Revisiting travel time in Mumbai: the value of time saving or the value of access?

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This study analyzes the association between travel time and the individual capability in Mumbai. We first formulated a conceptual hypothesis based on Backer's time allocation theory to understand differences between the consumption and production aspects of travel. Then, two operationalized hypotheses are introduced for empirical verification: (1) travel time is significantly related to individual capability and is lower for less capable, and (2) the variance of travel time, indicating the degree of freedom of movement, has positive association with individual capability. To empirically confirm the hypotheses, an activity-travel survey was conducted in middle income group housing, slums, and slum rehabilitation units. Our results support both hypotheses, suggesting that, when people are less capable, they attach more importance to the production aspects of travel, and gradually with the increase in their capability value on the consumption aspects become more vital. Hence, the value of travel time saving may underestimate the benefit from transport infrastructure investment. Therefore, including the value of access in transport infrastructure evaluation would make it more inclusive.

Key Words : *the value of travel time saving, the value of access, individual capability, Mumbai*

1. INTRODUCTION

Though travel time saving has long been the major benefit component in the evaluation of transportation infrastructure investment, there is a controversial discussion: Metz (1) emphasizes the importance of looking at the value of access to different activity opportunities rather than the value of travel time saving. He underscores this point with the fact that travel time expenditure (TTE) has not been changed for a long time, and saved travel time has just been spent to obtain better activity opportunities at different destinations. This phenomenon has been widely confirmed in number of countries (2-6). Though there is no clear consensus about to what extent the value of travel time saving is similar with the value of access, we would like to take the same position with Van Wee and Rietveld (7), that is to consider the value of access is at least higher than the value of travel time saving, primarily because the time, money and other costs of travel must be offset against the benefits obtainable from activities engagement at destinations (8).

Another important empirical fact is that TTE is constant only by socio-economic segment such as income group or gender group (9-12). As noted in Goodwin (8), such variation in TTE would be more useful than the stability of TTE. In line with this

Chikaraishi et al. (6) using Mobility German Panel data confirmed that, though the average TTE is basically constant over time, the intra-individual variations has steadily increased over time. Such variation change can be understood as the increase in the degree of choice or freedom in their daily activity-travel schedule: they may enjoy travel time saving on some days, while they could also spend more time to travel to reach more desirable destinations on some other days. In other words, transport infrastructure investment may contribute not only (1) to reduce travel time, but also (2) to increase activity opportunities, from the perspective of the travelers. Travelers might take the latter advantage when they think it is more beneficial.

This study extends this line of discussions to cities in the developing world where poverty reduction remains as a significant issue to be solved. In particular, this study hypothesizes that people in the disadvantaged group, such as slum dwellers, would not even reach the constant TTE situation due to social, economic, and mobility constraints: thus making them incapable of undertaking enough travel to obtain better activity opportunities, hence may less enjoy the travel time savings. Understanding the linkage between the individual capability and travel would bring important implications for policy debates. First, the above hypothetical statement indicates that, if the newly introduced transportation infrastructure is not affordable for the disadvantaged group (which is often the case), the investment could potentially lead to the increase in disparities among various socio-economic sections, at least in the short run. For example, clearly, expressway construction does not bring direct benefit to those who do not have a car. Likewise, even public transport may not substantially benefit to those who cannot afford to use it. These cases are certainly problematic and need to be included in policy debates. Meanwhile, it may not be a substantial issue in the long run if the trickle-down effects are expected. The investment would bring some benefits to those who can afford to use it, and this benefit could spill over into the disadvantaged group. Such aspects can be discussed by looking at the stock effects of infrastructure investment. Second, probably more importantly, when the newly introduced transport infrastructure is affordable for the disadvantaged group, travel time saving would substantially underestimate the benefit of the infrastructure investment. This would be primarily because travel for the poor tends to directly link with their productivity, and the true benefits would be the improvement in the access to better job opportunities, rather than travel time saving. In other words, the benefits of induced demand by transport infrastructure investment would be substantial for the disadvantaged group.

With the above discussions in mind, this study first conceptualizes how the individual capability links with time spent for travel based on time allocation theory proposed by Becker (13), followed by two operationalized hypotheses to be confirmed in this study. To empirically confirm the hypotheses, we implemented an activity-travel survey for 3 different groups in Mumbai, India: (1) people living in middle income group housing [MIG], (2) people living in slum areas [Slum], and (3) people living in Slum Rehabilitation Authority housing [SRA]. SRA is a new policy implementation in Mumbai where slum areas are converted to rehabilitation housing units (14).

The following sections are organized as follows. Section 2 explains a basic conceptual and analytical framework of this study. Section 3 introduces the study area, Mumbai, with a brief explanation of slum issues there, followed by a brief explanation of a small-scale pilot survey implemented in Mumbai in 2015. The empirical results and discussions are shown in Section 5. Section 6 concludes our study mentioning future tasks.

2. CONCEPT AND HYPOTHESES

(1) Basic concept

In the evaluation of the benefit of transportation infrastructure investment, travel time is often considered as a cost (i.e., travel time expenditure) which should be reduced by policy intervention. On the other hand, travel time can also take part in production through allowing people to reach better activity opportunities. For example, one could get a better job farther away from existing opportunity, where the increase in income is high enough to compensate for the loss of time and money for travel. This viewpoint has been little taken into consideration in transportation practice, in spite of Becker (13) showing the benefits of production aspects of travel through exploring the linkages between allocation of time and income. There are at least two useful insights to the discussions on travel time expenditure. First, he introduced the concept of “full income”, which is the sum of money income and forgone by the use of time and goods to obtain utility, emphasizing that time and income should not be discussed independently. From this perspective, it is expected that the time use of the disadvantaged group would be largely restricted by income. This makes them allocate more time to productive activities rather than non-productive activities (such as leisure) and its associated travel. Second, more importantly, Becker introduced the

concept of "productive consumption" to cover "commodities" that contribute to work as well as to consumption. Travel may be considered as this type of "commodity". This aspect of travel may be one of the main causal factors of the two controversial views of travel: "value of travel time saving" focusing more on consumption aspects, and the "value of access" focusing more on production aspects of travel.

This study argues that distinguishing between the consumption aspects of travel from the production aspects would be crucial particularly in an area where poverty reduction remains as a significant issue to be solved. In particular, this study puts the following conceptual hypothesis:

When people are less capable to enjoy "beings and doings" which add value to life, then people attach more importance to the production aspects of travel, and gradually put more value on the consumption aspects of travel with the increase in their capability.

The hypotheses could easily be accepted, since people anyway have to produce something to live. When one has not produced enough, one's time may tend to be allocated to productive activities to fulfill the basic needs (15) and this may also be applicable for travel, i.e., longer travel time would be acceptable only when it contributes to the increase in returns from production. The inherent difficulty may be in operationalization of this construct. Among others, monetizing value of access to non-productive activities is particularly challenging. This may be primarily because, it is not clear that to what extent policy maker should consider the value of access to non-productive activities, and, to give a clear conclusion, some normative judgement may need to be made. On the one hand, for the value of access to productive activities, there would be a relatively large space that needs to be and can be fulfilled. In fact, the benefit from the improvement of access to productive activities can be directly observed through income improvement, though it may be partial. Such benefit could be substantial and significantly different from the one obtained from travel time saving, and, to the authors' knowledge, it has little been discussed in the evaluation of transport infrastructure investments.

(2) Operationalized Hypotheses and Metrics

The direct confirmation of the above conceptual hypothesis would be considerably difficult. Thus, this study formulates the following two operationalized hypotheses:

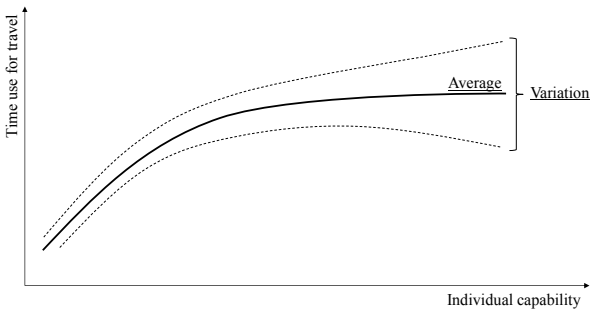


Fig.1 Place the caption below the drawing.

1. Travel time is significantly related to individual capability and is lower for less capable
2. The variance of travel time, indicating the degree of freedom of movement, has positive association with individual capability

Putting these hypotheses together, the association between time use for travel and individual capability considered in this study can be illustrated as shown in Figure 1. As we discussed, when the individual capability is quite low, people may allocate less time to travel due to economic, social, and/or mobility constraints (hypothesis 1). On the other hand, when the individual capability is improved, sometimes they may enjoy faster travel mode to the same destination, and other time they may enjoy visiting a bit far place to obtain better activity opportunities, resulting in the higher variation of travel time (hypothesis 2). The following section provides an empirical analysis of these hypotheses.Note that we use the term "individual capability" which is to some extent similar to "accessibility". Though, we avoid to use "accessibility", since our main focus is not just accessibility in terms of transportation, but rather the ability of access to various activity opportunities under social, economic, and mobility constraints that individual face.

One of the critical aspects for implementing empirical analysis is to define and measure the individual capability. As Sen (16) notes that, the issue of the person's ability to do certain basic things one values has been less paid attention in welfare analysis, and this is also true to a large extent in the evaluation of transportation infrastructure investment. Thus little empirical application has been found in transportation studies (17). On the other hand, after Sen (18) proposes the capability approach, considerable amount of studies have been made in various fields concerning human well-being (e.g., (19)). Among others, individual capability defined based on socio-economic conditions is an attractive method in practical context. For example, United Nations Development Program (20) introduces the Human

Develop Index (HDI) which is defined based on a long and healthy life (measured by life expectancy), being knowledgeable (measured by years of schooling) and have a decent standard of living (measured by gross national income per capita). Also, Socio-economic Cultural Index (SECI) provided a useful idea for the practical definition of capability: the SECI comprises three domains: income, employment, and education and culture (21; 22). Following these studies, this study define the individual capability based on the socio-economic and asset variables like income, years of schooling, and car ownership. The Capability Index is developed as the weighted aggregation of theses variables and the weights for each variable are calculated by the first component loading of the eigenvector based principal component extraction. Researches especially in developing countries like India have provided evidence that using such asset based index can successfully surrogate for relative wealth and that using the weights from first component loadings "provides plausible and defensible weights for an index of assets to serve as a proxy for wealth" (23; 24). Such studies also emphasize the use of variables like "car ownership" in defining economic status. Thus the Capability Index is calculated using the following Eq. (1).

$$CI = w_1 Z_{x_1} + w_2 Z_{x_2} + \cdots + w_n Z_{x_n} \quad (1)$$

where w_n is the weight of the variable x_n, Z_{x_n} is the score of variable x_n, and n is the number of variables.

3. STUDY AREA: MUMBAI

Mumbai has a population of 12.5 million (25) and is one of the world's most densely populated cities. Connotation of high population density in such cities from developing countries increase the pressure on the city's infrastructure systems. Shortage of housing in Mumbai remains one of its major societal woes. Out of the total population, it is estimated that more than 50% stay in squatter or improper housing settlements but only occupy 6% of Mumbai's urban space (26-28). Since India's independence many policies have been formulated to improve, rehabilitate or eradicate slums. Bardhan et al. (14) in their study concluded that the top-down approach to the policies were one of the major reasons for the propagation of slums. Slum rehabilitation scheme under the slum rehabilitation authority is among the latest policies under implementation, envisioned majorly as an in-situ rehabilitation scheme. These units are supposed to be an improvement over their previous informal units by enhancing their overall quality of life. SRA schemes use the tools of increased floor space index and transferable development rights to effectuate the plans. However, this is leading developers to create housing in areas with higher real-estate prices and subsequently leading to a slower implementation of the planned schemes (14; 29).

Mumbai's transport system comprises of the suburban rail system. The suburban rail system has four lines and carries a total of 7.3 million passengers everyday (30). Then there are bus services operated by the Brihanmumbai Electric Supply and Transport Undertaking (BEST) which carry over 3.67 million passengers per day. In addition, there is a monorail and a metro system. Baker et al. (26) studied income's relationship with travel characteristics. They surveyed 5000 households across different socioeconomic groups in Mumbai and found that about 45% of the total trips were made on foot. The same proportion increased to 63% for the disadvantaged group.Cropper and Bhattacharya (30) pointed out that the subsidized fares of the public transport systems in Mumbai is also high enough for the disadvantaged group and they spend a larger proportion of their total income on transportation as compared to their richer counterparts. They observed how the public transport subsidies is actually being utilized by the middle income group and not by the disadvantaged group with 26.06 % of the households belonging to the such section not receiving rail subsidy, whereas this figure was 13% for the non-poor. The average travel time for work trips in Mumbai is 31 minutes (31), but this value considerably changes when we consider the income of trip makers. Baker et al. (26) in their study observed that the number of people working in the same zone where they stay decreases when the income of the household increases. The travel time per trip for the disadvantaged group was 20.4 minutes whereas for households with income greater than Indian National Rupee (INR) 20,000 it was 34 minutes. This might be the result of urban poor household's reluctance to stay far from their workplaces and spend more money on commuting. Thus making them settle for poor quality housing and a compromised quality of life. It is evident that income plays a very important role on determining an individual's traveling patterns.

4. DATA COLLECTION

To observe activity-travel patterns in MIG, Slum, and SRA, an activity-travel survey was designed. The questionnaire comprised of (1) individual and household characteristics with questions pertaining to education, vehicle ownership, personal income,

individual's type of occupation, and nature of engagement, (2) the frequencies of different types of activities performed across space and time along with the representative travel mode and travel time, and (3) one-day individual travel diary of the previous day.

The survey was conducted in Mumbai in June, 2015. The samples collected were equally distributed among people residing in MIG, Slum, and SRA housing. A total of 158 samples were collected from 73 households from two slums :Phoolenagar slum and the Gareebnagar slum situated at Powai area, two SRA : Tagore nagar and Sangharsh nagar located in Vikhroli and Chandivali areas respectively, and middle income housing societies spread across different parts of the city. (See Figure 2). Paper based surveys were conducted on site, where the individuals were interviewed and responses were recorded by the interviewer.

Table 1 shows the distribution of the samples across the different housing types. Out of the 158 respondents, 48, 58, and 52 from MIG, Slum, and SRA, respectively. The distribution was 22, 23 and 28 for households of MIG, Slum, and SRA, respectively. Out of 158 individuals, 127 made at least one trip. Figure 3(a) shows the range of travel time per trip for people from different socioeconomic groups based on their personal income. It varies between 5 to 25 minutes for most of the slum dwellers, 15 to 35 minutes for SRA housing residents, and 30 to 45 minutes for the residents belonging to the middle income group. Similar trend is observed for the travel time per day (Figure 3(b)) with middle income group traveling the most followed by residents of SRA houses and slums. One interesting finding is that, while there is a positive association between travel time and personal income for Slum and SRA residents, MIG residents do not show such trend.

5. RESULTS AND DISCUSSIONS

This study intended to understand the association of capability of an individual to the total travel time spent. Three distinct housing typologies: MIG, Slum, and SRA, within the city of Mumbai, was chosen as the study samples. The travel time spent for various trip purposes were collated to develop the one-day aggregate travel time. A composite capability index, based on intrinsic parameters including personal income (X1), level of education (X2) and car ownership (X3), was built using weighted aggregation approach. The weights of the parameters were derived from the component loadings of the eigenvecr based component extraction method. Concretely, the

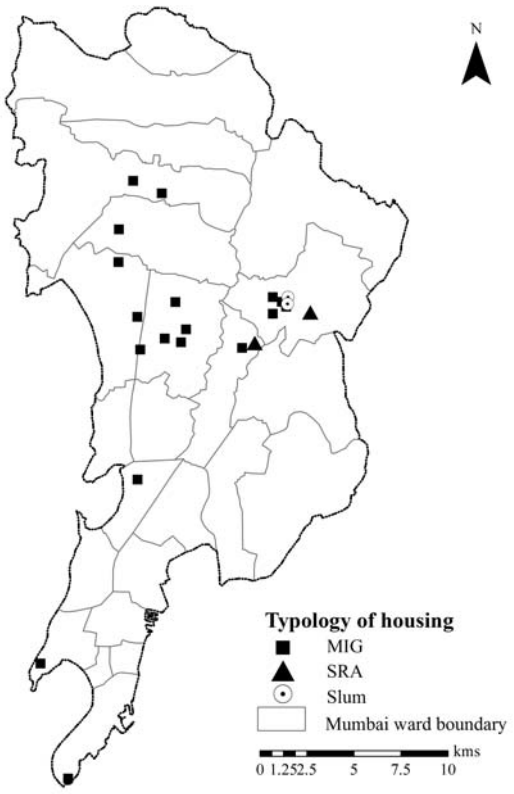
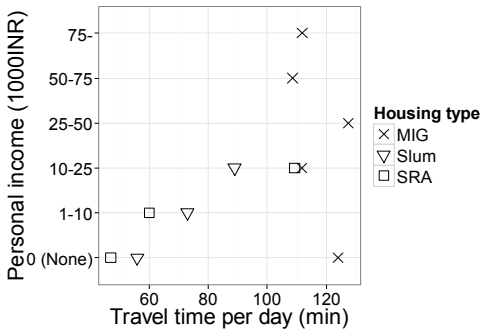


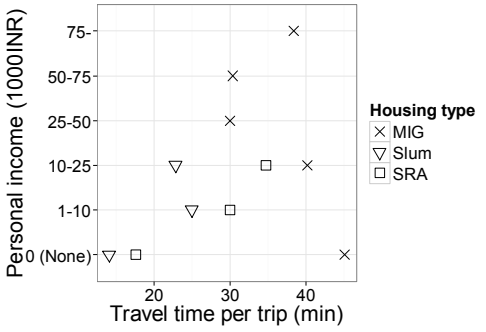
Fig.2 Survey locations in Mumbai

Table 1 Distribution of samples across different housing types

Type of housing	Individuals	Households
MIG	48	22
Slum	58	23
SRA	52	28
Total	158	73



(a) Travel time per trip



(b) Travel time per day

Fig.3 Associations between personal income and travel time by housing type

Table 2 Distribution of samples across different housing types

	Mean			Comparison between MIG, Slum and SRA - Results of statistical tests		
	MIG	Slum	SRA	MIG-Slum	MIG-SRA	Slum-SRA
Mean of individual capability[1]:	1.313	-0.887	-0.665	11.79**	10.06**	-1.78+
Mean of travel time[1]:	117.1	66.3	61.0	4.13**	3.74**	0.41
Variance of travel time[2]:	4912.9	2240.6	3861.5	2.19*	1.27	0.58
Mean of travel cost[1]:	119.6	19.8	12.9	3.20**	3.49**	1.72

Notes: 1: Welch's t-test is used for statistical tests; 2: F-test is used for statistical tests.
**: Significant at 0.01 level; *: Significant at 0.05 level; +: Significant at 0.10 level

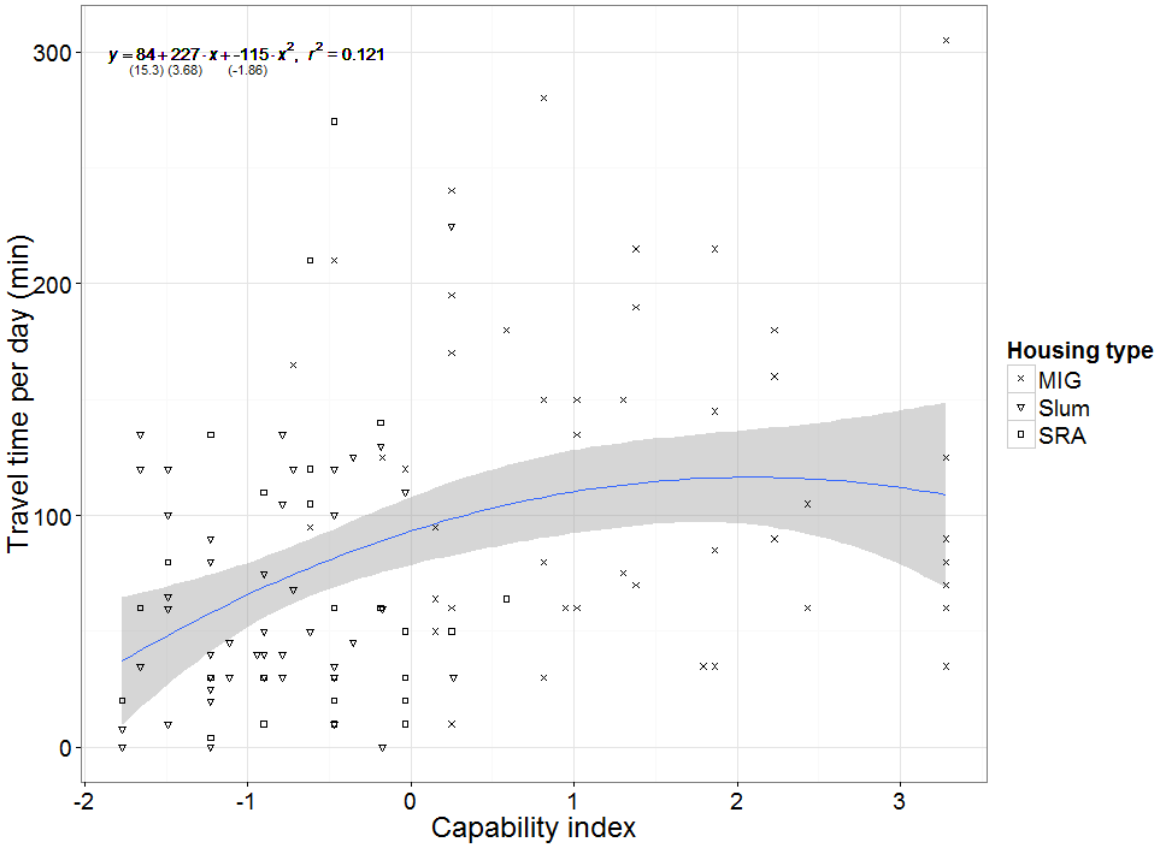


Fig.4 Identified associations between capability and travel time

Capability Index (CI) identified is: CI = 0.858*X1 + 0.765*X2 + 0.604*X3, which explains 56.2% of total variance. The capability index increased with rise in income, higher level of education and had high dependency on car ownership i.e. owning a car displayed higher capability of the individual. In developing countries like India the ownership of assets such as vehicles vs "no vehicle", bears a high correlation to the relative wealth of an individual. Hence such assets can only be owned at an increased capability. Finally the capability index was plotted against the total time allocation to travel to estimate the likelihood of association between them. The results are shown in Table 2 and Figure 4.

The Slum and SRA had shorter travel times in compared to the people living in MIG housing. The mean capability and travel time of individuals from MIG housing was found to be significantly higher than those of Slum and SRA. A positive association was confirmed, which supports the first hypothesis. On the other hand, mean travel time difference between Slum and SRA was not significant, while based on capability, SRA was located in the transition of Slum and MIG housing.

As Figure 4 shows, the average travel time showed a linear increase with capability, however the steepness of the slope decreased as one moved from a one threshold capability to the higher order. The variance in travel time increased with the capability of the individual, confirming the second hypothesis. This

Table 3 Frequencies of mandatory activities by housing type

Workers:	MIG (n=42)	Slum (n=38)	SRA (n=24)
4 or less working days per week	2.4%	2.6%	12.5%
5 working days per week	73.8%	10.5%	4.2%
6 working days per week	21.4%	68.4%	75.0%
7 working days per week	2.4%	18.4%	8.3%

Table 4. Frequencies of discretionary activities by housing type

	Average value			Welch's t test		
	MIG	Slum	SRA	MIG-Slum	MIG-SRA	Slum-SRA
Entertainment/Recreation (per week)	1.38	0.40	0.51	4.18**	3.06**	-0.58
Social (per week)	0.78	0.79	0.42	-0.06	1.82+	1.30
Non-daily shopping (per 3 months)	2.44	0.77	0.90	3.82**	3.43**	-0.50
Long-distance trips (per year)	2.73	1.09	1.06	3.43**	3.47**	0.17

**: Significant at 0.01 level; *: Significant at 0.05 level; +: Significant at 0.10 level

means while individual with lower capability were constrained by their inability to enjoy reduced travel time or better accessibility, individuals with higher capability had the choice of either reducing their travel time or spending longer travel time to reach better activity opportunities.

Based on the results we partially confirm that there is a significant positive association between travel time spent and the capability of the individual. However, this can be strengthened when we see the travel time spent by purpose of trips. While individuals with higher capability had the ability to spend more time to discretionary activities like entertainment/recreation or non-daily shopping, the people in the lower order of capability were constrained to spend more time in mandatory activities like work, grocery shopping, and medical trips. The mode of working days per week for people staying in MIG was 5 while Slum and SRA had a mode of 6 working days per week. This clearly indicates that individuals in the lower order of capability spent their maximum time in activities for economic generation only (see Table 3).

While people living in Slum and SRA were engaged more in mandatory activities, people living in MIG had a choice to pursue discretionary activities. Table 4 confirms this for entertainment/recreation and non-daily shopping. For social activities, the differences are insignificant. This might be because, (1) maintaining social relations in Slum is important for social security and symbiotic co-existence (32) and/or (2) most of the relatives/friends are staying within the same Slum, and hence lower travel time incurred for such trips.

Difference in travel mode distribution between MIG and other groups shown in Table 5 indicates people living in MIG have more flexible choices whereas other groups rely more on walking. This indirectly shows that at a lower capability the decisions are more constraint driven.

Table 5. Modal share by housing type

Travel mode	MIG	Slum	SRA
Walk	15.4%	64.0%	54.4%
Bicycle/motorcycle	6.0%	9.0%	8.9%
Car	24.8%	3.4%	4.4%
Taxi	6.0%	0.0%	1.1%
Rickshaw	16.8%	14.6%	11.1%
Bus	13.4%	5.6%	3.3%
Train	17.4%	3.4%	16.7%

Overall, the above results indicate people at a higher capability generate more travel by adding non-productive activities, while people at a lower capability tend to spend more time for productive activities. This adds a new layer to travel time expenditure discourse: it is generally seen when newly introduced transport infrastructure is affordable for the disadvantaged group, travel time saving would substantially underestimate the benefit of the infrastructure investment. That emphasizing that travel demand for disadvantaged group is primarily for productive activities. Hence, effective benefits would be realized if the investment is more targeted to the improvement in the access to better activity opportunities. The value of travel time saving may not be a good proxy indicator for assessing infrastructure investment. Instead, it should be evaluated based on the value of access as proposed by Metz (1), especially for less capable cities, as looking at value of access would make infrastructure more inclusive. Moreover, including capability in infrastructure investment benefit discourse would create cities having equi-beneficial assets. Overlooking this aspect might hinder the inclusivity of the city: In other words, rich will become richer, while poor will become poorer.

6. CONCLUSIONS

This study has analyzed the association between travel time and the individual capability for rapidly urbanizing cities of developing nations. The main contribution of this study is to emphasize the importance of looking at the production aspects of travel in transportation investment discourse. We forward empirical evidences on the value of access proposed by Metz (1) with a case study in Mumbai where the disadvantaged group forms the majority of socio-economic class.

The behavior of the curve describing the association between travel time and the individual capability showed positive trend up to a certain capability threshold and then continue at a constant travel time. However, our study has two technical limitations. One is in terms of sample size. Second is in terms of limited one-day travel diary. Additionally, while in this study we contrasted the MIG, Slum, and SRA, incorporation of HIG (high income group) and HNI (high net worth individual) might give a comprehensive empirical evidence on the proposed theory.

To formally theorize our discussions, as argued by Ironmonger and Norman (12), it would be worth developing general equilibrium models which describe the impacts of transport infrastructure investment on individual's time allocation behavior in the long run. In this regard, the impacts of transport infrastructure investment may need to be modeled, with the focus not only on relocation of time, but also on relaxing the income constraint, particularly for the disadvantaged group. Empirical analyses for such long-term impacts are challenging but would be worth implementing.

Another limitation is that our analysis has been made for given residential location. However, residential location choice may need to be simultaneously modeled, since mobility constraints could induce residential location change depending on the individual capability. Is the argument valid the other way around, do people have to travel more to attain a better quality of life or whether better capability of individuals are making them travel more? Answering this question may strengthen our argument made in this paper.

Finally, in terms of policy discussions, the investment of transport infrastructure can be directly targeted to the disadvantaged group (e.g., investing in slum areas), but this paper has not really focused on this aspect. Different targeting schemes would lead to different consequences, but the impacts of targeting schemes have been little known. Clarifying it would also beneficial in policy debates.

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