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Estimating the Value of Airport Access Time in Developing Countries with a Case Study of Nanjing, China

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Abstract: The valuation of time is one of the most important public policy issues in project cost-benefit analysis. This paper estimates the value of airport access time and time variability in developing countries with a case study of Nanjing, China. An international meta-analysis is being used to identify the factors that may affect heterogeneity in the value of travel time. Regression models are then established for the prediction of the value of travel time. The results provide some new insights into the impacts of survey region, traffic mode, and trip purpose on the value of travel time. Considering the significant influencing factors that were obtained, stated preference surveys are designed and used to collect data on preferred arrival time and decision choice under various hypothetical situations. A multivariate regression model is used with the data to explore the significant factors that influence the travelers' preferred arrival time. Mixed logit models are developed to estimate the value of airport access time, value of schedule delay early, and value of schedule delay late by incorporating the effects of travel delay variability on users' scheduling costs. The tax system is being used to illustrate the contribution of different income groups to social funds, which also calculates the social value of airport access time, social value of schedule delay early, and social value of schedule delay late. The results identify the significant factors that may affect the valuation of airport access time and provide reasonable estimates for these values. The findings also bring new enlightenment on the effects of the variation of airport access time.

Keywords: value of access time; air travelers; meta-analysis; discrete choice models; stated preference

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1. Introduction

With the rapid development of the social economy and transport industry in China, increasing attention is being paid to improving the efficiency of the transport system. For air travelers, airport access time plays an important role in measuring transport system efficiency and airport accessibility as a performance indicator. The valuation of access time for air travelers is useful for two different purposes. On the one hand, it is vital for the choice of airport and decision on departure time from origin (e.g., home). On the other hand, it can be used as an input for cost-benefit analysis of projects concerning airport accessibility [1]. Thus, the valuation of airport access time is regarded as an important process for policymakers in airport ground transportation system planning. The value captures a number of costs, including travel time and parking and fuel or ticket expenses, referred to as the generalized access cost [2]. Since DeSerpa proposed the time allocation theory [3], lots of studies have been led to assess the value of travel time (VTT) in various countries, for example, the Dutch national VTT study [4,5], the Swedish national VTT study [6], the Norwegian national VTT study [7], the Swiss national VTT study [8], and the VTT research of the United Kingdom [9,10]. The estimates of VTT are very different from nation to nation. Shires et al. carried out an international meta-analysis of the values of travel time savings, and the result summarized the previous research. The study gave an account of VTT for 25 European counties, in which the mean value of air traffic is 33.05 €/h, the mean value of bus is 19.26 €/h, and the mean value of other modes is 24.00 €/h (value in 2003) [11].

In recent years, a series of studies have been conducted to estimate VTT considering the variation of country, travel purpose, travel distance, etc. Among the current research, various types of discrete choice models such as MNL and Mixed logit (ML) models have been proposed to estimate VTT. The models are based on the maximum utility theory. It is assumed that the original time spent on traveling can be utilized to do something else. Rational decision makers would like to pay a specific amount of money to reduce travel time if their utilities can be increased by doing so. Usually, stated preference (SP) surveys or revealed preference (RP) surveys are conducted to obtain the VTT for a specific region or a chosen group. The respondents are invited to make choices among several alternatives, i.e., a path with less cost and more travel time vs. another path with more cost and less travel time. The value of travel time savings can be computed as the marginal rate of substitution of the estimated coefficient values of time and cost.

With the increasing emphasis on intermodal connections for airports, among the various literature to estimate VTT for different traffic modes, a few studies are conducted with regard to the accessibility of airports and the value of travel time for air travelers. For example, a report has been undertaken to document the state of practice for airport ground access mode choice models [12]. Thierry and Anne established both linear and nonlinear models to estimate the value of time for airplane users. The synthesis stresses the statistical superiority of nonlinear form and emphasizes the big differences in economic parameters (value of time, elasticity), which are caused by the a priori selected specification [13]. Koster et al. analyzed the cost of access travel time variability for air travelers. The willingness to pay method was used to estimate the value of a reduction in access travel time at the airport and the probability of missing a flight. The results of the numerical exercise display that the cost of access travel time variability for business travelers account for 3–36% of total access travel cost, and for non-business travelers account for 3–30% [14]. Recently, Birolini et al. investigated air passengers' choice of the access mode at low-cost airports. The study provided estimated values of time measures for traffic, out-of-vehicle travel time, and in-vehicle travel time, respectively. It was also revealed that low-cost airline passengers are not exclusively cost-driven when confronted with the access mode choice but do place considerable value on access time savings [15]. Gunay and Gokasar investigated the effect of destination type of mode choice using mixed logit, using a market segmentation approach. Their study showed that there were significant differences between domestic and international travel markets in terms of airport access mode choice [16].

Although several studies have been conducted with respect to VTT for air travelers, until recently, the research estimating the value of airport access time in developing countries such as China is still limited. Sun et al. conducted a comparative accessibility study of Chinese airports and high-speed railway stations. Their research indicated that with the massive infrastructure expansions in airports and high-speed railways in China, the passengers' perspective has yet to be clearly analyzed and compared [17]. Also, people's willingness to pay has yet to be discovered. Because of the socioeconomic and demographic disparities across different nations, people's choices may be quite different. The heterogeneity of travelers may lead to the analyses being more complicated, considering the existence of various travel purposes and trip modes [18]. Additionally, different air travelers may have different choices of preferred arrival times at the airport. Research is needed to investigate travelers' preferences to have a clear understanding of their behaviors. In addition, considering the variation of access time, early arrivals may cause travelers to wait at the airport to kill time, while late arrivals may increase the probability of missing a flight. It is expected that the value of schedule delay early and the value of schedule delay late would vary significantly.

This paper estimates the subjective and social value of access time for air travelers through the application of China's experience. More specifically, this paper: (a) explores the significant factors that may affect the value of travel time as presented in previous research, through an international meta-analysis; (b) identifies how the various factors influence people's preferred arrival time at the airport and estimates the subjective value of access time (VOAT), the value of schedule delay early (VSDE), and the value of schedule delay late (VSDL) for air travelers using discrete choice models, at the same time, the random tastes that may exist among different respondents are considered; and (c) estimates the social value of access time (SVOAT), the social value of schedule delay early (SVSDE), and the social value of schedule delay late (SVSDL) for air travelers that can be used in the transportation-related project evaluation.

2. An International Meta-Analysis of Values of Travel Time

This section explores the significant factors that affect the value of travel time in previous research and determines their relevance to the value of access time for air travelers.

2.1. The Datasets Used

The data used for this meta-analysis come from previous research published in the period 2000 to 2021. A total of 240 values of travel time were originally collected. The original dataset is provided in Appendix A. The data includes survey region (country), trip purpose (e.g., business, commute, private, leisure, shopping), traffic mode (e.g., car, bus, train, subway, air), research methods (e.g., stated versus revealed preference), sample size, travel distance (short distance, long distance), and the value of travel time savings. To ensure comparability, all the data of value of travel time savings were transformed into US dollars accounting for the currency rates and inflation factors as of 2021. A summary of the dataset is shown in Table 1.

Table 1. Summary of the dataset.

Variables		Sample Size	Percent (%)
Region	Europe	192	80.00
	North America	25	10.42
	Asia	14	5.83
	Oceania	9	3.75
Trip purpose	All purposes	10	4.17
	Business	53	22.08
	Commute	70	29.17
	Other (Private/Leisure/Shopping)	75	31.25
	NA	32	13.33
Traffic mode	All	3	1.25
	Car	67	27.92
	Car & bus	3	1.25
	Car & train	3	1.25
	Public transport	65	27.08
	Train	41	17.08
	Air	12	5.00
	Air & High-speed Rail	3	1.25
	Highway	9	3.75
	Surface	6	2.50
	Ferry	4	1.67
	Auto	3	1.25
	Drop-off	3	1.25
	Coach	2	0.83
	NA	16	6.67
Research method	SP	52	21.67
	RP	25	10.42
	SP & RP	5	2.08
	NA	158	65.83

2.2. Test of Heterogeneity

In this paper, the Q and I^2 statistic tests are used, which are effective and recognized methods for the test of heterogeneity. The Q statistic estimates the degree of deviation between the actual observation value of statistical samples and the theoretically inferred mean value, and is determined as:

$$Q = \sum_i^k w_i \left(T_i - T\right)^2 \tag{1}$$

where w_i is the weight of the i-th study, which is related to its sample size. The larger the sample size, the higher the weight. T_i is the effect size of the ith study. T is the mean effect size of all the studies, calculated as:

$$T = \frac{\sum w_i T_i}{\sum w_i} \tag{2}$$

Thus, the value of Q can be determined as:

$$Q = \sum_{i=1}^{k} w_i T_i^2 - \frac{\left(\sum w_i T_i\right)^2}{\sum w_i} \tag{3}$$

Q follows the chi-squared statistical distribution with degrees of freedom of $n-1$. The smaller the Q value, the smaller the deviation. Generally, if the p value corresponding to the Q value is less than 0.1, there is heterogeneity. Otherwise, heterogeneity can be not considered. Based on the Q value, the I^2 statistic is calculated as:

$$I^2 = \begin{cases} \frac{Q-df}{Q} & if\ Q > df \\ 0 & if\ Q \leq df \end{cases} \tag{4}$$

The value of I^2 varies from 0% to 100%. The higher the I^2 value, the greater the heterogeneity. I^2 values up to 25% represent a mild heterogeneity, with 50% being moderate and 75% being high. In this paper, both the Q value and the I^2 value are calculated using the STATA software. The Q value is 181.01 (p = 0.006), Tau2 is 0.517, and the value of I^2 is 24.9% (p = 0.000), which is between mild and moderate heterogeneities. Previous research indicated that segmentations (e.g., by income or mode) act a pivotal part in capturing the heterogeneity in these values.

2.3. Regression Models for the Prediction of Value of Travel Time

To better understand the impacts of various factors on the value of travel time savings, a general multivariate regression model is tested. The model estimation results are shown in Table 2. Different segmentations are tried. It is found that the survey region (Asia, Europe, Oceania), trip purpose (business, commute, and other), traffic mode (air, surface and public transport), trip distance (short distance), other attributes (out-of-vehicle), and per capital GDP are the crucial factors that may affect heterogeneity [19–21]. The model estimation results are summarized in Table 2.

Table 2. Model estimation results.

	Coeff (*t*)
Region	
Asia	−32.198 (6.510)
Europe	−21.152 (6.672)
Oceania	−21.773 (4.237)
Trip purpose	
Business	17.681 (6.201)
Commute	−7.563 (2.842)
Other (private/leisure/shopping)	−8.868 (3.272)
Trip mode	
Air	34.264 (9.037)
Surface	−25.990 (4.393)
Public transport	−4.218 (2.126)
Trip distance	
Short distance	−6.214 (2.485)
Other	
OVTT (out-of-vehicle)	18.299 (2.509)
Income	
Per capita GDP ($)	0.0002 (3.139)
Const	36.089 (9.204)
Adjusted R^2	0.633

According to the model estimation results, the general multivariate regression model can be obtained to predict the value of travel time for different countries:

$$\begin{aligned} V_{TT} = -32.198R_A - 21.152R_E - 21.773R_O + 17.681P_B - 7.563P_C - 8.868P_O + 34.264M_A \\ -25.99M_S - 4.218M_P - 6.214D_S + 18.299A_O + 0.0002G + 36.089 \end{aligned} \quad (5)$$

where
V_{TT} = value of travel time ($/h);
R_A = geographic location for Asia;
R_E = geographic location for Europe;
R_O = geographic location for Oceania;
P_B = trip purpose for business;
P_C = trip purpose for commute;
P_O = trip purpose for other (private/leisure/shopping);
M_A = transportation mode for airplane;
Ms = transportation mode for surface;
M_P = transportation mode for public transport;
Ds = trip distance for short distance;
A_O = out of vehicle trip;
G = gross domestic product per capita of the target region.

The regression model provides an R^2 of 0.633. As compared with the findings from previous research, the regression model provides some new insights in the impacts of survey region, traffic mode, trip purpose, and GDP on the value of travel time.

3. Subjective Values of Airport Access Time

The results from Section 2 indicate that the survey region and traffic mode are important in capturing the heterogeneity in the value of travel time, which means that the value of access time for air travelers can be quite different from that of travelers with other traffic modes, and the values for air travelers may distinguish among countries. This section provides a methodology for estimating the values with a case study of Nanjing city, China.

3.1. Model Formulations

Figure 1 shows the assumed structure of the deterministic access cost function of an air traveler. The x-axis represents the time of day, and the y-axis indicates the cost. A traveler decides when to depart from home according to the intended traffic mode, the corresponding access time, the final check-in time, and preferred arrival time. The preferred arrival time may vary from person to person, which may be affected by factors including socioeconomic characteristics, trip purpose (business/non-business), traffic mode that he/she intends to use and trip cost. Travelers expect that they can arrive at the airport accurately at their preferred arrival time. However, due to the variation of access time, this is not often the case. Early arrivals may cause the travelers to wait at the airport to kill time, e.g., a traveler arrives at time TA. Late arrivals may increase the probability of missing a flight, e.g., a traveler arrives at time TB, which may incur a large penalty of cost, including the cost of the flight ticket, re-booking, and waiting. The schedule delay early (SDE) is defined as the duration from early arrival time to the preferred arrival time. The schedule delay late (SDL) is defined as the duration from the preferred arrival time to actual arrival time. The travelers make a trade-off between being early and late and whether they arrive early or late compared to their preferred arrival time [22–25]. According to the rational choice theory, if a decision maker (k) faces two options (i and j), and the utilities U_i is higher than U_j, the decision maker always chooses option i, expressed as [26]:

$$P_{ik} = P\left(U_{ik} > U_{jk}\right) \tag{6}$$

where
P_{ik} = the probability of choosing option i for decision maker k;
U_{ik} = the utility that k obtains from choosing option i;
U_{jk} = the utility that k obtains from choosing option j.

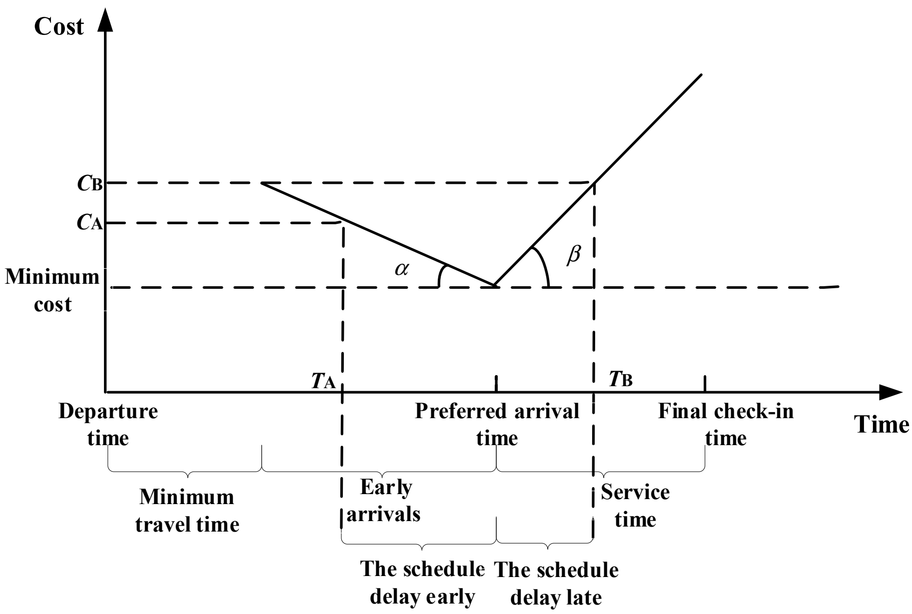

Figure 1. Diagram of the relationship between travel time and cost for air travelers.

The random utility can be represented as the sum of the systematic utility and an unobserved error term, which is shown as:

$$\begin{aligned} P_{ni} &= P\left(V_{ik} + \varepsilon_{ik} > V_{jk} + \varepsilon_{jk}\right) \\ &= P\left(\varepsilon_{ik} - \varepsilon_{jk} > V_{jk} - V_{ik}\right) \\ &= P\left(\varepsilon_{jk} - \varepsilon_{ik} < V_{ik} - V_{jk}\right) \\ &= \int F\left(\varepsilon_{jk} - \varepsilon_{ik} < V_{ik} - V_{jk}\right) f(\varepsilon) d\varepsilon \end{aligned} \tag{7}$$

where
V_{ik} = the systematic utility that *k* obtains from choosing option *i*;
V_{jk} = the systematic utility that *k* obtains from choosing option *j*;
ε = the unobserved error term;
F = the 'if' statement that the difference between the error terms ε_{jk} and ε_{ik} is lower than the difference between the systematic utility V_{ik} and V_{jk} is true or not (=1 if the statement is true, 0 if the statement is false);
$f(\varepsilon)$ = the priori assumed density function of the unobserved error term ε.

The systematic utility V_{ik} and V_{jk} can be expressed as a linear function of the various attributes of an alternative, such as access travel time, schedule delay early, schedule delay late, and travel cost, multiplied by their coefficients.

$$V_{ik} = \alpha i + \beta_{COST} \cdot E(c_{ik}) + \beta_{TIME} \cdot E(T_{ik}) + \beta_{SDE} \cdot E(SDE_{ik}) + \beta_{SDL} \cdot E(SDL_{ik}) \tag{8}$$

$$V_{jk} = \alpha j + \beta_{COST} \cdot E(c_{jk}) + \beta_{TIME} \cdot E(T_{jk}) + \beta_{SDE} \cdot E(SDE_{jk}) + \beta_{SDL} \cdot E(SDL_{jk}) \tag{9}$$

where
$E(c_{ik})$ = the expected travel cost for *k* choosing option *i*;
$E(c_{jk})$ = the expected travel cost for *k* choosing option *j*;
$E(T_{ik})$ = the expected access time for *k* choosing option *i*;
$E(T_{jk})$ = the expected access time for *k* choosing option *j*;
$E(SDE_{ik})$ = the expected schedule time early for *k* choosing option *i*;
$E(SDE_{jk})$ = the expected schedule time early for *k* choosing option *j*;
$E(SDL_{ik})$ = the expected schedule time late for *k* choosing option *i*;
$E(SDL_{jk})$ = the expected schedule time late for *k* choosing option *j*;
β_{COST} = the coefficient of cost;
β_{TIME} = the coefficient of access travel time;
β_{SDE} = the coefficient of schedule time early;
β_{SDL} = the coefficient of schedule time late;
α_i, α_j = the other known factors influencing the decision making.

As travel cost and travel time are both undesirable variables, their coefficients should be negative. The value of access time (VOAT) is the ratio of the marginal utility of time to the marginal utility of cost, which can be estimated as the ratio of the access time coefficient β_{TIME} to the cost coefficient β_{COST}:

$$V_{AT} = \frac{\partial U / \partial E(T)}{\partial U / \partial E(c)} = \frac{\beta_{TIME}}{\beta_{COST}} \tag{10}$$

where V_{AT} represents the value of access time (RMB/h, where RMB is the Chinese currency unit). Similarly, the value of schedule delay early (V_{SDE}) can be estimated as the ratio of the schedule delay early coefficient (β_{SDE}) to the cost coefficient (β_{COST}); and the value of schedule delay late (V_{SDL}) can be estimated as the ratio of the schedule delay early coefficient (β_{SDL}) to the cost coefficient (β_{COST}), which are shown as follows:

$$V_{SDE} = \frac{\partial U / \partial E(SDE)}{\partial U / \partial E(c)} = \frac{\beta_{SDE}}{\beta_{COST}} \tag{11}$$

$$V_{SDL} = \frac{\partial U/\partial E(SDL)}{\partial U/\partial E(c)} = \frac{\beta_{SDL}}{\beta_{COST}} \tag{12}$$

where
V_{SDE} = the value of schedule delay early (RMB/h),
V_{SDL} = the value of schedule delay late (RMB/h).

3.2. The Stated Preference Survey

For the purpose of estimating VOAT, VSDE and VSDL, a stated preference (SP) survey was conducted in the city of Nanjing from October 2016 to July 2020. A questionnaire is designed for collecting the respondents' information. The survey consists of three parts. The first is about the respondents' socioeconomic characteristics, including gender, age, education, occupation, personal monthly income, family monthly income, and number of missed flights and reasons. The second part is about the information about the respondents' recent air travel, including questions about travel purpose, travel distance, travel mode, time and money spent, and whether the travel expenses could be reimbursed. The third part presents a series of assumed choice situations. The respondents were first asked about their preferred arrival time. Then they were asked to make some choices among different scenarios. These scenarios are distinguished in terms of expected access time to the airport, transportation fees, schedule delay early, or schedule delay late as compared with their expected arrival time. An illustration of the SP survey is listed in Table 3. There are some slight differences in values of different questionnaires for traffic mode, fare, trip time, and the actual arrival time as compared with the preferred arrival time. The questionnaires are randomly selected by the respondents.

Table 3. Illustration of the SP survey.

When you travel by airplane, assuming that the check-in time of your flight is 19:00 (during the peak hour), how many minutes earlier do you generally expect to arrive at the airport?
Answer:________

What would you like to choose among the following options? Please choose A or B for each scenario.

Scenarios		Mode	Fare	The trip time	The arrival time as compared with your preferred arrival time
1	A	subway	10 RMB	75 min	10 min later
	B	taxi	80 RMB	40 min	30 min earlier
2	A	subway	8 RMB	90 min	60 min earlier
	B	shuttle	110 RMB	35 min	15 min earlier
3	A	taxi	90 RMB	65 min	5 min later
	B	shuttle	85 RMB	45 min	10 min later

When you travel by airplane, assuming that the check-in time of your flight is 15:00 (during the non-peak hour), how many minutes earlier do you generally expect to arrive at the airport?
Answer:________

What would you like to choose among the following options? Please choose A or B for each scenario.

Scenarios		Mode	Fare	The trip time	The arrival time as compared with your preferred arrival time
4	A	subway	10 RMB	75 min	10 min later
	B	taxi	80 RMB	40 min	30 min earlier
5	A	subway	8 RMB	90 min	60 min earlier
	B	shuttle	110 RMB	35 min	15 min earlier
6	A	taxi	90 RMB	65 min	5 min later
	B	shuttle	85 RMB	45 min	10 min later

Both internet surveys and face-to-face interviews were conducted. The former involved air travelers in Nanjing to collect the data necessary for the analysis of the access utility function. In the initial sample of 1500 respondents, 894 responded, indicating a total response rate of 59.6%. To ensure that the sample is representative of the entire population, a second stage face-to-face interview was conducted in Nanjing Lukou airport, collecting another 281 effective questionnaires to ensure that the proportion of each group in the survey conforms to the mean occupancy ratio from the yearbook. A comparison of the two ratios is shown in Table 4. Together with the questionnaires collected in the first stage, a total of 1175 questionnaires were collected. As each respondent is invited to make choices in 6 scenarios, the total number of choice samples is 7050. Table 4 describes the social-economic characteristics of the respondents.

Table 4. Comparison of the proportion of each group in the survey and the mean occupancy ratio from the yearbook.

Variables		Mean Occupancy Ratio from the Yearbook	Sample Size	Proportion of Each Group in the Survey	Difference Rate
GENDER	Male	50.34%	598	50.89%	−0.55%
	Female	49.66%	577	49.11%	+0.55%
AGE	12–30 years old	18.20%	187	15.91%	+2.29%
	31–45 years old	49.16%	650	55.32%	−6.16%
	46–60 years old	22.99%	259	22.04%	+0.95%
	Over 61 years old	9.65%	79	6.73%	+2.92%
EDUCATION	Junior high school	18.53%	170	14.47%	+4.06%
	High school	28.35%	344	29.28%	−0.93%
	Junior college	22.66%	333	28.34%	−5.68%
	Undergraduate	18.04%	234	19.91%	−1.87%
	Master and above	12.42%	94	8%	+4.42%
CAREER	Middle managerial staff and above	15.86%	229	19.49%	−3.63%
	Managerial staff under the middle level	23.04%	263	22.38%	+0.66%
	Employees and farmers	36.40%	436	37.11%	−0.71%
	Students	15.44%	198	16.85%	−1.41%
	Others	9.26%	49	4.17%	+5.09%
PMI (Personal Monthly Income)	≤5000 RMB	22.58%	294	25.02%	−2.44%
	5000–8000 RMB	36.98%	409	34.81%	+2.17%
	8000–12,500 RMB	23.21%	286	24.34%	−1.13%
	12,500–38,500 RMB	13.36%	157	13.36%	0.00%
	≥38,500 RMB	3.87%	29	2.47%	+1.4%
FMI (Mean family Monthly Income per person)	≤5000 RMB	15.94%	187	15.91%	+0.03%
	5000–8000 RMB	18.47%	217	18.46%	+0.01%
	8000–12,500 RMB	36.98%	434	36.94%	+0.04%
	12,500–38,500 RMB	22.59%	265	22.55%	+0.04%
	≥38,500 RMB	6.02%	72	6.14%	−0.12%

3.3. *Preferred Arrival Time for Air Travelers*

Each air traveler may have a preferred arrival time at the airport. Some travelers prefer to arrive early to ensure that they have ample time for checking and registering luggage. Others prefer to arrive on time, as long as they do not miss the flight. Thus, the preferred arrival may vary from person to person. In this paper, a multivariate regression model is used to explore the significant factors that may affect the travelers' preferred arrival time. The dependent variable is the duration from travelers' preferred arrival time to the departure time of the flight. The independent variables are the various potential influencing factors, shown in Table 5.

Table 5. Definition of candidate explanatory variables.

Variable Notation	Type	Definition	
GENDER	Dummy	Gender of the respondent	0 = Female 1 = Male
AGE	Continuous	Age of the respondent	
EDUCATION	Discrete	Education background of the respondent	1 = Junior high school and lower 2 = High school 3 = Junior college 4 = Undergraduate 5 = Master and above
CAREER	Discrete	Occupation of the respondent	1 = Middle managerial staff and above 2 = Managerial staff under the middle level 3 = Employees and farmers 4 = Students 5 = Others
PMI	Continuous	Personal Monthly Income (RMB)	
FMI	Continuous	Family Monthly Income (RMB)	
TRAN	Discrete	Traffic mode to the airport	1 = Bus 2 = Subway 3 = Private car 4 = Taxi 5 = Fast car 6 = Airport shuttle bus
REIM	Dummy	Whether the travel expenses can be reimbursed	0 = Cannot be reimbursed 1 = Can be reimbursed
PURPOSE	Discrete	Trip purpose	1 = Traveling or shopping 2 = Visiting friends and relatives 3 = Business trips 4 = Go abroad to study or work
MISS	Continuous	Times of missed flights	
BAGGAGE	Continuous	number of baggage	
AIR	Dummy	International or domestic flights	0 = Domestic flights 1 = International flights
TRAVEL TIME	Continuous	Access travel time (minutes)	
SDE TIME	Continuous	Schedule delay early (minutes)	
SDL TIME	Continuous	Schedule delay late (minutes)	
COST	Continuous	Trip cost (RMB)	

The model can be explained as follows:

$$\begin{aligned} T_{PAT} = \beta_0 &+ \beta_{GENDER}x_{GENDER} + \beta_{AGE}x_{AGE} + \beta_{EDUCATION}x_{EDUCATION} + \beta_{CAREER}x_{CAREER} \\ &+\beta_{PMI}x_{PMI} + \beta_{FMI}x_{FMI} + \beta_{TRAN}x_{TRAN} + \beta_{REIM}x_{REIM} + \beta_{PURPOSE}x_{PURPOSE} \\ &+\beta_{LUGGAGE}x_{LUGGAGE} + \beta_{MISS}x_{MISS} + \beta_{REASON}x_{REASON} + \beta_{AIR}x_{AIR} + \varepsilon \end{aligned} \tag{13}$$

where
T_{PAT} = the duration from travelers' preferred arrival time to departure time of the flight;
β_0 = a constant;
$x_{GENDER}, x_{AGE}, x_{EDUCATION}, x_{CAREER}, x_{PMI}, x_{FMI}, x_{TRAN}, x_{REIM}, x_{PURPOSE}, x_{LUGGAGE}, x_{MISS}, x_{REASON}, x_{AIR}$ = independent variables;
$\beta_{GENDER}, \beta_{AGE}, \beta_{EDUCATION}, \beta_{CAREER}, \beta_{PMI}, \beta_{FMI}, \beta_{TRAN}, \beta_{REIM}, \beta_{PURPOSE}, \beta_{LUGGAGE}, \beta_{MISS}, \beta_{REASON}, \beta_{AIR}$ = the coefficients of independent variables;
ε = the random error.

The results are shown in Table 6.

Table 6. Analysis of preferred arrival time.

Variables	Coefficients	Standard Deviation	*p*	Lower Limit of Confidence Interval	Upper Limit of Confidence Interval
AGE	0.124	0.077	0.017	0.276	0.008
EDUCATION	1.395	0.695	0.045	2.761	0.030
PMI	−0.001	0.000	0.007	−0.234	0.015
MISS	1.377	0.071	0.039	−0.016	2.771
BAGGAGE	0.065	0.077	0.058	−0.860	2.180
_CONS	45.290	6.912	0.000	31.729	58.851

As seen from Table 6, the significant variables include age, education, personal monthly income, number of missed flights, and amount of luggage. The coefficients of AGE and EDUCATION are positive, indicating that the elderly and people with higher education tend to arrive earlier at the airport. The coefficient of PMI is negative, indicating that people with higher income are more willing to arrive just on time. The coefficients of MISS and BAGGAGE are positive. Travelers with the experience of missing a flight tend to arrive earlier. In addition, those with luggage prefer to arrive earlier to ensure that they have enough time for luggage registration. According to the estimation results, the following model is derived to estimate the preferred arrival time for air travelers:

$$T_{PAT} = 0.124x_{AGE} + 1.395x_{EDU} - 0.001x_{PMI} + 1.377x_{MISS} + 0.065x_{BAG} + 45.29 \quad (14)$$

where
T_{PAT} = preferred arrival time;
x_{AGE} = age variable;
x_{EDU} = education variable;
x_{PMI} = personal monthly income variable;
x_{MISS} = miss flight variable;
x_{BAG} = luggage variable.

The regression model provides a R^2 of 0.862, indicating that the regression models have reasonable goodness-of-fit to collected data.

3.4. Results of Subjective Values of Airport Access Time

With the collected data of respondents' choices, discrete choice models can be developed to estimate the value of access time (VOAT), the value of schedule delay early (VSDE), and the value of schedule delay late (VSDL). In this research, both the Multinomial Logit (MNL) model and Mixed Logit (ML) models are established. Using the software package STATA, the coefficients of the discrete choice model are estimated. Considering the diversity in the marginal utility of each independent variable across individuals, the selected variables may have random coefficients. The variables with random parameters are determined by allowing each variable to have a random parameter and checking the *t*-statistic of the standard deviation of the distribution of each parameter. The results show that SDE TIME and SDL TIME have random parameters. Different types of distributions for coefficients are proved, including the normal and lognormal. The results are summarized in Table 7.

Table 7. Results of the MNL and ML models.

Variables	MNL Model		ML Model 1 $\beta_{SDE}\sim N(\mu_1,\sigma_1^2)$ $\beta_{SDL}\sim N(\mu_2,\sigma_2^2)$		ML Model 2 $\beta_{SDE}\sim N(\mu_3,\sigma_3^2)$ $\beta_{SDL}\sim N(\mu_4,\sigma_4^2)$		ML Model 3 $\beta_{SDE}\sim N(\mu_5,\sigma_5^2)$ $\beta_{SDL}\sim N(\mu_6,\sigma_6^2)$	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
GENDER-E	—	—	—	—	−0.0011 **	0.0022	—	—
AGE-L	−0.0006 **	0.0004	−0.0005 **	0.0003	−0.0005 **	0.0003	−0.0007 **	0.0003
EDUCATION-L	−0.0053 **	0.0018	−0.0058 **	0.0028	−0.0058 **	0.0028	−0.0059 **	0.0030
PMI-L	3.4×10^{-7} **	5.0×10^{-7}	4.3×10^{-7} **	8.7×10^{-7}	3.9×10^{-7} **	7.9×10^{-7}	4.1×10^{-7} **	8.0×10^{-6}
REIM-E	—	—	—	—	—	—	5.2×10^{-6} **	0.0024
REIM-L	0.0004 *	0.0047	—	—	0.0003 **	0.0069	—	—
PURPOSE-L	—	—	—	—	—	—	-0.0152 **	0.0017
LUGGAGE-E	0.0005 *	0.0019	—	—	0.0004 **	0.0031	0.0011 **	0.0071
MISS-L	–	–	—	—	-0.0009 ***	0.0028	−0.0085 **	0.0240
AIR-E	0.0067 *	0.0285	—	—	0.0056 **	0.0352	—	—
AIR-L	—	—	—	—	—	—	−0.0156 **	0.0009
SDE TIME	0.0014 **	0.0066	0.0037 **	0.0015	0.0009 ***	0.0082	—	—
SDL TIME	0.0016 ***	0.0018	0.0678 ***	0.0201	0.0021 ***	0.0017	0.0758 **	0.0352
TIME	0.0015 *	0.0014	0.0020 *	0.0014	0.0017 *	0.0016	0.0019 *	0.0011
COST	0.0012 *	0.0010	0.0013 **	0.0008	0.0013 ***	0.0009	0.0711 ***	0.0232
Std of SDE TIME	—	—	0.0009 *	0.0048	0.0008 *	0.0048	0.0125 *	1.7227
Std of SDL TIME	—	—	0.0108 *	0.0277	0.1573 *	0.4259	0.0217 *	4.9981
AIC	5042.479		4898.253		4895.053		4898.498	
Log likelihood	−2511.239		−2440.127		−2433.527		−2436.249	
RL	0.000		0.202		1.000		0.179	

Note: *, **, and *** indicate that the variables are statistically significant at the 90%, 95%, and 99% levels, respectively.

The likelihood ratio test is carried out, and the relative quality of statistical models are compared according to Akaike information criterion (*AIC*) and the relative likelihood (*RL*) of different models.

$$RL = \exp((AIC_{min} - AIC_i)/2) \tag{15}$$

where AIC_{min} represents the lowest *AIC* value among the models. The value of RL varies from 0 to 1. The closer to 1, the better the model is. According to Table 7, it can be seen that, generally, the ML models outperform the MNL model. The best estimation is when the coefficient of SDE TIME (β_{SDE}) follows the normal distribution and the coefficient of SDL TIME (β_{SDL}) follows the lognormal distribution; results can be obtained. However, the difference in log likelihood values is not significant in percentage terms. Eighteen explanatory variables are included in the model, including gender, age, education, income, reimbursement, number of luggage, number of missed flights, domestic or international flights, schedule delay early, schedule delay late, and travel cost. According to the estimated coefficients, females tend to arrive at the airport earlier than males. The elderly also preferred to arrive earlier than younger travelers. Lower education (lower diploma) also has negative impacts on schedule delay late. Personal monthly income has a positive effect on schedule delay late, meaning that people with lower income tend to arrive earlier to avoid economic loss due to late arrivals. If the ticket can be reimbursed, travelers tend to arrive just on time. When it comes to the amount of luggage and number of missed flights, as expected, the former has a positive effect on schedule delay early, while the latter has a negative impact. Compared with domestic flights, people who take international flights tend to arrive earlier at the airport. The result is intuitive, although this factor has rarely been mentioned in previous studies. By using the model estimation results, the subjective values of access travel time can be obtained. The Monte Carlo simulation method is used to conduct uncertainty analysis by randomly sampling from probability descriptions of the coefficients (β_{SDE}, β_{SDL}, β_{TIME}, and β_{COST}) to generate a probability description of results. The results determine that the values of access time, schedule delay early, and schedule delay late are 78.46 RMB/h, 41.19 RMB/h (std. 37.22 RMB/h), and 104.32 RMB/h (std. 95.40 RMB/h), respectively.

4. Social Values of Airport Access Time

As shown in the previous section, the values of access time, schedule delay early, and schedule delay late can be calculated using the individual willingness-to-pay figures. However, as indicated in Jara-Díaz's research, the social view of individual benefits is not necessarily equal to the private view. The estimation of social benefits and social prices requires further elaboration [16]. Thus, this section aims to propose and apply experimentally an approach to determine the social values of access time that result from transport investments funded with money collected through taxes; that is social investment.

4.1. Model Formulations

The social welfare that benefits from saving travel time can be estimated as the sum of the utility of each individual group.

$$U = U_1 + \cdots + U_k + \cdots + U_n \tag{16}$$

where
U = the total social utility obtained from travel time savings;
U_k = the social utility for individual group k (k = 1, . . . ,n). The individual utility is can be expressed as the function of individual monthly income (I_k), travel cost©) and travel time (T), which is shown as follows:

$$U_k = f(I_k, C, T) \tag{17}$$

When the travel time changes result from airport ground tranportation system (dt), the change in social welfare (dU) can be estimated as:

$$dU = \sum_{k=1}^{n} dU_k = \sum_{k=1}^{n} \frac{\partial U}{\partial U_k} \frac{\partial U_k}{\partial I_k} \frac{\partial I_k}{\partial t} dt = \sum_{k=1}^{n} \frac{\partial U}{\partial U_k} \lambda_k dt \tag{18}$$

where
λ_k = the marginal utility of income for individual group k;
dU_k = the benefit for individual group k.

According to expression (18), the social welfare (dU) result from saving of access travel time (in terms of utility) is the weighted sum of all individual benefits (in terms of monetary values). The weight is calculated as λ_k multiplied by $\partial U/\partial U_k$, where λ_k represents the importance in terms of utility that individual k that assigns to a variation in income; $\partial U/\partial U_k$ is the social welfare for individual k. Assuming that the contribution of individual utility to society can be reflected by taxation, when the marginal tax paid by air passenger k is dT_k, the total tax is:

$$dT = \sum_{k=1}^{n} dT_k \tag{19}$$

Meanwhile, due to the payment of taxes, the total utility changes as:

$$dL = \sum_{k=1}^{n} \lambda_k dT_k \tag{20}$$

It can be obtained that:

$$\lambda_s = \frac{dL}{dT} = \frac{\sum_{k=1}^{n} \lambda_k dT_k}{\sum_{k=1}^{n} dT_k} = \sum_{k=1}^{n} \lambda_k \theta_k \tag{21}$$

where
λ_s = the social utility of a unit of money, which is the ratio of the change in social marginal benefits to the marginal tax paid by all groups;
θ_k = the marginal tax rate for income of individual group k. θ_k can be estimated as:

$$\theta_k = \frac{dT_k}{dT} = \frac{\varepsilon_k \eta_k}{\sum_n \varepsilon_k \eta_k} \tag{22}$$

where
dT_k = the marginal tax amount of individual group k;
dT = the total marginal tax amount;
ε_k = the average tax amount of individual group k as a percentage of the social group income;
η_k = represents the average income of individual k as a percentage of Gross National Product (GNP).

It can be obtained that:

$$dU = \sum_{k=1}^{n} dU_k = \sum_{k=1}^{n} \lambda_k VOAT_k dt \tag{23}$$

where
$VOAT_k$ = the subjective value of ravel time savings for individual k, that is, the ratio of the marginal utility of travel cost to the marginal utility of travel time, and can also be expressed as the ratio of travel time coefficient (β_{TIME}) to travel cost coefficient (β_{COST}).

Therefore, the social value of travel time savings is estimated as:

$$SVOAT = \frac{\sum\limits_{k=1}^{n} \lambda_k VOAT_k dt}{\lambda_s \cdot ndt} = \frac{1}{\lambda_s \cdot n} \sum_{k=1}^{n} \lambda_k VOAT_k = \frac{|\beta_{TIME}|}{\lambda_s} \tag{24}$$

where
$SVOAT$ = the social value of travel time savings;
λ_s = the social utility of a unit of money.

Similarly, the social value of schedule delay early ($SVSDE$) and social value of schedule delay late ($SVSDL$) can be calculated as:

$$SVSDE = \frac{|\beta_{SDE}|}{\lambda_s} \tag{25}$$

$$SVSDL = \frac{|\beta_{SDL}|}{\lambda_s} \tag{26}$$

4.2. Results of Social Values of Airport Access Time

Considering that people of different income levels contribute different marginal wage ratios to society as taxes, the collected data is divided into five groups, including "PMI-1" (monthly income < 3500 RMB), "PMI-2" (3500 RMB $\leq$ monthly income < 5000 RMB), "PMI-3" (5000 RMB $\leq$ monthly income < 8000 RMB), "PMI-4" (8000 RMB $\leq$ monthly income < 12,500 RMB), and "PMI-5" (monthly income $\geq$ 12,500 RMB). According to the Statistical Yearbook of Jiangsu Province, it can be found that the GNP of Nanjing is 54,198 RMB. Based on the collected data, the average income and tax payment for each group is calculated, as shown in Table 8.

Table 8. Tax payments as a percentage of income in China.

Range of Income (RMB)		Average Income of the Sample (RMB)	Income as % of GNP (ε_k)	Tax Payments as % of Income (η_k)
PMI-1	0–3500	2823	5.21	0.00
PMI-2	3500–5000	5674	10.47	0.59
PMI-3	5000–8000	6549	12.08	6.39
PMI-4	8000–12,500	10,293	18.99	11.99
PMI-5	Over 12,500	28,860	12.08	19.37

The marginal tax rate for income of individual group k (θ_k) is calculated according to Equation (22), which are shown as follows.

$$\begin{aligned} \varepsilon_1 \times \eta_1 &= 0.0000 \times 0.0521 = 0.0000 \\ \varepsilon_2 \times \eta_2 &= 0.0059 \times 0.1047 = 0.0006 \\ \varepsilon_3 \times \eta_3 &= 0.0064 \times 0.1208 = 0.0008 \\ \varepsilon_4 \times \eta_4 &= 0.1199 \times 0.1899 = 0.0228 \\ \varepsilon_5 \times \eta_5 &= 0.1937 \times 0.5325 = 0.1031 \end{aligned} \tag{27}$$

$$\begin{aligned} \theta_1 &= \frac{\varepsilon_1\eta_1}{\sum\limits_5 \varepsilon_5\eta_5} = \frac{0.0000}{0.1273} = 0.0000 \\ \theta_2 &= \frac{\varepsilon_2\eta_2}{\sum\limits_5 \varepsilon_5\eta_5} = \frac{0.0006}{0.1273} = 0.0047 \\ \theta_3 &= \frac{\varepsilon_3\eta_3}{\sum\limits_5 \varepsilon_5\eta_5} = \frac{0.0008}{0.1273} = 0.0063 \\ \theta_4 &= \frac{\varepsilon_4\eta_4}{\sum\limits_5 \varepsilon_5\eta_5} = \frac{0.0228}{0.1273} = 0.1791 \\ \theta_5 &= \frac{\varepsilon_5\eta_5}{\sum\limits_5 \varepsilon_5\eta_5} = \frac{0.1031}{0.1273} = 0.8099 \end{aligned} \tag{28}$$

According to Equation (21), the social utility of a unit of money (λ_s) can be calculated as:

$$\begin{aligned}\lambda_s &= \sum_{k=1}^{n} \lambda_k \theta_k \\ &= \lambda_1 \times \theta_1 + \lambda_2 \times \theta_2 + \lambda_3 \times \theta_3 + \lambda_4 \times \theta_4 + \lambda_5 \times \theta_5 \\ &= 0.004 \times 0.000 + 0.003 \times 0.0047 + 0.007 \times 0.0063 + 0.005 \times 0.1791 + 0.001 \times 0.8099 \\ &= 0.0017\end{aligned} \tag{29}$$

According to the model estimation results, the best results can be obtained when the coefficient β_{SDE} follows the normal distribution, the coefficient β_{SDL} follows the lognormal distribution and β_{TIME} is a constant. Therefore, the social value of access time (SVOAT), schedule delay early (SVSDE) and schedule delay late (SVSDL), which can be estimated as the ratio of β_{SDE}, β_{SDL}, and β_{TIME} to λ_s, are 105.88 RMB/h, 98.82 RMB/h (std 30.94 RMB/h), and 151.76 RMB/h (std 155.87 RMB/h), respectively. The results are shown in Table 9.

$$\begin{aligned} SVOAT &= \frac{|\beta_{time}|}{\lambda_s} = \frac{0.003}{0.0017} \times 60 = 105.88 \text{ RMB/h} \\ SVSDE &= \frac{|\beta_{SDE}|}{\lambda_s} = \frac{0.0028}{0.0017} \times 60 = 98.82 \text{ RMB/h} \\ SVSDL &= \frac{|\beta_{SDL}|}{\lambda_s} = \frac{0.0043}{0.0017} \times 60 = 151.76 \text{ RMB/h} \end{aligned} \tag{30}$$

Table 9. Income distribution and contribution of each income group to social funds.

Variable	ε [a] (%)	k [b] (%)	η [c] (%)	$\varepsilon * \eta$ (%)	θ [d] (%)	λ [e]	$\mid\beta_{TIME}\mid/\mid\beta_{SDE}\mid/\mid\beta_{SDL}\mid$	***SVOAT/ SVSDE/ SVSDL*** **(RMB/h)**
PMI-1	0.00	25.02	5.21	0.00	0.00	0.004		
PMI-2	0.59	34.81	10.47	0.06	0.47	0.003		
PMI-3	6.39	24.31	12.08	0.08	0.63	0.007	0.003 0.0028 0.0043	105.88/ 98.82/ 151.76
PMI-4	11.99	13.36	18.99	2.28	17.91	0.005		
PMI-5	19.37	2.47	53.25	10.31	80.99	0.001		
Total	–	100	100	12.73	100	0.0017		

[a] ε represents mean tax payments as % of income; [b] k is the percent of population for each income group; [c] η represents percent of GNP from each income group; [d] θ represents contribution to social funds; [e] λ is the conversion factors from utility to monetary values.

5. Conclusions and Discussion

This paper estimates the subjective and social value of access travel time for air passengers through an empirical application in Nanjing, China. An international meta-analysis is conducted to identify the significant factors that may affect the value of travel time. SP surveys are designed to collect data on the travelers' preferred arrival time and decision choice under various hypothetical situations. Discrete choice models are built to estimate how various parameters influence traveler choice. Considering that there are random tastes among different respondents, this paper uses mixed logit models to estimate the coefficients of various parameters. Based on the model estimation results, the following conclusions can be made:

(1) According to the meta-analysis results from 240 studies, the survey region (Asia, Europe, Oceania), trip purpose (business, commute, and other), traffic mode (air, surface, and public transport), trip distance (short distance), other attributes (out-of-vehicle), and per capital GDP are the crucial factors that may affect heterogeneity. A multivariate regression model is then established for the prediction of value of access travel time.

(2) With the collected data from SP surveys in Nanjing, a linear regression model is used to explore the significant factors that may affect the travelers' preferred arrival time.

The significant variables include age, education, personal monthly income, number of missed flights, and amount of luggage. According to the estimation results, a prediction model is then obtained to estimate the preferred arrival time for air travelers.

(3) Mixed logit models are developed to estimate the value of access travel time (VOAT), value of schedule delay early (VSDE) and value of schedule delay late (VSDL). Eighteen explanatory variables are included in the model, gender, age, education, income, reimbursement, amount of luggage, number of missed flights, domestic or international flights, schedule delay early, schedule delay late, and travel cost. The results determine that the values of access time, schedule delay early, and schedule delay late are 78.46 RMB/h, 41.19 RMB/h (std. 37.22 RMB/h), and 104.32 RMB/h (std. 95.40 RMB/h), respectively. While comparable to those in other countries, these values are significantly lower than in developed countries.

(4) Using the tax system to illustrate the contribution of different income groups to social funds, the social value of access travel time (SVOAT), schedule delay early (SVSDE) and schedule delay late (SVSDL) are calculated also. The values are 105.88 RMB/h, 98.82 RMB/h (std 30.94 RMB/h), and 151.76 RMB/h (std 155.87 RMB/h), respectively. The estimated values can be directly used in the cost-benefit analysis of operational related projects in China.

Although there is a lot of research that provides quantification of the value of travel time, estimating the values and using them in the cost-benefit analysis of projects may result in greater challenges than expected. This study summarizes these challenges faced by other researchers:

(1) The value of travel time may vary significantly across different survey regions, traffic modes, trip purposes, etc. Proper selection of these values can lead to more accurate results in economic evaluation of projects. For example, this paper estimates the value of airport access time with a case study of Nanjing, China. The value can be used in cost-benefit analysis of projects concerning airport accessibility in this region. Local program managers should also select relative values based on the project types and data available.

(2) When estimating the value of time, the impacts of time variability should be considered together since the impacts of early arrivals and late arrivals may be quite different. In addition, although the value of schedule delay late is much higher than the value of schedule delay early, the user costs of early arrival time may also constitute a large part of the total costs.

(3) The social value of travel time, instead of the subjective value of time should be used in the cost-benefit analysis of related projects. Estimating social value includes two main elements, which are the formulation of the social welfare change which can be estimated as a weighted sum of individual benefits, as well as the conversion of social welfare to monetary terms. The framework implemented in the study can also be used to estimate the economic benefits of projects in other countries by incorporating the corresponding tax collection policy.

One of the limitations of this study is that due to the lack of data in collected documentation, results from a few studies that do not have complete data sets are not included in the meta-analysis process. Further research is still needed in order to better understand those factors affecting the value of travel time, as well as the heterogeneity across nations by enlarging the sample size. Besides, the seasonal effects on the estimated values are not considered, as the season associated variables were not provided from the survey. It is expected that the value of access time may be affected by the weather conditions, as most travelers would not like to be exposed to extreme hot or cold days. Further research needs to be conducted to obtain more accurate results. Additional studies are also needed to test the transferability of the presented procedure and selected models using data collected from other cities or other countries. The authors suggest that future studies focus on these issues.

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Appendix A

	Author(s)	Country	Region	Trip Purpose	Trip Distance	Mode	Survey Type	VTTS	Per Capita GDP ($)	VTTS in 2021 ($/h)
1	Blayac and Causse (2001) [27]	France	Europe			Train	SP	133.0 FF/h	22,433	36.68
2		France	Europe			Air	SP	223.0 FF/h	22,433	61.50
3	Ghosh (2001) [28]	USA	North America	Commute			SP	17.82 $/h	37,133	27.23
4		USA	North America	Commute			RP	26.21 $/h	37,133	40.06
5	Kenneth et al. (2001) [29]	USA	North America	Commute		Highway	SP	20.63 $/h	37,133	31.53
6	Lam and Small (2001) [30]	USA	North America	Commute		Highway	RP	22.87 $/h	37,133	34.95
7	Hensher (2001) [31]	New Zealand	Oceania	Non-business	Long	Car	SP	9.42 $NZ/h	13,882	10.19
8	Mackie et al. (2003) [9]	United Kingdom	Europe	Commute		Car		8.17 €/h	34,487	14.22
9		United Kingdom	Europe	Other		Car		7.25 €/h	34,487	12.62
10		United Kingdom	Europe	Business		Car		32.47 €/h	34,487	56.52
11		United Kingdom	Europe	Business		Train		38.35 €/h	34,487	66.75
12	Brownstone and Small (2005) [25]	USA	North America	Commute		Highway	SP & RP	12.55 $/h	44,114	17.38
13	Small et al. (2005) [32]	USA	North America	Commute		Car	RP	21.46 $/h	44,114	29.71
14		USA	North America	Commute		Car	SP	11.92 $/h	44,114	16.50
15	Hess et al. (2005) [33]	Canada	North America				SP	108.72 $Aud/h	36,382	113.24
16	Bhat and Sardesai (2006) [34]	USA	North America	Commute		Highway	RP	15.08 $/h	46,298	20.23
17		USA	North America	Commute		Highway	SP	11.59 $/h	46,298	15.55
18		USA	North America	Commute		Highway	SP & RP	12.31 $/h	46,298	16.52
19	Cirillo and Axhausen (2006) [35]	Germany	Europe	Commute		Highway	RP	13.6 DM/h	36,323	10.80
20		Germany	Europe	Other		Highway	RP	19.6 DM/h	36,323	15.57
21	Hensher (2006) [36]	Australia	Oceania	Commute		Car	SP	22.71 $/h	36,117	30.47
22	Fosgerau (2006) [37]	Denmark	Europe	Non-business		Car	SP	89.2 DKK/h	52,026	19.04
23	Axhausen et al. (2006) [38]	Switzerland	Europe	Business		Car		37.87 €/h	59,300	60.15
24		Switzerland	Europe	Business		PT (bus/train)		35.31 €/h	59,300	56.08
25	Asensio and Matas (2007) [39]	Spain	Europe	Commute		Car	SP	14.7 €/h	32,549	22.71
26	Fosgerau et al. (2007) [40]	Denmark	Europe	Commute		Car	SP	11.87 €/h	58,487	18.34
27		Denmark	Europe	Other		Car	SP	11.87 €/h	58,487	18.34
28		Denmark	Europe	Commute		PT (bus/train)	SP	11.87 €/h	58,487	18.34
29		Denmark	Europe	Other		PT (bus/train)	SP	11.87 €/h	58,487	18.34
30	Axhausen et al. (2008) [41]	Switzerland	Europe	Business		PT	SP	25.18 CHF/h	74,572	34.66
31		Switzerland	Europe	Commute		PT	SP	18.93 CHF/h	74,572	26.05
32		Switzerland	Europe	Leisure		PT	SP	11.90 CHF/h	74,572	16.38
33		Switzerland	Europe	Shopping		PT	SP	13.10 CHF/h	74,572	18.03
34		Switzerland	Europe	All		PT	SP	14.10 CHF/h	74,572	19.41
35		Switzerland	Europe	Business		Car	SP	27.66 CHF/h	74,572	38.07
36		Switzerland	Europe	Commute		Car	SP	19.04 CHF/h	74,572	26.21
37		Switzerland	Europe	Leisure		Car	SP	18.83 CHF/h	74,572	25.92
38		Switzerland	Europe	Shopping		Car	SP	17.84 CHF/h	74,572	24.55
39		Switzerland	Europe	All		Car	SP	20.98 CHF/h	74,572	28.88

	Author(s)	Country	Region	Trip Purpose	Trip Distance	Mode	Survey Type	VTTS	Per Capita GDP ($)	VTTS in 2021 ($/h)
40	Steimetz (2008) [42]	USA	North America	Commute	Short	Car	SP	21.02 $/h	48,382	26.43
41	Swiss Association of Road and Transportation Experts (2009) [43]	Switzerland	Europe	Commute		Car		26.70 €/h	72,083	39.90
42		Switzerland	Europe	Other		Car		6.19 €/h	72,083	9.25
43		Switzerland	Europe	Commute		PT (bus/train)		16.19 €/h	72,083	24.20
44		Switzerland	Europe	Other		PT (bus/train)		8.72 €/h	72,083	13.03
45	Shires and de Jong (2009) [11]	Netherlands	Europe	Commute		Car		11.05 €/h	52,514	16.51
46		Netherlands	Europe	Commute		Train		11.05 €/h	52,514	16.51
47		Netherlands	Europe	Commute		BTM		9.14 €/h	52,514	13.66
48		Netherlands	Europe	Business		Car		30.94 €/h	52,514	46.24
49		Netherlands	Europe	Business		Train		30.94 €/h	52,514	46.24
50		Netherlands	Europe	Business		BTM		24.83 €/h	52,514	37.11
51		Netherlands	Europe	Other		Car		8.85 €/h	52,514	13.23
52		Netherlands	Europe	Other		Train		8.85 €/h	52,514	13.23
53		Netherlands	Europe	Other		BTM		6.21 €/h	52,514	9.28
54	Ramjerdi and Flügel (2010) [44]	Norway	Europe	Commute	Short	Car		11.7 €/h	87,693	17.21
55		Norway	Europe	Other	Short	Car		10.01 €/h	87,693	14.72
56		Norway	Europe	Business	Short	Car		49.40 €/h	87,693	72.66
57		Norway	Europe	Commute	Long	Car		26.00 €/h	87,693	38.24
58		Norway	Europe	Other	Long	Car		18.98 €/h	87,693	27.92
59		Norway	Europe	Business	Long	Car		49.40 €/h	87,693	72.66
60		Norway	Europe	Commute	Short	PT (bus/train)		7.80 €/h	87,693	11.47
61		Norway	Europe	Other	Short	PT (bus/train)		5.98 €/h	87,693	8.80
62		Norway	Europe	Business	Short	PT (bus/train)		49.40 €/h	87,693	72.66
63		Norway	Europe	Commute	Long	Train		20.28 €/h	87,693	29.83
64		Norway	Europe	Other	Long	Train		11.96 €/h	87,693	17.59
65		Norway	Europe	Business	Long	Train		49.40 €/h	87,693	72.66
66		Norway	Europe	Commute	Long	Bus		13.39 €/h	87,693	19.70
67		Norway	Europe	Other	Long	Bus		9.49 €/h	87,693	13.96
68		Norway	Europe	Business	Long	Bus		49.40 €/h	87,693	72.66
69		Norway	Europe	Commute	Long	Air		37.44 €/h	87,693	55.07
70		Norway	Europe	Other	Long	Air		23.40 €/h	87,693	34.42
71		Norway	Europe	Business	Long	Air		57.85 €/h	87,693	85.09
72	Li et al. (2010) [45]	Australia	Oceania	Commute		Car	SP	30.04 $Aud/h	52,087	28.08
73		Australia	Oceania	Non-commute		Car	SP	12.22 $Aud/h	52,087	11.42
74	Hanssen (2011) [46]	Norway	Europe			Ferry	SP	131.6 NOK/h	100,600	18.44
75		Norway	Europe			Ferry	SP	101.7 NOK h	100,600	14.25
76		Norway	Europe			Ferry	SP	67.5 NOK/h	100,600	9.46
77		Norway	Europe			Ferry	SP	88.4 NOK/h	100,600	12.39
78	Börjesson et al. (2012) [47]	Sweden	Europe	Commute		PT (Metro/train)	SP	6.00 €/h	58,037	8.38
79	Devarasetty et al. (2012) [48]	USA	North America			Highway	SP & RP	51.0 $/h	51,602	60.14

	Author(s)	Country	Region	Trip Purpose	Trip Distance	Mode	Survey Type	VTTS	Per Capita GDP ($)	VTTS in 2021 ($/h)
80	Mickaël et al. (2012) [13]	USA	North America			Train	SP	42.89 €/h	51,602	59.87
81	Trafikverket (2012) [49]	Sweden	Europe	Commute	Long	Car		10.96 €/h	58,037	15.30
82		Sweden	Europe	Other	Long	Car		10.96 €/h	58,037	15.30
83		Sweden	Europe	Business	Long	Car		29.54 €/h	58,037	41.24
84		Sweden	Europe	Commute	Long	Bus		3.96 €/h	58,037	5.53
85		Sweden	Europe	Other	Long	Bus		3.96 €/h	58,037	5.53
86		Sweden	Europe	Business	Long	Bus		29.54 €/h	58,037	41.24
87		Sweden	Europe	Commute	Long	Train		7.41 €/h	58,037	10.34
88		Sweden	Europe	Other	Long	Train		7.41 €/h	58,037	10.34
89		Sweden	Europe	Business	Long	Train		25.07 €/h	58,037	35.00
90		Sweden	Europe	Other	Long	Air		17.56 €/h	58,037	24.51
91		Sweden	Europe	Business	Long	Air		29.54 €/h	58,037	41.24
92		Sweden	Europe	Commute	Short	Car		8.83 €/h	58,037	12.33
93		Sweden	Europe	Other	Short	Car		5.99 €/h	58,037	8.36
94		Sweden	Europe	Business	Short	Car		29.54 €/h	58,037	41.24
95		Sweden	Europe	Commute	Short	Bus		5.38 €/h	58,037	7.51
96		Sweden	Europe	Other	Short	Bus		3.35 €/h	58,037	4.68
97		Sweden	Europe	Business	Short	Bus		29.54 €/h	58,037	41.24
98		Sweden	Europe	Commute	Short	Train		7.00 €/h	58,037	9.77
99		Sweden	Europe	Other	Short	Train		5.38 €/h	58,037	7.51
100		Sweden	Europe	Business	Short	Train		25.07 €/h	58,037	35.00
101	Douglas and Jones (2013) [50]	Australia	Oceania	Education		PT (bus/train)		7.5 $/h	68,156	8.71
102		Australia	Oceania	Other		PT (bus/train)		8.7 $/h	68,156	10.11
103		Australia	Oceania	Commute		PT (bus/train)		15.7 $/h	68,156	18.24
104		Australia	Oceania	Business		PT (bus/train)	SP	12.8 $/h	68,156	14.87
105	CGSP (2013) [51]	France	Europe	Commute		Car & bus		10.0 €/h	42,592	13.75
106		France	Europe	Other		Car & bus		6.8 €/h	42,592	9.35
107		France	Europe	Business		Car & bus		17.5 €/h	42,592	24.07
108		France	Europe	Commute		Car & train		12.6 €/h	42,592	17.33
109		France	Europe	Other		Car & train		8.7 €/h	42,592	11.97
110		France	Europe	Business		Car & train		22.3 €/h	42,592	30.67
111		France	Europe	Other		Car		14.4 €/h	42,592	19.81
112		France	Europe	Business		Car		32.7 €/h	42,592	44.97
113		France	Europe	Other		Coach		12.1 €/h	42,592	16.64
114		France	Europe	Business		Coach		27.6 €/h	42,592	37.96
115		France	Europe	Other		Train		22.7 €/h	42,592	31.22
116		France	Europe	Business		Train		43.3 €/h	42,592	59.55
117		France	Europe	Other		Air		53.4 €/h	42,592	73.44
118		France	Europe	Business		Air		72.9 €/h	42,592	100.26

	Author(s)	Country	Region	Trip Purpose	Trip Distance	Mode	Survey Type	VTTS	Per Capita GDP ($)	VTTS in 2021 ($/h)
119		Netherlands	Europe	Commute		Car		9.25 €/h	52,184	12.72
120		Netherlands	Europe	Other		Car		7.5 €/h	52,184	10.32
121		Netherlands	Europe	Business		Car		26.25 €/h	52,184	36.10
122		Netherlands	Europe	Commute		Train		11.5 €/h	52,184	15.82
123		Netherlands	Europe	Other		Train		7.00 €/h	52,184	9.63
124	Significance et al. (2013) [52]	Netherlands	Europe	Business		Train		19.75 €/h	52,184	27.16
125		Netherlands	Europe	Commute		PT (Bus/Train)		7.75 €/h	52,184	10.66
126		Netherlands	Europe	Other		PT (Bus/Train)		6.00 €/h	52,184	8.25
127		Netherlands	Europe	Business		PT (Bus/Train)		19.00 €/h	52,184	26.13
128		Netherlands	Europe	Other		Air		47.00 €/h	52,184	64.64
129		Netherlands	Europe	Business		Air		85.75 €/h	52,184	117.94
130		Germany	Europe	Commute	Short	Car		4.20 €/h	47,959	5.69
131		Germany	Europe	Other	Short	Car		3.49 €/h	47,959	4.72
132		Germany	Europe	Business	Short	Car		6.01 €/h	47,959	8.14
133		Germany	Europe	Commute	Short	PT (Bus/Train)		3.89 €/h	47,959	5.27
134		Germany	Europe	Other	Short	PT (Bus/Train)		3.85/ €/h	47,959	5.21
135		Germany	Europe	Business	Short	PT (Bus/Train)		4.65 €/h	47,959	6.29
136		Germany	Europe	Commute	Long	Car		9.58 €/h	47,959	12.97
137	Axhausen et al. (2014) [53]	Germany	Europe	Other	Long	Car		9.26 €/h	47,959	12.54
138		Germany	Europe	Business	Long	Car		12.11 €/h	47,959	16.39
139		Germany	Europe	Commute	Long	Train		8.21 €/h	47,959	11.11
140		Germany	Europe	Other	Long	Train		8.44 €/h	47,959	11.43
141		Germany	Europe	Business	Long	Train		11.06 €/h	47,959	14.97
142		Germany	Europe	Other	Long	Air		22.89 €/h	47,959	30.99
143		Germany	Europe	Business	Long	Air		33.87 €/h	47,959	45.85
144		Sweden	Europe	Commute		Car		10.65 €/h	60,020	14.42
145		Sweden	Europe	Commute		Train		7.2 €/h	60,020	9.75
146	Börjesson & Eliasson (2014) [54]	Sweden	Europe	Commute		BTM(Bus, Train, Metro)		5.3 €/h	60,020	7.17
147		Sweden	Europe	Other		Car		6.4 €/h	60,020	8.66
148		Sweden	Europe	Other		Train		5.0 €/h	60,020	6.77
149		Sweden	Europe	Other		BTM		2.8 €/h	60,020	3.79
150		Netherlands	Europe	Commute		Car		9.25 €/h	52,830	12.52
151		Netherlands	Europe	Commute		Train		11.5 €/h	52,830	15.57
152		Netherlands	Europe	Commute		BTM		7.75 €/h	52,830	10.49
153		Netherlands	Europe	Business		Car		26.25 €/h	52,830	35.53
154	Kouwenhoven et al. (2014) [55]	Netherlands	Europe	Business		Train		19.75 €/h	52,830	26.74
155		Netherlands	Europe	Business		BTM		19.00 €/h	52,830	25.72
156		Netherlands	Europe	Other		Car		7.50 €/h	52,830	10.15
157		Netherlands	Europe	Other		Train		7.00 €/h	52,830	9.48
158		Netherlands	Europe	Other		BTM		6.00 €/h	52,830	8.12

	Author(s)	Country	Region	Trip Purpose	Trip Distance	Mode	Survey Type	VTTS	Per Capita GDP ($)	VTTS in 2021 ($/h)
159		Netherlands	Europe	All		Car		9.00 €/h	52,830	12.18
160		Netherlands	Europe	All		Train		9.25 €/h	52,830	12.52
161		Netherlands	Europe	All		BTM		6.75 €/h	52,830	9.14
162	Sheikh et al. (2014) [56]	USA	North America			Car	RP	36.0 $/h	55,049	41.17
163		USA	North America			Car	RP	26.0 $/h	55,049	29.73
164	Chinh et al. (2015) [57]	Australia	Oceania			Car	SP	13.5 $/h	56,707	15.42
165	Department for Transport (2015) [58]	United Kingdom	Europe	Commute		All		12.51 €/h	45,404	16.92
166		United Kingdom	Europe	Other		All		5.71 €/h	45,404	7.72
167		United Kingdom	Europe	Business	Short	Car		12.60 €/h	45,404	17.04
168		United Kingdom	Europe	Business	Medium	Car		20.38 €/h	45,404	27.56
169		United Kingdom	Europe	Business	Long	Car		31.40 €/h	45,404	42.46
170		United Kingdom	Europe	Business	Short	Train		12.60 €/h	45,404	17.04
171		United Kingdom	Europe	Business	Medium	Train		20.38 €/h	45,404	27.56
172		United Kingdom	Europe	Business	Long	Train		45.24 €/h	45,404	61.18
173		United Kingdom	Europe	Business		Bus/LRT		12.60 €/h	45,404	17.04
174	USDOT (2016) [59]	USA	North America	Non-business	Local	Surface		13.60 $/h	58,021	15.34
175		USA	North America	Business	Local	Surface		25.40 $/h	58,021	28.64
176		USA	North America	All	Local	Surface		14.10 $/h	58,021	15.90
177		USA	North America	Non-business	Intercity	Surface		19.00 $/h	58,021	21.43
178		USA	North America	Business	Intercity	Surface		25.40 $/h	58,021	28.64
179		USA	North America	All	Intercity	Surface		20.40 $/h	58,021	23.01
180		USA	North America	Non-business	Intercity	Air & High-speed Rail		36.10 $/h	58,021	40.71
181		USA	North America	Business	Intercity	Air & High-speed Rail		63.20 $/h	58,021	71.27
182		USA	North America	All	Intercity	Air & High-speed Rail		47.10 $/h	58,021	53.12
183	Kou et al. (2017) [60]	China	Asia	Commute		PT	SP	11.34 ¥/h	8094	1.94
184		China	Asia	Commute		Car	SP	17.81 ¥/h	8094	3.05
185	Ojeda-Cabral et al. (2016) [61]	United Kingdom	Europe	Non-business		Car	SP	8.61 pence/min	41,499	8.02
186		United Kingdom	Europe	Non-business		Car	SP	6.72 pence/min	41,499	6.26
187		Denmark	Europe	Non-business			SP	112.08 DKK/h	54,663	20.10
188		Denmark	Europe	Non-business			SP	86.45 DKK/h	54,663	15.51
189	Beck et al. (2017) [62]	Sweden	Europe	Commute		Car	SP & RP	43.08 KR/h	53,791	5.55
190		Sweden	Europe	Commute		PT	SP & RP	19.16 KR/h	53,791	2.47
191	Yang et al. (2018) [18]	China	Asia	Commute		All	SP	35.8 ¥/h	8016	6.34

	Author(s)	Country	Region	Trip Purpose	Trip Distance	Mode	Survey Type	VTTS	Per Capita GDP ($)	VTTS in 2021 ($/h)
192	Börjesson et al. (2019) [63]	Sweden	Europe	Commute	Short	Car		9.8 €/h	54,589	12.51
193		Sweden	Europe	Commute	Short	Bus		5.3 €/h	54,589	6.77
194		Sweden	Europe	Commute	Short	Train		7.2 €/h	54,589	9.19
195		Sweden	Europe	Other	Short	Car		6.1 €/h	54,589	7.79
196		Sweden	Europe	Other	Short	Bus		2.8 €/h	54,589	3.58
197		Sweden	Europe	Other	Short	Train		5.0 €/h	54,589	6.38
198		Sweden	Europe	Other	Long	Car		11.7 €/h	54,589	14.94
199		Sweden	Europe	Other	Long	Bus		3.8 €/h	54,589	4.85
200		Sweden	Europe	Other	Long	Train		7.3 €/h	54,589	9.32
201	Varghese et al. (2018) [64]	India	Asia				RP	179.2 INR	2030	2.62
202		India	Asia				RP	132.2 INR	2030	1.93
203		India	Asia				RP	157.3 INR	2030	2.30
204		India	Asia				RP	84.7 INR	2030	1.24
205		India	Asia				RP	184.1 INR	2030	2.69
206		India	Asia				RP	96.6 INR	2030	1.41
207		India	Asia				RP	133.9 INR	2030	1.95
208		India	Asia				RP	113.5 INR	2030	1.66
209		India	Asia				RP	223.6 INR	2030	3.26
210		India	Asia				RP	150.2 INR	2030	2.19
211		India	Asia				RP	158.0 INR	2030	2.31
212	Birolini et al. (2019) [15]	Italy	Europe	All		Train	RP	€24.02/h	32,657	30.13
213		Italy	Europe	All		Train	RP	€18.76/h	32,657	23.53
214		Italy	Europe	Business		Train	RP	€37.3/h	32,657	46.79
215		Italy	Europe	Business		Train	RP	€23.95/h	32,657	30.04
216		Italy	Europe	Non-business		Train	RP	€37.48/h	32,657	47.01
217		Italy	Europe	Non-business		Train	RP	€19.38/h	32,657	24.31
218	Alonso-González et al. (2020) [65]	Dutch	Europe	Leisure		direct flexi		11.18 €/h	52,304	13.86
219		Dutch	Europe	Leisure		flexibus1		7.76 €/h	52,304	9.62
220		Dutch	Europe	Leisure		flexibus2		8.01 €/h	52,304	9.93
221		Dutch	Europe	Leisure		busbus1		7.89 €/h	52,304	9.78
222		Dutch	Europe	Leisure		busbus2		6.60 €/h	52,304	8.18
223		Dutch	Europe	Leisure		waiting transfer flexibus		7.40 €/h	52,304	9.17
224		Dutch	Europe	Leisure		waiting transfer busbus		5.77 €/h	52,304	7.15
225		Dutch	Europe	Commute		direct flexi		12.54 €/h	52,304	15.54
226		Dutch	Europe	Commute		flexibus1		8.24 €/h	52,304	10.21
227		Dutch	Europe	Commute		flexibus2		7.84 €/h	52,304	9.72
228		Dutch	Europe	Commute		busbus1		8.94 €/h	52,304	11.08
229		Dutch	Europe	Commute		busbus2		9.30 €/h	52,304	11.53

	Author(s)	Country	Region	Trip Purpose	Trip Distance	Mode	Survey Type	VTTS	Per Capita GDP ($)	VTTS in 2021 ($/h)
230		Dutch	Europe	Commute		waiting transfer flexibus		8.99 €/h	52,304	11.14
231		Dutch	Europe	Commute		waiting transfer busbus		9.12 €/h	52,304	11.30
232		Turkey	Europe			Auto	SP	0.294 $/min	9539	17.64
233		Turkey	Europe			Drop-off	SP	0.332 $/min	9539	19.92
234		Turkey	Europe			Public Transit	SP	0.246 $/min	9539	14.76
235		Turkey	Europe			Auto	SP	0.262 $/min	9539	15.72
236	Gunay et al. (2021) [16]	Turkey	Europe			Drop-off	SP	0.314 $/min	9539	18.84
237		Turkey	Europe			Public Transit	SP	0.227 $/min	9539	13.62
238		Turkey	Europe			Auto	SP	0.345 $/min	9539	20.70
239		Turkey	Europe			Drop-off	SP	0.383 $/min	9539	22.98
240		Turkey	Europe			Public Transit	SP	0.338 $/min	9539	20.28

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