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Summary

The opportunity Value of Travel Time (VTT) is one of the most important parts of the total cost of recreation day-trips and arguably the most difficult to estimate. Most studies build upon the theoretical framework proposed by Becker's (1965) by using a combination of revealed and stated preference data to estimate a value of time which is uniform in all activities and under all circumstances. This restriction is relaxed by DeSerpa's (1971) model which allows the value of saving time to be activity-specific. We present the first analysis which uses actual driving choices between open access and toll roads to estimate a VTT specific for recreation trips, thereby providing a value which conforms to both Becker's and DeSerpa's models. Using these findings we conduct a Monte Carlo simulation to identify generalizable results for use in subsequent valuation studies.

Keywords: Value of Time, Value of Travel Time Savings, Recreation Demand Models, Revealed Preferences, Willingness To Pay Space

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Using Revealed Preferences to estimate the Value of Travel Time to Recreation Sites

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Abstract

The opportunity Value of Travel Time (VTT) is one of the most important parts of the total cost of recreation day-trips and arguably the most difficult to estimate. Most studies build upon the theoretical framework proposed by Becker's (1965) by using a combination of revealed and stated preference data to estimate a value of time which is uniform in all activities and under all circumstances. This restriction is relaxed by DeSerpa's (1971) model which allows the value of saving time to be activity-specific. We present the first analysis which uses actual driving choices between open access and toll roads to estimate a VTT specific for recreation trips, thereby providing a value which conforms to both Becker's and DeSerpa's models. Using these findings we conduct a Monte Carlo simulation to identify generalizable results for use in subsequent valuation studies.

Key-words: value of time, value of travel time savings, recreation demand models, revealed preferences, willingness to pay space.

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1. Introduction

About 10 years ago, Larson and Shaikh (2001) described the integration of the role of time into environmental valuation models as "one of the most challenging and important areas of recreation demand research". This conclusion is supported by Feather and Shaw (1999), who observe that welfare estimates generated via recreation demand models can vary by up to a factor of three depending on the approach used to calculate the Value of Travel Time (VTT). Therefore, the large volume of trips made to open-access recreational sites every year (e.g. National Survey on Recreation and the Environment, 2000; Natural England, 2010) places the VTT among the key parameters for environmental and public policy evaluation. Nevertheless, a consensus on the appropriate VTT to use in recreation demand modeling is far from being achieved (Palmquist et al., 2010). This paper contributes to the debate by developing a novel Revealed Preference (RP) method for estimating a VTT specific to leisure-related journeys by modelling route choices to open access recreation sites. In addition, it presents a Monte Carlo simulation to derive simple and generalizable rules for estimating the VTT in future environmental valuation studies.

VTT estimates are typically based on the theoretical models describing economic decisions under limited time allocation developed by Becker (1965) and DeSerpa (1971). Becker's framework assumes fixed time and monetary prices for each good and derives a (shadow) value of time which is uniform in all activities and under all circumstances. While this result can appear questionable, it allows the VTT to be derived by analyzing any decision in which individuals trade-off money for time. For example, Stated Preference (SP) questions concerning labor market choices have been often used in the environmental valuation literature to derive the VTT for recreation demand models (e.g. Bockstael et al., 1987; Feather and Shaw, 1999; Lew and Larson, 2005).

DeSerpa's theory can be thought as a generalization of Becker's framework. While in Becker's approach both money and time costs are fixed, in DeSerpa's model only the monetary costs are set, while the amount of time devoted to each activity is allowed to vary depending on individuals' preferences. This generalization allows the marginal utility of time (or the value of saving time) to vary from one activity to the other. Intuitively, the more an individual dislikes an activity, the higher must be her value of saving time in that specific

task. While this new framework is certainly richer than Becker's original model, it has not yet been implemented in empirical recreation demand studies because of its strict data requirements. Ultimately, within DeSerpa's model, only decisions made by individuals when travelling to recreation sites can reveal their VTT for recreation. Nevertheless, estimating the VTT within a recreation demand model without including any further stated preference information (e.g. McConnell and Strand, 1981) is problematic because of the high correlation between the travel-cost and travel-time variables (e.g. Haab and McConnell, 2002; Small et al., 2005).

The contribution of this paper is to resolve this issue by modelling the time-money trade-offs faced by individuals travelling to recreation sites when choosing between toll and free access roads, thereby providing an estimate of the VTT which is valid in both Becker's and DeSerpa's frameworks. This analysis provides both a contribution to the environmental valuation literature and is distinguished from the RP VTT approaches typically implemented in transport economics studies (e.g. Bhat, 1995; Brownstone and Small, 2005; Small et al., 2005, Steimetz and Brownstone, 2005; Fosgerau et al., 2010). First, rather than analyzing rush-hour commuters' choices on single toll road section we consider respondents travelling from home to different recreation sites. This allows us to consider much larger time savings and longer trips. For example, the mean travel time saving in Small et al. (2005) is around 6 minutes, while our respondents, on average, can save more than one hour of travel time by using toll roads. Second, by sampling respondents directly on the visited sites, we can focus on leisure-related journeys and estimate a VTT specific for recreation. While there is numerous empirical evidence reporting significant changes in the VTT according to the purpose of the trip, the mode of travel or the level of congestion (e.g. Beesley, 1965; Makie et al., 2001; Brownstone and Small, 2005; Small et al., 2005, Fosgerau et al., 2010), to our knowledge this is the first RP analysis which estimates a VTT specific for recreational trips.

Our case-study sites are three beaches located on the Italian Riviera Romagnola, whose road network is a mix of toll and free access roads. Toll roads are faster and can save a significant amount of travel time, particularly for long-distance trips. However, they require a higher monetary cost. By re-constructing respondents' routes to the beach, we indentify individuals' trade-offs and their willingness-to-pay to save time when travelling to recreation sites. In line with previous literature (e.g. Lew and Larson, 2005; Small et al, 2005) we find that individuals differ substantially in their VTT, and that both observed and un-observed

heterogeneity are significant. In order to investigate the robustness of a readily generalizable, yet empirically supported, VTT for future studies, we implement a Monte Carlo simulation showing that (while obviously accounting for person-specific attitudes is preferred) using a fixed fraction (about 80%) of the average income generates defensible welfare estimates. However, our findings suggest that the strategy of assuming a VTT equal to 1/3 of the wage rate (following Cesario, 1974) produces a substantial and statistically significant downward bias in the results.

The remainder of the paper is organized as follows: Section 2 summarizes both Becker's and DeSerpa's models and their implications for the VTT for recreation. Section 3 presents the data collection strategy and reports the descriptive statistics. Section 4 discusses the specification and the estimation of the econometric models and reports the resulting VTT. Section 5 presents the results of the Monte Carlo simulation investigating the effect that different VTT definitions have on non-market valuation estimates. Section 6 concludes.

2. Becker's and DeSerpa's models on the allocation of time and their implications for the VTT

Becker (1965) developed the first theoretical framework concerning individuals facing decisions subject to both money and time constraints. In this model the consumption of each good has fixed monetary and time costs, which allow the derivation of the shadow value of time. Models inspired to Becker's original contribution represent the theoretical foundation of most VTT studies in recreation demand modelling (e.g. Bockstael et al., 1987; Feather and Shaw, 1999; Lew and Larson, 2005). The subsequent generalization proposed by DeSerpa (1971) replaces the fixed time cost with time constraints inequalities, providing a more flexible and elegant framework in which the shadow value of time is replaced by a value of saving time specific for each activity. While previous work has already pointed out the advantages provided by this second approach (e.g. Troung and Hensher, 1985), the more stringent data required for estimation have severely constrained its application in recreation demand modelling. Since, to our knowledge, this is the first paper providing RP estimates of the VTT specific for recreation valid within the DeSerpa's framework, it is worth illustrating both Becker's and DeSerpa's approaches and their implications for recreation demand modelling.

Considering first Becker's model, let x_i (i =1,...,k) indicate commodities or activities with associated money cost p_i and time cost t_i, with w representing the fixed wage rate and T the total time available. The utility-maximization problem of an individual can be written as:

(1.1) $\max U(x_1,..., x_k)$, subject to the money and time constraints:

(1.2) $\sum_{i=1}^{k} p_i x_i = wT_w + V$,

(1.3) $\sum_{i=1}^{k} t_i = T - T_w$,

where T_w indicates the time dedicated to work and V a non-discretionary non-wage income. The resulting Lagrangian function is:

(2) $L_{B,LR} = U(x_1,..., x_k) + \lambda(V + wT_w - \sum_{i=1}^{k} p_i x_i) + \mu(T - T_w - \sum_{i=1}^{k} t_i)$,

with first-order conditions:

$\partial L_{B,LR} / \partial T_w = \lambda w - \mu = 0$

$\partial L_{B,LR} / \partial x_i = \partial U / \partial x_i - \lambda p_i - \mu t_i = 0$, with i = 1,...,k.

The ratio of the Lagrange multipliers relative to the time and money constraints, μ/λ, is the shadow value of time, which equals to the wage rate w. This relationship is valid only if workers are free to adjust their hours of employment T_w. When an individual faces rigid working schedules, the value of time μ/λ can be higher or lower than the wage rate depending on the relationship between the optimal and the actual working hours (e.g. Feather and Shaw, 1999; Lew and Larson, 2005). Therefore, in modelling short-run choices, such as those related to day-trip and other recreational activities, one may want to assume long-run, work-time decisions as given. However, within this hierarchical decision-making framework labor market decisions do not provide any information on the VTT for recreation, since the two choices take place across different time-horizons and are characterized by different constraints (e.g. Palmquist et al., 2010). Indicating with $I = wT_w^* + V$ the total income

available when the time at work has been set to T_w^* and with $T_0 = T - T_w^*$ the total free-time available, the short-run utility maximization problem relevant to recreational choices is:

$$(3)\ L_{B,SR} = U(x_1,...,x_k) + \lambda(I - \sum_{i=1}^{k} p_i x_i) + \mu(T_0 - \sum_{i=1}^{k} t_i)\,.$$

The corresponding shadow value of time is:

$$(4)\ \frac{\partial L_{B,SR} / \partial t_i}{\partial L_{B,SR} / \partial Y} = \frac{\mu}{\lambda}, \qquad \text{for } i = 1, ..., k.$$

As in the case with labor-market decisions represented in equation (2), the value of time is uniform in all activities and, therefore it is also the appropriate VTT for recreation. As a consequence, the VTT can be inferred by analyzing people trading-off money with free time in any decision undertaken in this time horizon. Palmquist et al. (2010), for instance, use household maintenance decisions.[2] While it is clear that the VTT should be included in the recreation visit costs for environmental valuation, a unique shadow value of time raises questions regarding how we should measure the value of time spent at the recreation site and whether its value should be considered at all. Findings to date appear to be controversial. While theoretical analyses suggest that on-site time should be accounted for (Wilman, 1980; Smith et al., 1983), further research showed that when the on-site time is endogenous it actually makes little difference to include it or not as part of the cost of a visit (McConnell, 1992). In practice, most analyses sidestep the issue by assuming a constant amount of on-site time per recreation experience (e.g. Phaneuf and Smith, 2005).

We now move on to consider the theoretical model developed by DeSerpa (1971), which relaxes the unnecessary assumption of fixed time costs. In this framework, individuals not only optimize across the consumption quantities x_i, as shown in equation (3), but also across the consumption times t_i. This increases the decisions variables from k to $2k$, creating a more flexible and more convincing representation. Fixed prices are replaced by consumption times' inequalities such as:

[2] However, their approach does not strictly conform to Becker's approach, but it is more general and allows the marginal utility of time in recreation to be non-constant.

(5) $t_i \geq a_i x_i$, for $i = 1, ..., k$,

where a_i is the minimum amount of time necessary to consume one unit of x_i. These restrictions can be interpreted as natural and institutional constraints related to the activities' characteristics. Examples are the length of a football game, the duration of a movie, minimum travel times due to speed limits and so on. While these constraints place a lower bound on the amount of t_i consumed, individuals are still free to allocate more than the required time to any activity. Considering labor market decision as fixed, the corresponding utility maximization problem can be represented with the following Lagrangian function:

$$(6)\ L_{D,SR} = U(x_1,...,x_k;t_1,...,t_k) + \lambda(I - \sum_{i=1}^{k} p_i x_i) + \mu(T_0 - \sum_{i=1}^{k} t_i) + \sum_{i=1}^{k} \theta_i (t_i - \sum_{i=1}^{k} a_i x_i),$$

The corresponding maximization conditions are:

$$(6.1)\ \partial L_{D,SR} / \partial x_i = \lambda p_i + \theta_i a_i, \quad \text{for } i = 1, ..., k,$$

$$(6.2)\ \partial L_{D,SR} / \partial t_i = \mu - \theta_i, \quad \text{for } i = 1, ..., k,$$

$$(6.3)\ \theta_i (t_i - a_i x_i) = 0, \quad \text{for } i = 1, ..., k.$$

Equations (6.3) are the Kuhn-Tucker conditions corresponding to (5) and indicate that either $t_i = a_i x_i$ (i.e. the time allocated to the consumption of x_i is equal to the minimum amount needed and the constraint is binding) or $\theta_i = 0$ (the individual allocates to the consumption of x_i more time than it is strictly necessary).

As in Becker's model (3), the Lagrange multipliers λ and μ represent the marginal utility of money and the marginal utility of time. The ratio μ/λ is the shadow value of time. DeSerpa calls this quantity the "value of time as resource", which derives from the fact that time is available only in a limited amount. However, its value cannot be measured since incrementing the amount of total time available makes little sense both according to this model and in reality. Therefore, the "value of time as a resource" is not the appropriate quantity for environmental valuation. Rather, the relevant VTT corresponds to the cost associated with spending time driving rather than doing another activity which generates

greater utility. This is the "value of saving time from an activity" can be calculated by dividing equation (6.2) by the marginal utility of money:

$$(7)\ \frac{\partial L_{D,SR}/\partial t_i}{\lambda} = \frac{\mu}{\lambda} - \frac{\theta_i}{\lambda}, \qquad \text{for } i = 1, ..., k.$$

These equations show the marginal rate of substitution of t_i for money, i.e. the value of the time allocated to the consumption of x_i. DeSerpa refers to this quantity the "value of time as a commodity", which is equal to μ/λ only if $\theta_i = 0$, i.e. when an individual allocates more than the required amount of time to the consumption of x_i. On the other hand, when the time spent in consuming x_i is equivalent to the minimum required, the ratio θ_i/μ can be interpreted as the marginal value of relaxing the corresponding constrain or the "value of saving time from the activity". This notion presuppose that time can be saved and transferred to another use which generates greater utility. In addition, its saving value is an activity-specific quantity since it derives from the parameters θ_i. Therefore, the VTT for recreation cannot be inferred by measuring any time-money trade-offs other than those pertaining to driving decisions for recreation. This stringent requirement has significantly limited the application of the rich framework proposed by DeSerpa for applied environmental economics analysis.

From equation (7) it also emerges the notion of leisure activity as an activity for which the allocated time is higher than the minimum required. For all these activities the "value of saving time" is zero because utility cannot be increased by transferring time to any other use. Their corresponding $\theta_i = 0$ and their "value of time as a commodity" is equal to the "value of time as a resource". The time spent at a recreational site is obviously leisure time and, therefore, the corresponding value of time is equal to the shadow value of time as a resource μ/λ. In this framework, therefore, the time spent on site has already the maximum possible value and it should not be included in the total cost of the trip because there is no alternative use which provides higher utility.

3. Empirical setting and data overview

As shown in the previous section, estimating a VTT for recreation valid within DeSerpa's framework requires observations on individuals facing trade-offs involving money and driving time to recreational sites. In addition, this data needs to present relatively low correlation between travel times and travel costs, in order to obtain precise estimates of the effect of both variables on respondents' behavior. Unfortunately, this important condition frequently fails to hold in practice. For example, recreation demand data are characterized by a very high collinearitiy between the travel-cost and travel-time variables, which makes the estimation of the VTT within standard RP travel cost models problematic (e.g. Haab and McConnell, 2002; Small et al., 2005).

In this paper we address this correlation issue through a novel RP setting from which we obtain precise estimates of the VTT specific for recreation. Rather than modelling site choices as in standard recreation demand models, we analyze how individuals choose between different routes to travel to a given site, with each route option characterized by different travel times and monetary costs. Our study takes advantage of the peculiar structure of the Italian road network, which is a mixture of toll and free-access roads, providing drivers with a rich array of different options for their travel costs and times. In Italy, most high-speed highways charge access fees proportional to the length of the highway used (with little variation on a per km basis) which are constant throughout the year and publicly available (e.g. on the site www.autostrade.it). These toll highways link all major Italian cities and can be accessed at specific stations, located roughly every 20-30 km, which connect them to the free road network. While tolls are proportional to the length of the highway used, the travel time savings can vary considerably, depending on the location of the stations relatively to the respondents' home and destination, and on the alternative routes available. This feature allows us to break-down the correlation between travel time and cost and to observe the choices of individuals facing very different time-money trade-offs.

We choose as case-study three beaches located on the Italian Riviera Romagnola: Rimini, Cesenatico and Igea-Marina. These are popular locations, attracting visitors from the entire Italian peninsula. Rimini is the most famous resort of the Riviera, and it is also the most expensive, Cesenatico is slightly cheaper and visited both by families and young people, while Igea-Marina is the smallest and cheapest beach of the three and it is mainly visited by

families. This diversity allows us to generate a heterogeneous sample, varying respondents' age, income and travelled distance. Furthermore, since the surrounding road network consists of one toll highway and a variety of free access roads, also the cost per minute of travel time saved is highly variable across our sample. As an illustration, Figure 1 shows possible route options for two individuals travelling to Rimini, one living in Imola (top panel) and one living in Lavezzola (bottom panel). Both panels contrast the fastest free route (FFR), indicated by the dotted line, with the fastest toll route (FTR), represented as a solid line. In both examples the FTR enters the toll road in "Imola" and exists in "Rimini South" and it is faster than the FFR while requiring a higher monetary cost (the toll between these two stations is 5€). However, the cost per travel time saved is very different. Travellers from Imola switching from the FFR to the FTR can save more than one hour of travel time at a cost of about 5 €/hour, while respondents from Lavezzola can only save about 20 minutes at the cost of almost 20 €/hour, which is nearly 4 times higher. Given this heterogeneity, by sampling respondents living in different locations we are able to observe a wide range of time-cost trade-offs which allows us to obtain precise estimates of the VTT.

[Figure 1 about here]

Since the main objective of this paper is to estimate the VTT specific for recreation trips, we survey individuals directly on the three sites under study. We interviewed individuals face-to-face during the months of August and September in the years 2010 and 2011 and asked them information on their trip, route choice and socio-economic characteristics. The rate of non-response was very low, with less than 5% of those approached declining to be interviewed.

We assume that respondents undertake a two-stage decision process. In the first stage they choose which site to visit while in the second one they select the best route among those available, taking into account travel time and monetary cost. Since we are interested in estimating the VTT for recreation and not in valuing the beaches, here the focus is on the second-stage decision only. For this reason we restrict the analysis to respondents who face both toll and open-access route options, and hence reveal trade-offs between money and travel time. This yields a sample of 457 observations, including 155 (34% of the sample) individuals travelling for short, one day, visits to the beach, and 302 (66%) respondents staying at the resorts for longer holidays, some of them lasting more than a week. This allows us to test weather different planning horizons imply different values of time.

Since respondents are unlikely to know a priori the exact length of each alternative route and its travel cost, the relevant variables for this study are the expected travel time and cost. We assume that individuals have a feel for the distribution of the travel time and cost required by each possible route, based on their experience and on the information they can gather before the trip. This approach is standard in VTT RP studies (e.g. Brownstone and Small, 2005; Small et al., 2005, Steimetz and Brownstone, 2005). As a benchmark, we use the site maps.google.com to calculate a proxy for expected travel times. As showed in previous research, these engineering estimates are more appropriate and reliable than using ex-posts people perceptions of travel time (Steimetz and Brownstone, 2005). The fuel travel costs are determined by assuming an average consumption of 1 litre per 18 km and the average fuel price in summer 2010 (1.29 €/litre) and 2011 (1.53 €/litre) as provided by the national statistics by the Department of Economic Development (http://dgerm.sviluppoeconomico.gov.it).

Since the number of possible routes connecting two points on a road network is, at least in theory, infinite, we use a few simple rules to indentify meaningful routes and thereby determine appropriate choice-sets for each respondent. A "core" choice-set for each respondent is defined by the following options: the FFR; the FTR; the FT1A (the fastest route accessing the toll road one station after that used in the FTR); the FT1B (the fastest route exiting the toll road one station before the one in the FTR). These last two choices are relevant if the respondent's house or the beach is located in-between toll road stations, and entering/exiting the highway in the next/earlier station provides better time-money trade-offs than either the FFR or the FTR. We finally include in each respondent's choice-set all the alternative routes chosen by individuals travelling from the same outset area. These areas are defined in terms of toll road use in order to group together individuals with the same entrance and exit according to the FTR (irrespective of whether or not they chose to use the toll road). Only 25% of the respondents belong to areas in which routes other than FRR, FTR, FT1A and FT1B are chosen.

[Table 1 about here]

Route choice descriptive statistics

Descriptive statistics for the route options are reported in Table 1. For most people (56%), the FTR is the preferred route, followed by the FRR (15%). Only 11% of the respondents choose a route outside the 4 options included in the "core" choice set. The variability in travel times is substantial. Considering the FTR, for example, travel times ranges from less than 30 minutes to more than 8 hours. Similarly, monetary costs vary from under €5 to more than €70, with a significant fraction made up by toll fees. For instance, choosing the FTR instead of the FFR increases average travel costs by 40%. To appreciate the time-money trade-offs faced by the individuals in our sample, we can calculate the cost per hour of travel time saved comparing the two most frequently chosen routes: FTR and FRR. For descriptive purposes, this ratio can be approximated by dividing the toll by the difference in travel times, since fuel costs are typically very similar between the two options. The distribution of the toll cost per hour of time saved is represented in the histogram in Figure 2. While most individuals in our sample face toll costs between €5 and €10/hour, there is considerable variability in trade-offs, with a significant proportion of respondents facing very high fees, rising to more than €50/hour.

[Figure 2 about here]

Descriptive statistics for all the other variables included in the study are reported in Table 2. Variables such as driver's income, age and number of passengers show great heterogeneity. Most drivers are male (71%) and most passengers are older than 16, with an average of 2.3 adults per party. By using the common assumption of 2000 work hours per year (e.g. Haab and McConnell, 2002; Hynes et al., 2009), we calculate respondents' average gross hourly wage rate as being about 15€/hour.

[Table 2 about here]

Descriptive statistics

4. The econometric model

4.1 The empirical specification

As illustrated in the previous section, we assume that individuals first decide which recreational site to visit and then choose one amongst the possible routes to get there. This allows us to estimate the VTT by focusing on the route choice, as conditional on the beach decision. Assuming that utility is linear in income and, for simplicity, eliminating that portion of utility which is constant among alternatives, we can write the (dis-) utility which person n (n=1,..., N) receives from choosing route j (j=1,..., J) as:

$$(8)\quad U_{n,j} = \mu_n c_{n,j} + \theta_n t_{n,j} + q_j + \varepsilon_{n,j} \ ,$$

where $t_{n,j}$ indicates the route time, $c_{n,j}$ the route cost (including both toll and fuel cost, which we assumed are equally shared among all adults in the car), θ_n represents the marginal (dis-) utility of spending time driving and μ_n is the marginal utility of money. Both coefficients correspond to the parameters of DeSerpa's model reported in equation (6), and are allowed to vary across respondents. Furthermore, q_j includes all observed characteristics of the route which have some implications for the choice and the residual term $\varepsilon_{n,j}$ encompasses the unobserved characteristics of both the respondent and the route. This residual component is assumed to be distributed as a type I extreme value with scale parameter k_n. Respondent n chooses route j if $U_{n,j} > U_{n,i}$ $\forall i$. Finally, the parameter of travel time, while allowed to be different across respondents, does not vary per route option. Therefore, while we encompass route characteristics through the term q_j, we also assume that driving produces the same (dis-) utility per unit of time regardless of the type of road travelled.[3]

[3] In addition, we do not consider the effect of possible road congestion, which is commonly referred to as the "travel time reliability". However, congested roads are not likely to be an issue for our estimates, since most of the respondents (around 90%) did not report any significant road traffic. In addition, only a small fraction of the interviewees who actually encountered road congestions adjusted their route accordingly, typically abandoning the congested highway for smaller but less trafficated roads. We eliminated these individuals (about 1% of the respondents) from the analysis since their travelled route differed from the one they had planned a priori based on expected travel cost and travel time. Finally, road congestion is commonly ignored in RP analyses, and typically investigated using SP data (e.g. Li et al., 2010) or by combining RP and SP information (e.g. Small et al., 2005).

As shown in equation (6.4), in this model the relevant VTT for recreation is the ratio of the marginal (dis-)utility of the time spent driving to the marginal utility of money:

$$(9)\ VTT_n = \frac{\partial U_{n,j} / \partial t_{n,j}}{\partial U_{n,j} / \partial c_{n,j}} = \frac{\theta_n}{\mu_n} \ .$$

As dividing or multiplying utility does not affect behavior, we can divide (8) by the scale parameter obtaining an error term with the same variance for all respondents:

$$(10)\ U_{n,j} = \frac{\mu_n}{k_n} c_{n,j} + \frac{\theta_n}{k_n} t_{n,j} + \frac{q_j}{k_n} + \omega_{n,j} \ .$$

Train and Weeks (2005) refer this equation as a model specified in "preference space". Un-observed heterogeneity in preferences can be encompassed by specifying a probability distribution for the time and cost coefficients and estimating the model as a mixed logit (e.g. Train, 1998, 2009). Among the most commonly applied distributions are the normal, the log-normal, the uniform and the triangular. Unfortunately, recent work has shown that models with preference parameters distributed according to these simple probability densities generate VTT distributions with counter-intuitive features, such as excessively long tails or non-finite moments (e.g. Scarpa et al., 2008). A possible solution is to define a cost coefficient which is constant across respondents (e.g. Revelt and Train, 1998). This assumption allows the VTT distribution to match that of the time coefficient. However, this restriction is somehow counter-intuitive, as there are good theoretical reasons underpinning taste heterogeneity in the cost parameter (e.g. Scarpa et al., 2008). Furthermore, as shown in equation (10), a fixed cost coefficient ($\mu_n=\mu, \forall n$) implies that the standard deviation of the residual term $\varepsilon_{j,n}$ is the same for all respondents ($k_n=k, \forall n$). If violated, this latter assumption will induce biased inference by erroneously attributing variation in scale to variation in VTT.

Train and Weeks (2005) resolve this issue by re-writing model (9) in what they define as being the "Willingness to Pay Space" (WTP) representation, which, in our context, corresponds to the VTT space. Defining $\mu_n^* = \mu_n / k_n$ and $q_{j,n}^* = q_j / \lambda_n$, we can re-write (10) as:

(11) $U_{n,j} = \mu_n^* [c_{j,n} + VTT_n t_{j,n} + q_{j,n}^*] + \omega_{j,n}$.

In this parameterization, the variation in VTT is independent from the variation in scale, which is encompassed in the cost coefficient μ_n^*. Another advantage of this approach is that we can directly specify a distribution for the VTT rather than generating it numerically as a ratio. In addition, we can include some observed factors within the specification of the VTT (e.g. $VTT_n = \alpha_{0,n} + \alpha_1 inc_n$, with inc_n = income of respondent n) and directly test their significance with standard inference (e.g. Thiene and Scarpa, 2009). The appeal of the "WTP space" parameterization over the traditional "preference space" specification for VTT estimates is confirmed by Hensher and Greene (2011), among others.

Model (11) is a non-linear in parameters mixed logit model and its estimation can be implemented via Simulated Maximum Likelihood (SML) (Train, 2009, Scarpa et al., 2008). Conditional on the values of the random parameters $\boldsymbol{\gamma}_n = \{\lambda_n, VTT_n\}$, the probability of person n choosing route j can be written as the standard logit formula (McFadden, 1974):

$$(12)\ p_n(j \mid \boldsymbol{\gamma}_n) = \frac{\exp(V_{n,j})}{\sum_{i=1}^{J} \exp(V_{n,i})},$$

where $V_{n,j} = U_{n,j} - \omega_{n,j}$. The unconditional probability is given by the integral of (12) over all possible values of $\boldsymbol{\gamma}_n$, weighted by their density:

$$p_n(j) = \int p_n(j \mid \boldsymbol{\gamma}_n) g(\boldsymbol{\gamma}_n) d\boldsymbol{\gamma}_n,$$

where $g(.)$ is the joint probability distribution function of the random parameters. Indicating with y_n the dummy variable identifying the route chosen by responded n, the log-likelihood function to be maximized is:

$$(13)\ \ln L = \sum_{n=1}^{N} p_n(j) y_n.$$

Rather than maximizing directly the likelihood (13), we approximate the integral over $\boldsymbol{\gamma}_n$ via simulation. This approach consists of taking draws from the distribution of the random

parameters, calculating $p_n(j)$ for every draw and then averaging the results. This SML estimator is consistent, asymptotically normal and efficient for an increasing number of draws (Train, 2009). Estimation is implemented in the free software R (R development core team, 2008) using the Nelder-Mead (1965) maximization algorithm and 50 Halton draws per person (as per Train, 2009).

4.2 Estimation results

The results provided by different model specifications are reported in Table 3. As a benchmark, the first column reports a standard conditional logit model in preference space with only route time and cost as choice attributes (Model A). The estimated VTT is about €9/hour which corresponds to roughly 60% of the average wage rate. This is between the value reported by Browstone and Small (2005) for non-work related trips ($11/hour), and the "baseline" value ($20/hour) estimated by Palmquist et al. (2010). For illustrative purposes, Model B in the second column reports the re-parameterization of Model A in VTT space. Since the two models do not include any random parameters, they yield exactly the same VTT estimate and log-likelihood. All the other models in Table 4 are estimated directly in VTT space. Model C, reported in the third column, extends the base specification by including route characteristics. The estimates show that, given the same cost and time, the fastest free route (FFR) and the fastest toll route (FTR) are much more likely to be chosen than those other routes containing different combinations of toll and free roads. This reflects the fact that FFR and FTR are the two most cognitively straightforward routes and those which, for example, can be automatically selected on standard satellite navigators. In contrast, alternative routes, such as FT1A or FT1B, require greater knowledge of the area and of its road network.[4]

[Table 3 about here]

Model estimates and corresponding VTT

[4] We did not include in the model other characteristics of the routes such as the scenery since most of the routes considered here cross similar landscapes without any particularly noteworthy features. For example, none of them is costal road. On the other hand, we tried to include a dummy variable to take into account if the road crosses the outskirts of major cities, which can be highly trafficated at peak times. Since it did not result significant, we removed it from the model and from the discussion to preserve space.

Model D (fourth column) relaxes the assumption of constant scale parameter and introduces un-observed taste heterogeneity. We specify both the cost and the VTT parameters to be normally distributed.[5] The results confirm findings in the literature (e.g. Lew and Larson, 2005) in showing significant un-observed heterogeneity, with both random parameters standard errors being highly statistically significant. Considering an interval equal to plus and minus one standard error, the VTT for recreation varies from about €9/hour to €16/hour. Model E, reported in the fifth column, tests whether VTT alters with the length of the holiday, estimating two separate VTT random-parameters: one for respondents undertaking a day visit and one for those staying for longer holidays. Both the mean and the standard error of the new random parameter are insignificant, suggesting that neither the route decision nor the VTT depend on the length of the holiday. Therefore, we continue our analysis by keeping the two groups of travellers pooled together.

Model F, reported in the last column of the table, includes both observed and un-observed heterogeneity yielding an average VTT around €12/hour. In line with our expectations and consistent with the results of previous work (e.g. Brownstone and Small, 2005; Small et al, 2005; Steimetz and Brownstone, 2005), income is a significant factor. With every additional €10,000 of gross yearly salary the VTT increases, on average, by €1. Furthermore, the VTT of respondents older than 60 years is, on average, about 45% lower than that of other age groups. This finding can be explained by the high proportion of retired workers in this age class who, by having more free time, also have lower VTT. Finally, we do not find any significant evidence of gender having any influence on the value of saving travel time.

These results support an average VTT for recreation which is around 80% of the wage rate. While our methodology is novel and focuses on the VTT for recreation, our empirical estimates fall within the range reported by previous RP studies on VTT for generic road trips (e.g. Deacon and Sonstelie, 1985, and Small et al., 2005, respectively report a VTT of 78% and 93% of the wage rate). However, while income is a significant factor in explaining the VTT, we also find strong unobserved heterogeneity, with estimated VTTs ranging from less than 50% to more than 100% of the personal wage depending on respondents' tastes and attitudes towards driving. Therefore, our findings agree with those of Lew and Larson (2005) and Small et al. (2005), which show that both observed and un-observed sources of

[5] We also investigated a log-normal distribution but, similarly to others (e.g. Small et al., 2005), we were unable to obtain convergence.

heterogeneity are important in VTT elicitation. While our study collected a rich dataset on route options, limited resources mean that it is not always possible to estimate a person-specific VTT within every recreation demand study. The next section analyzes which assumptions can be implemented in empirical studies when VTT estimation is not feasible. To do so, we undertake a simple Monte Carlo simulation comparing some of the options which have been implemented so far in the recreation demand modeling literature.

5. Testing alternative VTT assumptions for future studies: a Monte Carlo simulation

In this section we examine which assumptions can be implemented in applied recreation demand studies when the estimation of person specific VTT is not feasible. We design a Monte Carlo simulation based on our RP data and compare welfare estimates based on the true, un-observed VTT, with those obtained by using some of the simple approximations which are commonly implemented in the applied literature.

For simplicity and to emulate one of the most common valuation frameworks, we focus our simulation on a single beach. As the site to value we select the beach of Cesenatico, for which we have 247 survey respondents. For each individual in this sub-sample, we calculate the VTT according to our final model (Model F in Table 3) encompassing both observed and un-observed heterogeneity. We estimate person-specific random parameters following the approach outlined by Train (2009). Specifically, we derive the distribution of the VTT for each respondent as conditional to the data by using the Bayes' rule:

$$(14)\; h(VTT_n \mid j, z_n) = \frac{p_n(j \mid z_n, VTT_n) N(VTT_n \mid \Omega)}{p_n(j \mid z_n, \Omega)},$$

where VTT_n is the value of travel time for respondent n, j indicates the chosen option, z_n represents all the explanatory variables in the model (i.e. income, age, and gender and route characteristics) and $\boldsymbol{\Omega}$ are the parameter estimates, including the mean and standard error of the random parameters. The function $h(.)$ is the distribution of VTT_n given the observables, $N(.)$ is the Gaussian probability distribution of VTT_n given the parameters, $p_n(j \mid z_n, VTT_n)$ is the probability of the observed choice given the value of time and the explanatory variables, and $p_n(j \mid z_n, \boldsymbol{\Omega})$ is the integral of $p_n(j \mid z_n, VTT_n)$ on the parameter space. This denominator

is a constant and, therefore, $h(.)$ is proportional to the numerator. As suggested by Train (2009), we calculate the expected value of $h(.)$ by simulation randomly generating 500 draws of VTT_n from the normal population density $N(VTT_n \mid \mathbf{\Omega})$ and computing their weighted mean, with weights proportional to $p_n(j \mid z_n, VTT_n)$.

After having calculated the individual-specific VTT we generate the number of visits (R_n) to Cesenatico beach through a simple trip-simulation function specified with the following exponential form:

$$(14)\ R_n = \exp(b_0 + b_1 TC_n + u_n),$$

with TC_n = total round-trip cost from the respondents home to the beach (including both fuel cost and VTT_n), u_n = i.i.d. Gaussian residual term, and b_0 and b_1 functional form parameters. We compute the number of visits for each respondent by choosing: b_0 = 5, b_1 = 0.5 and s.e.(u_n) = 0.5. This definition generates a number of trips per respondent varying from almost 0 to around 100, and simulates the type of data which a typical single site recreational demand study could collect.

We can now estimate model (14) from the simulated visits using different definitions for the VTT (including the "true" un-observed person-specific VTT used to generate the data) and assess their impact on the welfare estimates. As consumer surplus we use the WTP of access as given by Haab and McConnell (2002):

$$(15)\ WTP = \int_{TC_n^*}^{\infty} \exp(\hat{b}_0 + \hat{b}_1 c)dc = -\frac{y_n}{\hat{b}_1},$$

where the "hat" indicates the parameter estimates via ordinary least squares, TC_n^* is the current travel cost and all other symbols are defined as previously. We compare the WTP estimates generated using the following VTT definitions: (*a*) the "true" person-specific value used to generate the data, (*b*) zero, (*c*) 1/3 of the respondent wage rate (Cesario, 1976), (*d*) the respondent full wage rate, (e) 80% of the respondent wage rate and (*f*) 80% of the average wage rate. The last two definitions use the average fraction of the salary estimated on our data but differ in that for option (*e*) the VTT is proportional to each person's salary while

option (*f*) assigns the same value to all respondents, including those who are currently un-employed.

[Table 4 about here]

Monte Carlo simulation: welfare estimates using different VTT

Results obtained from 5000 Monte Carlo repetitions are presented in Table 4 and in the box-plots in Figure 3. The WTP estimates vary considerably depending on how the VTT is determined. The first column/box-plot reports the WTP estimates obtained by using the "true" un-observed person-specific VTT. The mean WTP is around €9.3, but there is considerable variability between respondents, with the 5th percentile being only €0.3 and the 95th almost €11. The second column reports the estimates obtained by assuming that travel time has no value. As expected, this definition generates a significantly lower consumer surplus, roughly halving the average WTP to about €5.3. As shown in the third column, the common assumption that VTT is equal to 1/3 of the wage rate (as per Cesario, 1974, and in numerous other studies) produces downwardly biased estimates, with an average of about €6.7. On the other hand, the results presented in the forth column show that assuming that the VTT is equal to the full wage substantially inflate WTP values, the average being €11.5, which is higher than the 95th percentile calculated by using the "true" VTT.

[Figure 3 about here]

The best approximation of the true WTP is provided by adopting the assumption that VTT is 80% of the wage rate, reported in the last two columns of Table 4, with means and percentiles only slightly higher than the ones used to generate the simulated data. As shown by comparing the box-plots in Figure 3, these are the only assumptions which produce 95% confidence intervals which include the mean of the WTP calculated using the true VTT value. In addition, despite salary being a significant factor in the simulation of the person-specific VTT data, assuming the VTT to be 80% of average wage rate produces slightly better estimates than defining the VTT equal to 80% of the personal wage rate. This shows that un-observed factors play a very important role in the VTT definition and that approximating the VTT with a value which is a fraction of the average salary can be a simple and yet effective strategy for obtaining sensible WTP estimates. Another advantage of this approach is that it provides VTT estimates for both employed and unemployed respondents,

rather than implicitly assuming that those outside the workforce have zero VTT as in conventional analyses. As shown by Feather and Shaw (1999), among others, this latter approach can significantly bias downwardly WTP values if a large share of respondents is unemployed. Obviously, assuming the same VTT for all respondents still remains a second-best strategy, which should be implemented only when investigating individual-specific VTTs is not a feasible solution.

6. Conclusions and further research

We introduce a novel RP setting to estimate the VTT specific for recreation. Compared with previous studies, which use labor market choices (e.g. Feather and Shaw, 1999; Lew and Larson, 2005) or household maintenance options (Palmquist et al., 2010) to estimate the value of time, our analysis has the important advantage of being based on actual travel-choice decisions for recreation. Therefore, it provides a VTT which is appropriate in both Becker's (1965) model of economic decisions with time constraints and in the subsequent generalization by DeSerpa's (1971), while earlier analyses are valid only within the first and more restrictive framework.

The average VTT of our sample is around €12, which is approximately 80% of the average wage rate; a value which is within the range identified by previous RP studies on the VTT of generic road trips. In addition, our results confirm previous findings (e.g. Lew and Larson, 2005) in that individuals differ substantially in how they value travel time to recreational sites, and that both observed and un-observed characteristics are important. For instance, VTT increases with income and is lower for those who are older than 60 years, probably reflecting the higher proportion of retired people in this age group.

As shown in previous studies (e.g. Feather and Shaw, 1999), welfare estimates from recreation demand models are highly sensitive to the assumed VTT. Earlier work (e.g. Lew and Larson, 2005; Palmquist et al., 2010) included SP questions on labor market or household maintenance decisions within the standard RP recreational survey to recover individual-specific VTTs for recreation. Another feasible option is to add SP choices on alternative routes to reach the recreational sites providing respondents with different money-travel time trade-offs. However, further research is necessary to test if values provided by this

SP approach conform to RP estimates, since findings to date seem to indicate a significant gap between SP and RP estimates of VTT (e.g. Brownstone and Small, 2005; Small et al., 2005).

Finally, our Monte Carlo simulation shows which simple assumptions can be implemented for situations where it is not feasible to estimate a person-specific VTT measures. Assuming VTTs which are either zero or 1/3 of the wage rate (as suggested by Cesario, 1974, and implemented in many subsequent studies) clearly produces downward biased estimates, while defining the VTT to be equal to the full wage rate somewhat overestimates values. In our case-study we find that ignoring respondent heterogeneity and setting VTT equal to 80% of the average wage provides defensible results, which are not significantly different from those obtained using the "true", un-observed, VTT used to generate the data.

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Tables and Figures

Table 1

Routes: descriptive statistics

Route	*Time (minutes)*			*Fuel cost(€)*			*Toll (€)*			*% chosen*
	mean	*min*	*max*	*mean*	*min*	*max*	mean	*min*	*max*	
FTR	137.8	28.0	495.0	16.22	2.49	59.42	11.26	1.00	37	56
FFR	233.9	35.0	763.0	15.49	2.29	50.12	0.00	0.00	0.00	15
FT1A	148.7	37.0	498.0	16.35	2.74	59.45	10.29	0.3	36.3	14
FT1B	144.7	35.0	502.0	16.32	2.23	59.56	10.76	0.3	37.3	4
other routes	174.2	84	418.0	17.25	8.10	42.99	9.35	1.1	27.4	11

Notes: total number of observations equal to 457. The statistics of the "other routes" category refers only to those respondents who has these options within their choice-set it (25% of the sample), whereas the other statistics refer to the full sample. FTR the fastest tolls route, FFR the fastest free route, FT1A the fastest toll route by accessing the toll road one station after the one in FTR and FT1B the fastest route by exiting the toll road one station before the one in FTR. Cost deflated to year 2010 by using gross domestic product deflator (source: World Bank, www.worldbank.org).

Table 2

Descriptive statistics

	$\bar{x}$	$\hat{s}(x)$	min	max
Personal income (1000€/month)	2.51	1.50	0.35	12.60
age (years)	40.70	12.17	18.00	76.00
gender	0.29	0.45	0	1
people in the car	2.85	1.13	1	7
> 16 years old	2.27	0.86	1	7
< 16 years old	0.59	0.84	0	4
one-day	0.34	0.47	0	1

Notes: $\bar{x}$ indicates the sample mean, $\hat{s}(x)$ the sample standard deviation. The statistics on age and income (before tax) refer to the driver. Income deflated to year 2010 by using gross domestic product deflator (source: World Bank, www.worldbank.org).

Table 3

Model estimates and corresponding VTT

	Preference space	*VTT space*				
	Model A *Base model*	Model B *Base model*	Model C *route characteristics*	Model C *Un-observed Heterogeneity*	Model D *Trip length heterogeneity*	Model F *Full Model*
time	*-3.031****	*0.858****	*0.971****	*1.168****	*1.179****	*0.989****
	(0.361)	*(0.072)*	*(0.125)*	*(0.163)*	*(0.161)*	*(0.201)*
s.e.(time)				*0.367****	*0.354****	*0.315****
				(0.075)	*(0.078)*	*(0.107)*
cost	*-3.533****	*-3.533****	*-2.312****	*-4.870****	*-4.400****	*-4.507****
	(0.543)	*(0.543)*	*(0.431)*	*(1.178)*	*(1.099)*	*(1.174)*
s.e.(cost)				*2.534****	*2.282****	*2.282****
				(0.657)	*(0.595)*	*(0.611)*
d_FTR			*-0.533****	*-0.200****	*-0.224****	*-0.221****
			(0.1116)	*(0.066)*	*(0.076)*	*(0.078)*
d_FFR			*-0.509****	*-0.328****	*-0.383****	*-0.354****
			(0.139)	*(0.107)*	*(0.127)*	*(0.118)*
*time * one_day*					*0.215*	
					(0.278)	
*s.e.(time * one_day)*					*-0.290*	
					(0.274)	
*Time * sex*						*-0.080*
						(0.165)
*Time * age ≥ 60*						*-0.489***
						(0.140)
*Time * p_inc*						*0.116***
						(0.053)
Log-likelihood	*-580.06*	*-580.06*	*506.60*	*-497.53*	*-497.06*	*-491.13*
Pseudo R^2	*0.13*	*0.13*	*0.24*	*0.25*	*0.25*	*0.26*
Mean WTP (€/hour)	*8.58*	*8.58*	*9.71*	*11.68*	*12.58*	*12.04*

Notes: travel cost expressed in 10€ (e.g. 100€ = 10), travel time in hours, gross income in 1000€/year (e.g. 20,000€/year = 20). * = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level.

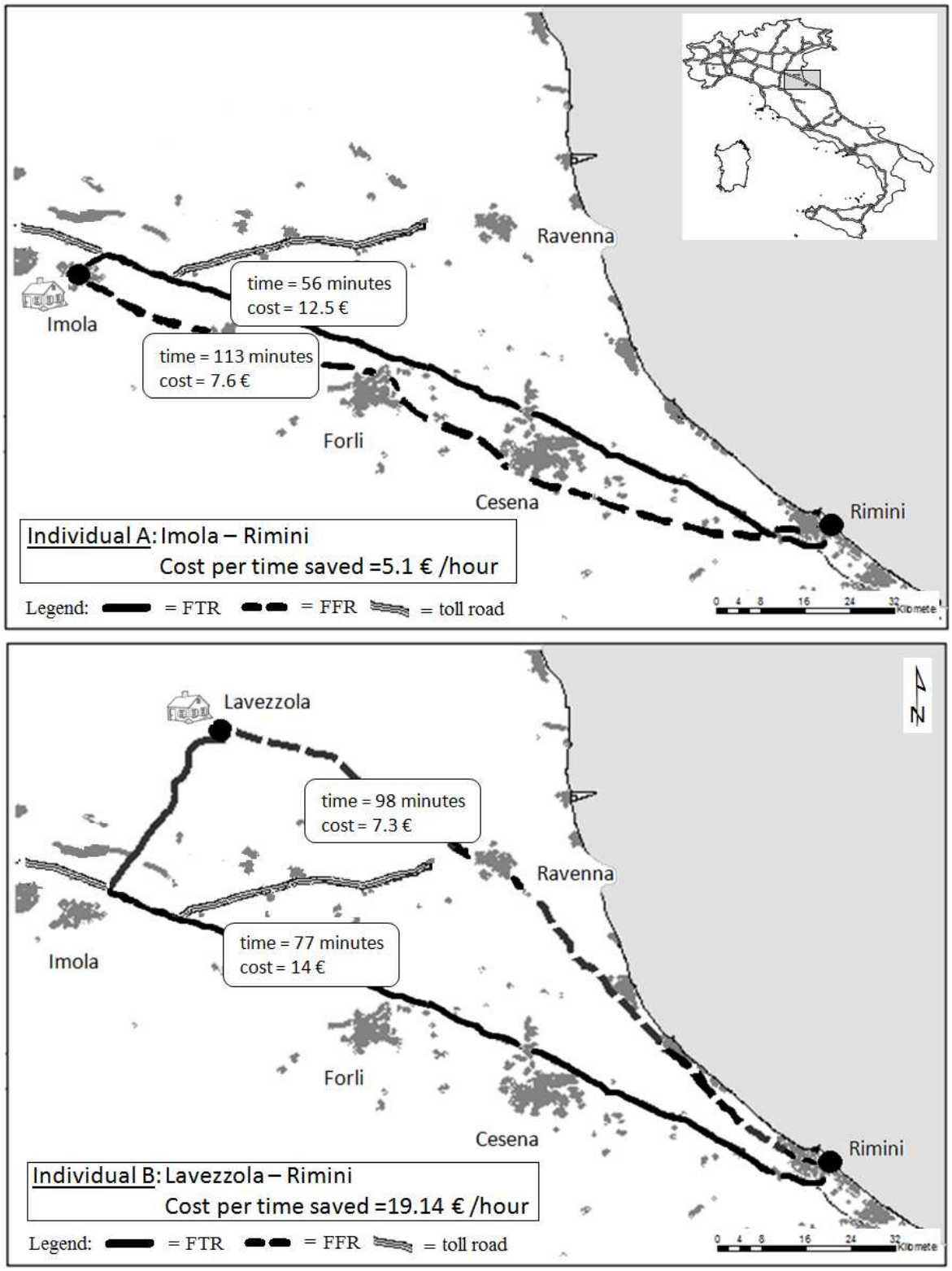
Table 4

Monte Carlo simulation: welfare estimates using different VTT

	"true" VTT_n	*$VTT_n = 0$*	*$VTT_n = 1/3w_n$*	*$VTT_n = w_n$*	*$VTT_n = 0.80w_n$*	*$VTT_n = 0.80\overline{w}$*
Mean WTP (€)	9.35	5.28	6.75	11.36	9.86	9.78
	[8.60, 10.25]	[4.86, 5.80]	[6.21, 7.41]	[10.47, 12.46]	[9.09, 10.81]	[9.00, 10.73]
5% quantile (€)	0.32	0.18	0.23	0.40	0.34	0.34
	[0.26, 0.41]	[0.14, 0.23]	[0.19, 0.30]	[0.32, 0.50]	[0.27, 0.43]	[0.27, 0.43]
95% quantile (€)	10.88	6.15	6.99	13.23	11.47	11.38
	[9.68, 12.23]	[5.47, 6.92]	[7.87, 8.85]	[11.76, 14.89]	[10.20, 12.90]	[10.12, 12.81]

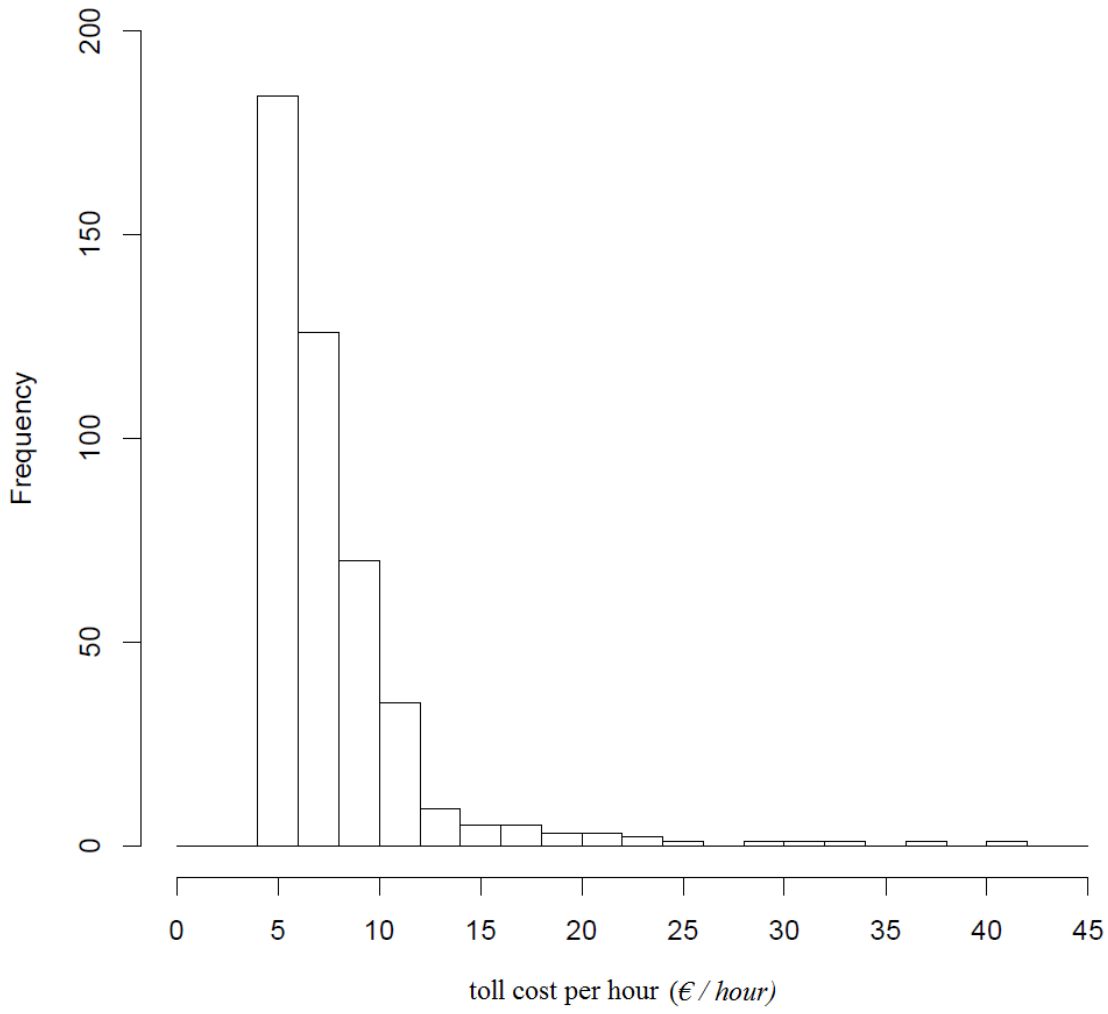
Notes: results generated with 5000 Monte Carlo repetition, w_n indicates the person specific wage rate and $\overline{w}$ indicates the sample mean wage rate. In brackets the 95% confidence intervals.

Figure 1: Possible routes and cost per time saved for two individuals living in different cities



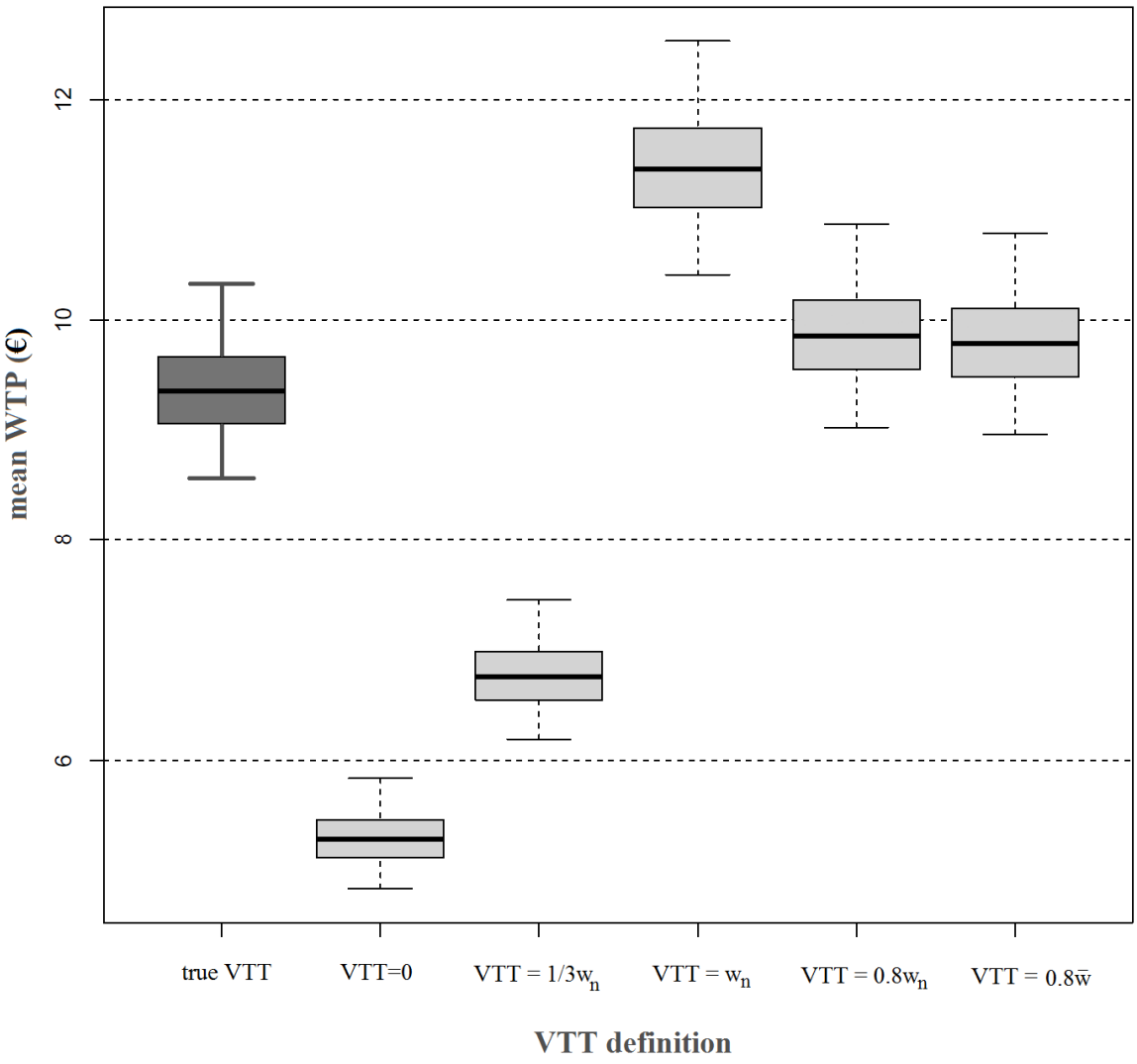
Notes: The small picture at the top represents the toll highway network in Italy, the top panel shows two possible routes for a person living in Imola and travelling to Rimini, with the dotted line representing the fastest free route (FFR) and the solid line indicating the fastest route including a toll road (FTR). The bottom panel represent the same route options for a person living in Lavezzola. Travel times calculated via the web site maps.google.com, fuel cost computed using the average fuel price in summer 2010 (1.29€/litre). The toll cost is €5.

Figure 2: Histogram of toll cost per hour of travel time saved



Notes: histogram of the toll cost per hour of travel time saved, which is defined as the ratio between (a) the toll and (b) the difference in time between the fastest toll route and the fastest free route for our sample (N=457). Nine respondents have a toll-time ratio higher than 50€/hour and lie outside the range of the plotted values.

Figure 3: average WTP estimates



Notes: Confidence intervals for the mean WTP of access, calculated with 5000 bootstrap repetitions. The gray box indicates the 1st and 3rd quartile, the wishers the 95% confidence interval. The symbol w_n indicates the person specific wage rate and $\overline{w}$ indicates the sample mean wage rate.

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