) degrees of freedom. The conventional homogenous assumption on WTP will be tested empirically in this study.

[4] Benefit estimation studies are not only expected to produce estimates of the levels of the mean and the variance of WTP but also their determinants such as income and the quantity and quality of the good or service in valuation.

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5.2 Results

5.2.1 WTP Response Categories

Table 4 shows the categories of WTP responses of the 1,512 respondents in the sample, which include protect responses, negative WTPs, zero WTPs, zero/very small positive WTPs (between 0 and 10 rupees, the lowest price shown in the payment card), and significant positive WTPs. In order to distinguish the protest responses from the valid positive WTP responses and investigate their motivations, we asked a follow-up question for those respondents regarding why they said "no" to the price of zero (**Appendix 4**). Among the 10 statements

Table 4: Categories of WTP Responses

Category	Category of response pattern	Percentage
1	Protest responses: respondents who gave a negative answer to the price of zero and chose one of the following as the reason: "I should not pay; it is government's or other persons' responsibility", "I disagree with the project design", "I would need more information or time to think about the issue", "I think only 'user fees' should be charged to finance the project", and "I don't trust the government"	2.71%
2	Negative WTP: respondents who gave a negative answer to the price of zero and responded "yes" to the reason "the project has negative impacts on my household"	3.90%
3	Zero WTP: respondents who gave a negative answer to the price of zero and chose one of the following as the reason: "the project is not useful or important to me", "I do not have money", "I am not interested in this project", and "I am satisfied with the current situation"	8.20%
4	Zero or very small WTP (between 0 and 10): respondents who said "yes" to the price of zero but "no" to 10 rupees, the lowest positive price listed in the payment card	55.62%
5	Significant positive WTP: respondents who said "yes" to the price of 10 rupees, the lowest positive price in the payment card.	29.43%
6	Missing WTP information	0.13%
	Total number of responses	1512

provided, five were classified as valid answers for zero/negative WTPs, and the other five were classified as protesting to the WTP scenario. Based on the answers to the follow-up questions, 41 responses were identified as protest responses, 59 as having negative WTPs and 124 as having true zero WTPs. To better understand the protest responses, we did a binary Probit analysis on those who said "no" to the price of zero, and the results are reported in of the roads close to the

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household, or thought that the project was useful or that the project might generate positive impact on their income, but still gave a negative response to the price of zero, the answer is more likely a protest one.

Table 5. In general, the results are consistent with expectations. If a respondent had a high income or bad condition of the roads close to the household, or thought that the project was useful or that the project might generate positive impact on their income, but still gave a negative response to the price of zero, the answer is more likely a protest one.

Table 5: Analysis of the Protest Bids

Variable	1=negative/zero bid; 0=protest bids
(1) Individual and household demographic characteristics	
Male	-.35 (-0.55)
Age	-.00086 (-0.06)
Hindu	-.48 (-0.51)
Married	.32 (0.59)
Highedu	.33 (0.86)
Notinlf	-.66 (-0.98)
Hhsize	-.058 (-0.73)
Distancetime	-.037 (-1.50)
(2) Household economic status	
Hhincome	-.099 (-3.04)***
Electricbill	-.90 (-0.31)
Travelexpense	-.47 (-0.18)
(3) Household current use of transportation system	
Transportimport	.14 (0.41)
Modewheeler	.35 (0.95)
BRTuse	-.016 (-0.04)
(4) Perception about proposed project	
Roadworse	-.82 (-1.99)**
Projectuseful	-1.74 (-3.13)***
PMCgoodjob	-.38 (-0.78)
(5) Future project impact	
environmentimpact	.85 (1.49)
Incomeimpact	-.71 (-1.64)*
Streetsafe	-.068 (-0.12)
Healthimprove	-.61 (-1.47)
Futurewalkcycle	-.60 (-1.59)
Futurevehicle	.14 (0.26)
Futurebus	-.44 (-1.13)
Morepeople	-.41 (-0.98)
Ward dummies	Yes
Obs.	222
Log Likelihood	-49.495

Note: 1) t values are in the parentheses; 2) *denotes p<.1; ** p<.05; *** p<.01

A total of 1,286 respondents, or 85% of the sample, were willing to contribute some positive values to the proposed project. Among the 1286 respondents, 841 respondents were only willing to pay a very limited amount, ranging between 0 and 10 Rupees per month; the remaining 445 respondents reported at least 10 Rupees per month as their WTP lower bounds. Two observations did not have complete information on WTP and they are removed from the sample before doing further analyses.

5.2.2 WTP Distribution Estimation

Table 6 shows the estimation results of the maximum likelihood procedure with six different model specifications. Coefficients, t-values (in parentheses), and log likelihood values were reported. The average values and the 95% confidence intervals of the mean and the standard variance of WTP were simulated using the approach proposed by Krinsky and Robb (1986). The levels of statistical significance are indicated using asterisks.

We started with a benchmark model (model 1) that included a full set of determinants and assumed that the variance heterogeneity was captured by the individual characteristics and uncertainties. An effective sample of 1,272 respondents who had positive WTPs was included. The simulated mean WTP for the NMT project was 20.9 Rupees per month (about 0.22% of income)[5] and the 95% confidence interval was 19.1-22.7 Rupees per month among the population that was willing to finance the project.

In model 1, it was assumed that those who were willing to pay zero or a very small amount behave in the same way as those who were willing to pay a significant, positive amount. In order to better understand the difference, we conducted analyses using a sub-sample of 437 respondents who were willing to pay more than 10 Rupees per month, with three alternative models under same heteroskedasticity assumption. Results were also listed in Table . Model 2 was simply the sub-sample analysis of model 1. Model 3 only kept individual

[5] It is about $10 in two years.

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Table 6: WTP Estimation Results

	Heteroskedasticity Model								Homoskedasticity Model	
	Model1		**Model2**		**Model3**		**Model4**		**Model5**	**Model6**
Variables	**Mu**	**lgsigma**	**Mu**	**lgsigma**	**mu**	**lgsigma**	**mu**	**lgsigma**	**mu**	**mu**
Constant	4.48 (0.95)	1.26 (5.64)***	-6.62 (-0.55)	1.33 (3.17)***	11.82 (0.78)	1.83 (5.71)***	36.73 (3.85)***	2.09 (7.60)***	-3.18 (-0.32)	11.57 (0.49)
(1) Individual and household demographic characteristics										
Male	-.39 (-0.31)	.012 (0.19)	6.84 (2.01)**	.098 (0.84)	6.72 (1.49)	.31 (3.03)***	.25 (0.08)	-.16 (-1.66)*	1.87 (0.59)	9.50 (1.32)
Age	-.017 (-0.40)	.00053 (0.22)	.18 (1.35)	.0048 (1.13)	.21 (1.19)	.0064 (1.59)	.049 (0.47)	.00062 (0.17)	-.0072 (-0.07)	.18 (0.69)
Hindu	-4.96 (-2.01)**	-.20 (-2.23)**	-1.66 (-0.37)	.34 (2.01)**	-6.13 (-1.18)	.53 (3.14)***	-8.11 (-2.25)**	.27 (1.84)*	-3.71 (-0.85)	-8.14 (-0.83)
Married	-2.83 (-1.69)*	-.17 (-2.00)**	.96 (0.22)	.029 (0.20)	6.61 (1.37)	.23 (1.68)*	.87 (0.27)	.030 (0.24)	.82 (0.20)	8.42 (0.93)
Highedu	1.61 (1.13)	.45 (8.12)***	19.14 (4.38)***	.51 (5.07)***	29.60 (5.07)***	.62 (6.58)***	7.15 (2.49)**	.15 (1.72)*	11.33 (4.16)***	31.66 (5.13)***
Notinlf	-2.49 (-1.53)	-.19 (-1.65)*	30.15 (2.70)***	.20 (0.75)	29.25 (2.73)***	-.23 (-0.85)	13.25 (2.11)**	-.14 (-0.56)	-4.93 (-0.95)	5.35 (0.31)
Hhsize	1.46 (4.29)***	.10 (8.00)***	.34 (0.41)	.059 (2.69)***	.50 (0.47)	.02 (1.36)	-.61 (-1.01)	.028 (1.62)	1.66 (2.68)***	1.50 (1.16)
Distancetime	.10 (2.24)**	.000060 (0.02)	-.37 (-2.69)***	-.0062 (-1.34)	-.23 (-1.28)	.0084 (2.29)**	-.19 (-1.95)*	.000056 (0.02)	.13 (1.12)	-.27 (-1.05)
(2) Household economic status										
Hhincome	.80 (4.01)***	.063 (10.64)***	2.02 (3.66)***	.032 (3.88)***	.81 (1.46)	.011 (1.53)	.39 (2.40)**	-.0054 (-0.87)	.65 (3.11)***	1.08 (2.60)***
Electricbill	37.96 (1.72)*	8.28 (14.06)***	280.49 (4.78)***	7.29 (6.72)***	84.54 (2.11)**		18.44 (0.88)		92.11 (3.46)***	219.80 (4.09)***
Travelexpense	20.73 (2.38)**	1.12 (2.88)***	12.59 (0.53)	.37 (0.55)	-.38 (-0.02)		9.36 (0.65)		15.69 (1.02)	22.13 (0.62)
(3) Household current use of transportation system										
Transportimport	-4.16 (-3.91)***	-.27 (-4.55)***	-9.89 (-3.04)***	-.29 (-2.76)***	-9.74 (-2.30)**		-4.54 (-1.92)*		-5.31 (-2.09)**	-3.68 (-0.62)
Modewheeler	2.77 (2.31)**	.21 (3.93)***	3.96 (1.16)	-.019 (-0.19)	8.42 (1.94)**		7.57 (2.84)***		2.51 (0.94)	3.75 (0.60)
BRTuse	-1.59 (-0.90)	-.069 (-1.01)	5.74 (1.55)	.25 (2.15)**	7.24 (1.46)		2.18 (0.71)		-3.35 (-0.95)	5.41 (0.75)
(4) Perceptions about proposed project										
Roadworse	1.11 (1.03)	.021 (0.40)	-1.48 (-0.47)	-.037 (-0.35)	-6.47 (-1.56)		-1.13 (-0.48)		-.57 (-0.22)	-10.89 (-1.79)*

Projectuseful	-2.39 (-1.26)	-.32 (-4.16)***	2.33 (0.53)	-.29 (-2.11)**	5.49 (1.01)	5.77 (1.72)*	-.94 (-0.26)	-3.77 (-0.47)
PMCgoodjob	6.88 (4.67)***	.21 (3.81)***	6.56 (2.14)**	-.16 (-1.79)*	9.37 (2.39)**	6.42 (2.61)**	8.67 (3.21)***	3.13 (0.55)
(5) Future impact and use								
Environment Impact	2.99 (1.64)*	.39 (5.33)***	-1.97 (-0.43)	.31 (2.70)***	.14 (0.03)	-4.09 (-1.51)	4.21 (1.29)	-4.75 (-0.69)
Incomeimpact	7.69 (3.09)***	.56 (6.43)***	-3.60 (-0.73)	-.040 (-0.26)	.0033 (0.00)	-3.49 (-1.00)	7.02 (1.79)*	-5.93 (-0.73)
Streetsafe	6.06 (2.57)***	.38 (5.63)***	13.36 (2.80)***	.38 (3.02)***	9.06 (1.68)*	-.60 (-0.19)	4.93 (1.37)	10.57 (1.39)
Healthimprove	7.16 (4.92)***	.35 (6.69)***	9.87 (3.11)***	.013 (0.13)	10.94 (2.56)**	7.15 (2.76)***	8.88 (3.21)***	9.80 (1.62)*
Futurewalkcycle	.057 (0.05)	-.12 (-1.99)**	3.65 (1.01)	-.32 (-2.81)***	5.28 (1.16)	9.40 (3.30)***	-.19 (-0.07)	6.56 (0.97)
Futurevehicle	.21 (0.16)	.38 (4.67)***	15.71 (4.38)***	.62 (4.20)***	12.69 (2.39)**	.50 (0.17)	1.83 (0.47)	16.50 (2.08)**
Futurebus	-1.04 (-0.71)	.0068 (0.10)	-2.40 (-0.61)	-.020 (-0.18)	-6.92 (-1.36)	-5.45 (-1.87)*	-2.48 (-0.78)	-5.72 (-0.82)
Morepeople	.55 (0.43)	.027 (0.45)	-6.49 (-1.83)*	.085 (0.76)	-6.52 (-1.29)	-4.93 (-1.60)	.46 (0.16)	-5.88 (-0.82)
(6) Personal uncertainty								
Notsureuse		.39 (5.33)***		.056 (0.41)	-.031 (-0.26)	.18 (1.89)*		
Notsureincome		-.12 (-1.80)*		.25 (1.93)**	.14 (1.27)	.13 (1.40)		
WTPinterval						.030 (15.64)***		
OBS	WTP 0+ respondents (#=1272)		WTP 10+ respondents (#=437)		WTP 10+ respondents (#=437)	WTP 10+ respondents (#=437)	WTP 0+ respondents (#=1272)	WTP 10+ respondents (#=437)
Log Likelihood	-2822.801		-930.582		-1020.59	-812.496	-3373.680	-1107.163
Mean Mu (Standard Deviation)	20.91 (0.97)		58.43 (2.96)		59.64 (3.72)	55.10 (2.38)	23.64 (1.15)	60.41 (2.60)
Mu %95 CI	19.09-22.75		52.61-63.69		52.34-66.37	50.43-61.60	21.38-25.78	55.31-65.43
Mean Sigma (Standard Deviation)	26.46 (1.82)		45.03 (5.17)		44.70 (10.19)	45.03 (4.97)	41.18	54.87
Sigma %95 CI	23.07-30.03		34.88-59.73		24.72-73.51	35.27-63.98		

* p<.1; ** p<.05; *** p<.01. Note: Mu and Sigma estimate both included ward dummies (results not shown here).

demographic characteristics and uncertainty in σ estimation and neglected the association between σ and other determinants of WTP. Model 4 treated the standard variance σ as a function of WTP interval, personal uncertainty as well as the basic individual demographic characteristics.[6]

Among the three alternative heteroskedasticity models, model 3 yielded the highest mean WTP estimate of 59.6 Rupee per month or $28.6 in two years (%95 CI: 52.3-66.4 Rupees per month), followed by model 2 for 58.4 Rupees per month (%95 CI: 52.6-63.7) and model 4 for 55.1 Rupees per month (%95 CI: 50.4-61.6); while the average standard variance was estimated to be 45.0, 44.7 and 45.0 Rupees per month for model 2, 3 and 4 respectively. However, the differences between the estimates obtained from the heteroskedasticity models with the subsample were not statistically significant.

The estimates, the signs and the significant levels, of some variables were quite different between model 1 and the three alternative models, even though in general the determinants of mean value μ and standard variance σ were quite consistent in four alternative heteroskedasticity models and the WTP estimates varied generally in logical ways with most explanatory variables and had a substantial face validity. Among individual demographic explanatory characteristics, religion, education and labor force status were found to be significantly associated with the WTP levels. The coefficient of home distance to the nearest renovated road, however, switched its sign from significantly positive in the full sample analysis to significantly negative in the sub-sample analysis. This indicates that the unexpected positive relationship between distance and WTP was primarily driven by the WTP responses from the people who were willing to pay merely a very small amount. In general the households living nearby are expected to be willing to spend larger amounts on the project because they were supposed to benefit more from the project.[7]

As to household economic status, we may expect that the richer households would be willing to pay more if the road construction is a normal good. This was confirmed by the positive and significant estimates of household

[6] The WTP distributions are likely to be more dispersed as WTP increases because for some respondents, their WTPs may be high enough to make them indifferent to a range of values around the mean. Therefore the estimated μ is correlated naturally with σ in the σ equation. In addition, the payment card design is such that the intervals between the two adjacent prices in the payment card are not constant but increase exponentially. Then, there should be a design effect on the correlation between the WTP mean and the variance. Alberini et al (1997) treated variance as a function of the distance between WTP and the bid price provided to the respondents. We also incorporated the difference between WTP lower bound and upper bound in the σ estimation as a replacement of μ.

[7] We do not know whether or not the property value is positively correlated with the distance to the nearby streets.

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income, travel expense, and electricity bill[8]. The households whose current transportation modes were mostly two-wheelers were willing to pay 30%-40% more than other transportation mode users. The sign of people's perception on project usefulness indicates an insignificant and negative relationship with WTP in the benchmark model, but the sign changed to positive in the three alternative models and the significance level substantially increased in model 4. As to the capability of project operation, the significant, positive signs suggest that the respondents who trust the capability more are willing to pay more, just as expected. Among the variables of project's future impacts, the effects of direct income increase, environmental benefit and street safety were mixed, depending on the samples analyzed, while the personal health improvement and the future street use were consistently associated with the respondents' valuation of the project across the four heteroskedasticity models[9].

Regarding the WTP standard variance equations, most of the significant variables found in the μ equations were also shown to be significantly correlated with σ in model 1 and 2. This supports our prior expectation that the estimated WTP captures a large portion of the WTP distribution heterogeneity. The difference between the WTP lower bound and upper bound also gave a significant and positive relationship with the WTP standard variance in model 4, confirming our second hypothesis that the WTP variance estimation is partly determined by the designed intervals in the payment card. The estimated log likelihood values associated with the different models on WTP standard variance σ suggest that incorporating WTP into the modeling processes in model 2 and 4 had led to a substantial improvement of model fit over Model 3 which included only individual and household demographic characteristics and individual uncertainties to capture WTP variance heterogeneities. The uncertainties in future street use mode further enlarged the WTP dispersion around the mean, as we expected, and the uncertainties in future household income also significantly and positively contributed to the WTP variances in the models using sub-samples.

Comparing the benchmark model with the three alternative heteroskedasticity models, we found that the alternative models, which were run for those who were willing to pay a significant amount for the project, performed much better. Two important variables – distance from home to the project streets and usefulness of the project, showed the expected signs in the alternative models. This may indicate that those who were willing to pay zero or very little had different behaviors from those who were willing to pay a significant amount.

[8] The effects of electricity bill may also capture some start point effects, as respondents started working on the payment cards at values close to one third of their electricity bills.

[9] We also tested on the effects of questionnaire version dummies in all four models and found that the dummy variables were not significant. The results are not shown in the tables but are available upon request.

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Among the three alternative models, model 4 gave the best results, which show that for those who had higher income or higher education, or were not in the job force (staying at home), using two-wheelers, viewing the project as useful, having positive health impact, believing that PMC can do a good job, or having family members walking or cycling in the renovated streets, the WTP was higher, while for those who were Hindu, far away from the renovated streets, or taking the bus in the renovated streets, or thought that transportation improvement in Pune was very important, the WTP was less. It seems counterintuitive for those who thought transportation improvement in Pune to be very important to be willing to pay less. One reason could be that those people were not satisfied with the current project design or scale and would like to have a bigger improvement. Significant variables in the variance equation included gender (men have lower variance), Hindu (higher variance with those Hindu), education (positive correlation), uncertainty in the future use of the renovated streets, and the payment card interval (the design effect and natural correlation between WTP mean and variance).

The last two columns of Table present the WTP mean (μ) estimates under homoskedasticity assumptions. Model 5 used all of the responses that were positive at the price of zero, which corresponds to model 1. In model 6, those who were negative at the lowest price (10 rupees) were removed, just like in model 2. Despite the differences in the significant levels of the models and in the signs of some coefficients, the two homoskedasticity models yielded generally similar estimation results to their heteroskedasticity model counterparts. A Hausman test suggested that the differences in coefficients between the homoskedasticity model and the heteroskedasticity model were systematic, and the likelihood ratio test also supported our hypothesis that the models controlling for variance heteroskedasticity substantially improved the data fit. Simulations with the homoskedasticity models generated significantly higher average WTP estimates than with the heteroskedasticity models. Homoskedasticity model 5 which was based on a full sample yielded an average WTP of 23.6 Rupees/month (%95 CI: 21.4-25.8), and an average WTP of 60.4 (%95 CI: 55.3-65.4) was obtained for those who reported WTPs significantly different from zero in the homoskedasticity model 6.

6. Implications for Benefit-Cost Analyses

The primary objective of this study was to estimate the total economic value of the benefits generated by the NMT project in Pune, India, and to compare the total benefit with the total cost of the project. With a stated preference approach, this study obtained an estimate of the total willingness-to-pay of the project beneficiaries in Pune for the project implementation. Most respondents living in

or close to the project area were found to be willing to finance the proposed NMT project, while about 35% of the respondents were willing to pay some positive amounts significantly higher than zero, or more than 10 Rupees per month for two years. On average, a household was willing to pay 21 Rupees per month for two years[10]for the project, and this generated an aggregate WTP of roughly 10 million US dollars. Even though this value can be viewed as of a conservative estimation of the total benefit, as will be discussed in more detail below, the total benefit estimated was thought to be considerable lower than the total cost as estimated by the World Bank for the first version of the project design, which was about 17 million US dollars.

A number of lessons can be learned from this study for conducting similar benefit-cost analyses elsewhere. First of all, there can be a large number of beneficiaries[11] who have very low values attached to a project, and the nature of these values can be very different from those significantly higher than zero. Including those who are only willing to pay a very small amount for the project into the modeling process is found to make the conventional WTP modeling technique not fit well, and excluding those responses with very small WTPs can provide a much better fit. It is suggested that when an augmented payment card approach is employed to elicit people's values, as used in this study, the first positive price should be designed to be as low as possible, so that less estimation bias would be generated when the observations with a lower bound of zero are excluded in the modeling process. Secondly, heterogeneity should be considered in modeling the WTPs, which can not only affect the efficiency of the estimations, but also the potential biases. The explanation and prediction powers of the WTP models can be stronger after the heterogeneity issues are taken into considerations.

While the models obtained in this study can hardly be used directly for the purposes of benefit transfer to estimate the total benefit of a similar project because the project scale cannot be quantified into the models, however, those significant determinants of WTP, both the mean value and the standard variance, found in this study can help provide some insights in judging the potential benefits of similar projects. In model 4, our favorable model with high estimation efficiency, household income, distance from the renovated streets, current use of the transportation services, future use of the project streets, perceived project impacts, views on the usefulness of the project, importance of the transportation

[10] This is about 0.2% of the household income.

[11] Where to draw a boundary for a project's beneficiaries, including those affected both positively and negatively by a project, can be an important issue in doing benefit-cost analyses, which involves trade-offs between the study costs and the potential accuracies of the analyses. In theory, the World Bank considers the benefits and the costs globally and therefore the beneficiaries of a project can include everyone in this world. But in reality, reasonable boundaries of a project's beneficiaries have to be determined first and the benefits and the costs incurred outside the boundaries have to be ignored.

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improvements in the city, effectiveness of the project management, as well as respondents' education, job status, religion background, were all found to be significant determinants of the WTP mean value. An increase of one thousand Rupees in monthly income can increase the WTP for 0.4 Rupees. A household head with educations of college or higher may be willing to pay 7 Rupees higher than those with lower educations. Those with Hindu religion were willing to pay 8 Rupees less. Those who stayed at home and do not have a paid job were willing to pay 13 Rupees more than those having a job. Those using two wheeler vehicles were willing to pay 8 Rupees more. Those who will mostly walk or ride bicycles on the renovated streets were willing to pay 9 Rupees more, and those who will mostly take bus in the renovated streets were willing to pay 5 Rupees less. The distance from home to the nearest street that would be renovated is in fact an indicator of project scale. The longer the streets to be renovated by the project, the shorter the distance will be. One more minute of walk from home to the nearest renovated street will generate 0.2 Rupees of less WTP. These payments are of monthly ones for two years.

There are limitations, however, in using the approach presented in this paper to do benefit-cost analyses. First of all, the value estimated is only for the benefits that can be perceived by the respondents. In theory, a survey can remind the respondents of all potential benefits, both the direct ones and the indirect ones, which can be generated by a project. However, it is possible that there are always some types of benefits that are beyond the level of comprehension for some respondents. Secondly, the value estimated is of stated preferences which may have deviations from the actual economic behaviors, even though the issue may not be very serious according to previous research (Smith, 2004). Thirdly, the value estimated is only of those residents close to the project area, and those who are living remotely are ignored. Excluding the benefits that a project can potentially generate to the people outside the predetermined project beneficiaries from a project benefit-cost analysis can seriously under value the project. However, this issue is not considered serious for this particular study, given that a large amount of near zero WTP has been included in the analyses.

Several issues potentially associated with the contingent valuation method, such as the potential hypothetical bias, strategic bias, and uncertainties, etc, may also influence the accuracy of the benefit estimation. The potential hypothetical bias with this study is thought to be at the minimum, as this is a real project in consideration for investment, and the respondents were found to be serious about the survey and they believed they would have to pay something for this project if the project was going to be implemented. The potential strategic behaviors of the respondents may produce a downward bias in the benefit estimation. In the survey, the respondents were told that if the total project cost could not be covered by the residents, the project would not be implemented. This scenario design was

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expected to be able to help correct some of the potential strategic bias, but there is no way to judge whether or not the bias still presents and how serious the bias is if it still present. The potential uncertainties that the respondents might have in valuation have been taken care of in the study design by using the augmented payment card approach and in the WTP modeling strategy where a variance function was explicitly specified and estimated.

There may be some factors that can influence a respondent's WTP for a project but in theory should not influence the level of benefits that the person will enjoy after the project is implemented. If there are such cases, calibrations should be conducted. Two variables in this study may belong to this category. One variable is pmcgoodjob, which indicates that the respondents trusted the government in implementing the project and had a positive significant correlation with the WTP. If one believes that those who did not trust the government in project implementation would be willing to pay less for the project rather than have less benefit from the project, this study would have underestimated the total value of the project benefit. Only 29% of the respondents fully trust the government and each of them would be willing to pay 6 Rupees more in average than those who did not trust in the government. Another variable is transportimport, which indicates that the respondents thought that transportation was one of top three problems that Pune should urgently address. A negative correlation of this variable with WTP is found, which could mean that such respondents were less satisfied with the project design or scale and there might be a protest feeling embedded in their WTP answers, because if otherwise, the correlation should be positive. If this is the case, the WTP estimation should be downward biased. 47% of the respondents belong to this category and each of them might be willing to pay 4 Rupees less. Calibration on the two variables can be conducted by making assumptions such as that all of the respondents trust that the government will do a good job and all of the potential benefits described in the project will be realized and that nobody thought that transportation was among the top three urgent issues of the city. These extreme assumptions can over-calibrate the WTP value, but the total benefit estimation after calibration was still lower than the total project cost.[12]

7. Conclusion

This paper reports a willingness-to-pay (WTP) study on the combined benefits of a non-motorized transport (NMT) project in Pune, India, using the contingent valuation (CV) method. The NMT project has multi-dimensional benefits in public health, safety, environment, congestion, travel convenience, and others. A

[12] The mean WTP can be increased from 21 to 27 Rupees per month with these assumptions.

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sample of project beneficiaries was randomly selected to participate in a survey where a detailed description of the project, including the current status and the use of the roads, the project objectives and activities, the potential impacts, etc., was presented to the survey participants, who were subsequently asked to vote on whether or not to have such a project under a list of costs to the households. The survey respondents were reminded that if the project passed the referendum with a total payment higher than the project cost, the project would be implemented and the payments would be enforced by the government via the electricity bill, but if the total payment was less than the project cost, the project would not be implemented. The econometric analyses of the survey data showed that the survey responses were generally reasonable and were consistent with prior expectations. The total WTP of the beneficiaries for the project was estimated to be lower than the total cost of an original design of the project, and the project design was later revised and the total cost of the project was reduced.[13]

An augmented payment card (APC) approach was used to elicit the preference information, and the respondents' uncertainties were considered both in the study design and in the data analyses. The results show that household income, distance from the renovated roads, current use of the transportation service, future use of the project streets, perceived project impacts, effectiveness of the project management, as well as respondents' education, job status, and religion background, can all significantly affect the WTP, as expected. The respondents' uncertainties in future income and in future use of the project roads are found to be positively correlated with the WTP variance, also as expected. It is also found that considering heteroskedasticity in the modeling process can produce different estimates of the model coefficients as well as the final WTP, suggesting that heteroskedasticity should be considered in such studies.

The conventional way of estimating the total value of a development project with multi-dimensional benefits is to first estimate the value of each benefit component and then add up together the values of all benefit components. Challenges exist with this conventional approach not only in estimating the values of different benefit components, each of which can be a very serious valuation study, but also in aggregating the values of different benefits, which are sometimes not mutually exclusive. The contingent valuation approach, as presented in this study, may provide an alternative solution. It is generally believed that individuals understand their own preferences better than the researchers, especially after a series of communications conducted on all relevant issues involved in a valuation process. However, it is always a challenge to help individuals to form and reveal their values accurately.

[13] One should note that the project benefit might have also changed due to the change in project design. But it would need another valuation study in order to assess the benefit change associated with the change in project design.

Appendix 1. Excerpts from the Questionnaire

Pune NMT Project:

The Pune Municipal Corporation (PMC) is committed to tackle the transportation problems faced by the citizens. PMC recognizes the problem with the current BRTS and is trying its best to fix the issues. In the mean time, PMC is considering a non-motorized transport (NMT) project and asking for financial assistance from the World Bank. The primary work of this project is to improve the quality of some of the feeder roads to the BRTS, so that pedestrians and cyclists can have better access to the BRTS.

The key objectives of the project include:

1) Facilitating the integration between BRTS and non-motorized transport;
2) Improving safety and comfortable environment for non-motorized transport;
3) Using the "raised crosswalk" concept and underpasses for both pedestrians and cyclists to connect important BRT stations and non-motorized transport clientele;
4) Formulating an integrated solution in the form of a network for non-motorized transport.

Project Finance:

In order to complete this project, it is necessary to invest large sums for which the Government will require new sources of financing. Given that the PMC cannot cover all the cost for improving the transport situation, it is only reasonable that some additional fees be collected from households like yours. Every effort will be made to ensure the fees collected will be solely used for this project. The purpose of this survey is to determine how strongly citizens like you will support this transportation project which may introduce some cost to the household. In other words, we want to know how much is the maximum increase in household expenditure you are willing to have in order to ensure that you have the proposed improvement in transport service . If the total fee collected from the households like yours is enough for the project, the project will be implemented and will be implemented properly. If the fee collected is not enough, this project will have to be cancelled.

Willingness to Pay Question (Payment Card):

As said, once this project passes a referendum, a special urban construction fee, which will be solely used for the project, will be charged to your household through the electricity bill or other utility bills from your household. Think of the project we just described and think of your income and other necessary

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expenditures of your household in the future on food, clothes, transport, and entertainment, etc.

Now suppose you have an opportunity to vote for such a project which would involve a certain cost to your home. Remember, if the majority of people voted for the project, the project would go into effect and every household would have to pay. If the majority of people voted against the project, no one would have to pay and the project would be called off.

We will list all potential costs to your households from 0 to a very large number that nobody would like to pay. For each cost, we would like to see how likely you would vote for the project. The cost is the total payment that your household would have to make for this project, but can be made monthly in the next two years, or 24 times. As said before, this would be collected as an additional urban construction fee through the electricity bill or other utility bills that you would have to pay.

Can you please tell me what the electricity bill of your household was last month? [Show and explain the payment card] Please take a look of the card. For each cost, we will need an answer from you. There is no right or wrong answer; we only want an honest answer from you. [Enumerator: Please start from the monthly cost number which is close to around 30 % of the electricity bill.]
Are you going to vote for this project? Please circle an answer for each of the costs.

Appendix 2. Survey Visual Aids

[Show the map and the pictures of BRTS, and explain]
Pune Municipal Corporation has been trying to improve the public transport system. Two pilot BRTS corridors are under execution at present. One corridor is on the Pune Satara Road running for a length of 5.6 kms and the other is on the Pune Sholapur Highway for a length of 8.2 kms. Buses run in the middle lanes with segregated cycle tracks adjacent to the footpaths on both sides of the right of way.

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[Show and explain the set of pictures of current streets that are to be renovated.]
You can see from the pictures that the current roads in Pune are not well designed or constructed and are not friendly for pedestrians and cyclists. The current traffic situation is not well disciplined and during peak hours, all vehicles, big and small, motorized and non-motorized, are in the race with each other to get ahead. Illegal parking, signals not working, insufficient cops to man the traffic, only worsens the situation. The pedestrians and cyclists are the worst hit. The pictures here only show the average roads. Situations in some places can be better and in some places be worse.

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[Show the project map]

Here is a map showing the scale and location of the project**.** The project streets are marked in blue color on the map. The total length of the feeder roads which are to be renovated is 41.5 kms, with 23.8 kms in the vicinity of BRTS1 (Satara Road) and 17.7 kms on BRTS2 (Sholapur Road). The average width of the feeder roads is 20 meters. The construction includes footpaths, cycle tracks, cycle stands, underpasses, and trees, etc. The width of the footpaths and cycle tracks are 2 meters each. The construction should be completed in about one year after the project is approved, and the quality will last for at least 10 years.

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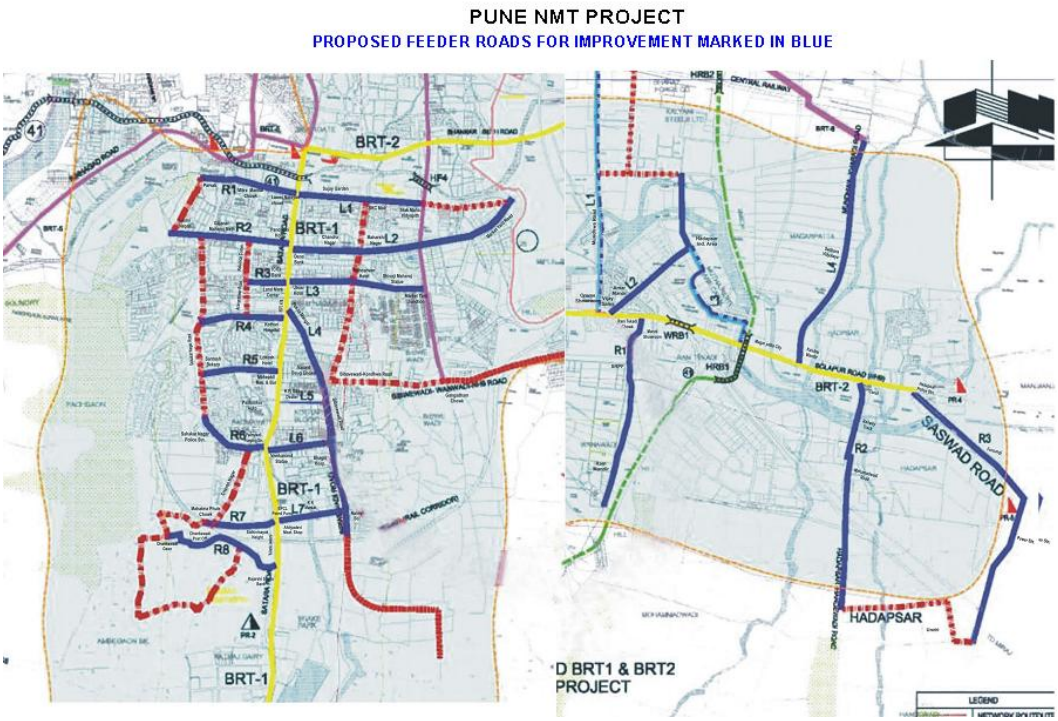

[Show and explain the set of pictures of improved situation after project implementation.]

This project aims to provide better access to urban activity centers for pedestrians and cyclists and make the roads a safer place for them to travel. Separate lanes for cyclists and pedestrians, wide roads, leveled pavements free of debris and other material will make walking & cycling attractive alternatives to using motorized vehicles. Visual signs in the form of road markings and signage would be put up and distinctive paving material used .The facilities which are created specially for pedestrians & cyclists would also make motor vehicle users conscious of the rights and privileges of the pedestrians & cyclists on the road. A more equitable distribution of road space would be sought to be achieved for motorized and non-motorized traffic. The whole project will be enthusiastically promoted to encourage citizens to use the facilities created for them.

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Appendix 3. Follow-up Questions on Potential Protest Bids

Some people told us that they would support for the project because improving the current transport situation was a high priority for them. Others said they would not support for the project because the project would not directly benefit them as they did not stay close to the project area. Some people told us that they would not support for the project because they were not convinced that the money collected would be used for improvements in the transportation system and yet others told us they could not afford to pay. [ASK ONLY IF the answer is not "yes" or "definitely yes" or "probably yes" when the payment is zero.] SHOWCARD: You seem unwilling to pay anything for this project. In the following card, we have listed a number of possible reasons that people like you may have for not willing to pay anything. Please tell me which of these reasons apply to you.

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The project is not useful or important to me.	01
I don't have money.	02
The project has negative impact on my household.	03
I am not interested in this project.	04
I am satisfied with the current situation.	05
I should not pay; it's government's or other persons' responsibility.	06
I disagree with the project design.	07
I would need more information or time to think about the issue.	08
I think only 'User fees' should be charged to finance the project.	09
I don't trust the government.	10
Any other. (Please specify)._____	11

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