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Why Live Far? – Insights from Modelling Residential Location Choice in Bangladesh

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ABSTRACT

Increasing commute distances often lead to increased auto-dependency and is a major problem in many developed as well as developing countries. While in developed countries, the propensity to commute long distances generally originates from the preference to work in the core of the city and live in the suburb or periphery, in developing countries, the trend is often quite the opposite. For example, in Bangladesh, people generally have a strong preference to live at the heart of the major cities even if they work at the peripheral areas of the city, in another city or in a rural area. Further, it is also not uncommon to maintain split-families where the earning member of the family lives near the workplace while the rest of the family is based in a big city (subject to affordability). These phenomena lead to substantial increase in Vehicle Miles Travelled (VMT) and add burden to the transport infrastructure.

The focus of the research is to explore the key factors that induce middle and upper-middle class commuters in Bangladesh to live away from their workplace and/or maintain split-families. A case study is conducted using Stated Preference (SP) surveys conducted among the faculty members of two universities: one located at the periphery of the capital city and the other quite far away. Discrete Choice Models are developed using the collected data. Results reveal that albeit some differences, for both cases, the choices are strongly driven by quality of the education institutes and the house rent. Factors like gender, income and car-ownership, which traditionally play a strong role in the context of developed countries, are found to be of less significance.

The models, though estimated with limited data, provide useful insights about the factors that drive residential location choices in the context of a developing country and can help in formulating policies for encouraging people to live closer to their workplaces and thereby reduce commuter VMT.

Keywords: Residential location, Developing country, Commuter VMT, University housing

1. BACKGROUND

Commuter vehicle miles travelled (VMT) constitute a major share of the total VMT, both in developed and developing countries. For instance, in 2009, the contribution of commute trips to total VMT in USA was 27.8% with more than one out of twelve workers spending an hour or more traveling one-way to work each day [1]. In absence of a well-developed public transport network, the commute trips can have a significant contribution in increasing congestion and can lead to increased environmental pollution. Moreover, increase in commuting distances very often leads to increased auto-dependency [2, 3, 4, 5, 6]. Several studies have been conducted in recent years that focus on the choice of residential location and its impact on VMT which reveal that individuals who live farther away from the city center tend to drive more than those living closer [5,6,7].

In developed countries, the propensity to commute long distances generally originates from the preference to work in the city and live in a suburb [8, 9, 10, 11, 12, 13]. However, in developing countries, the resources are scarce and the major cities offer much better economic opportunities as well as educational, healthcare, recreational and overall quality of life. This very often leads to huge influx of people migrating to large cities in developing countries. For example, Asia's urban population has increased by 38 million per year on an average in 2005-2010, and is still projected to grow by an annual 35 million a year or more till 2050 [14]. Similarly, Africa has gained 13 million additional urban dwellers per year on an average in 2005-2010, and is expected to gain 25 million a year or more till 2050 [14]. Further, in the developing countries, it is also not uncommon to maintain split-families where one earning member of the family (generally a male member) lives near the workplace while the other family members (generally the female members and the children), subject to affordability, live in the capital or other major cities which have better education, healthcare and other facilities. These families are generally reunited only during weekends. This phenomenon also leads to substantial increase in VMT and add burden to the transport infrastructure.

There are many studies that explore the factors affecting choice of residential location. Previous studies conducted in the context of the developed countries reveal that cost [15, 16, 17], dwelling quality [18, 19, 20], neighborhood attributes [18, 19, 20, 21,22,24], safety, demographic factors [18, 19, 20, 21, 23, 24, 25, 26], immigration background [27] etc. have significant impacts on the choice of residential location. Some studies revealed auto-ownership [9], transport connectivity and traffic conditions [16, 18,19, 20] and travel time [11,15,22] play a significant role in residential location choices. Research also revealed significant interdependence of home location, workplace location and transport mode choice of the household members [22, 28, 29,30]. A critical element of residential mobility decisions: relationships between home type choice and residential location choice (which are normally evaluated in isolation) have also been investigated and it has been suggested that location choice decisions can best be nested within the choice of home type [32]. However, all of these advanced models have been developed in the context of developed countries and may not be directly applicable to developing countries.

In the context of developing countries, there have been few research works that focused on residential location choice most of which are qualitative [33] , semi-empirical [34,34,36] or basic discrete choice modeling studies [38, 39,]. Findings of all these studies indicate significant deviations from developed countries. For example, it has been revealed that the residential location choices are often strictly dictated by affordability [40,36] and the travel time frontiers

(i.e. the maximum time people are willing to spend on their commute) is quite high [41]. Moreover, due to the limited housing availability and dominance of informal housing arrangements, social factors such as networks and informal channels prevail in the decision making process [33]. Also, in terms of potentially significant variables, factors like water availability, power availability, fire / police station availability have been considered in the choice models [38]. In the context of Bangladesh, residential location choice has been explored in a less comprehensive manner [40, 43] and the previous researches did not involve any rigorous mathematical modeling.

This motivates the current research, where we explore the factors affecting residential location choice in further detail through a discrete choice framework using data from Stated Preference (SP) survey. The survey design allows us to quantify effects of individual attributes and test how people will respond to potential policy interventions. The models, though estimated with limited data, provide useful insights about the factors that drive residential location choices in the context of a developing country. The findings of the research are likely to be useful for planners and policy makers in other developing countries (as well as Bangladesh) that are experiencing similar residential location and commuting patterns.

The rest of the paper is organized as follows: we first present the scope of the study and then present the details of the survey. This is followed by exploratory analysis of the data. The model structure and the estimation results are presented next. We conclude with the policy implications and directions for future research.

2. SCOPE AND OBJECTIVE

Dhaka, the capital of Bangladesh, is the economic, political, cultural and higher educational hub of the country and is the preferred residential location of the majority of the population. Over the years, the influx of people moving to Dhaka from other areas has turned it to one of the most densely populated cities in the world with one of the highest population growth rates: the average density being 23,000 per sq. km and the population growth rate being 5.1% [44]. The city has a polycentric mixed land-use pattern (Figure 1). It may be noted that despite the fact that the living costs in Dhaka are more than double compared to the other major cities in Bangladesh and more than triple compared to the smaller cities of the country [45], the city has a large residential population. The major reason for this is the concentration of resources in this city which strongly encourages people to live here, even if this involves commuting to surrounding areas and often to other cities and rural areas for work. The longer commutes are often more common in dual-career households which are in sharp rise in the country in the recent years [46].

In terms of trip generation and attraction, the city is estimated to generate 610,000 trips/day and attract 570,000 trips/day from other areas in the morning peak period alone [47] resulting a very different pattern compared to the developed countries. The focus of this research is investigating the reason for this large influx of outgoing trips from Dhaka and more specifically, why people in the city are opting to live in the expensive inner city and travelling outwards for work rather than living closer to their workplace.

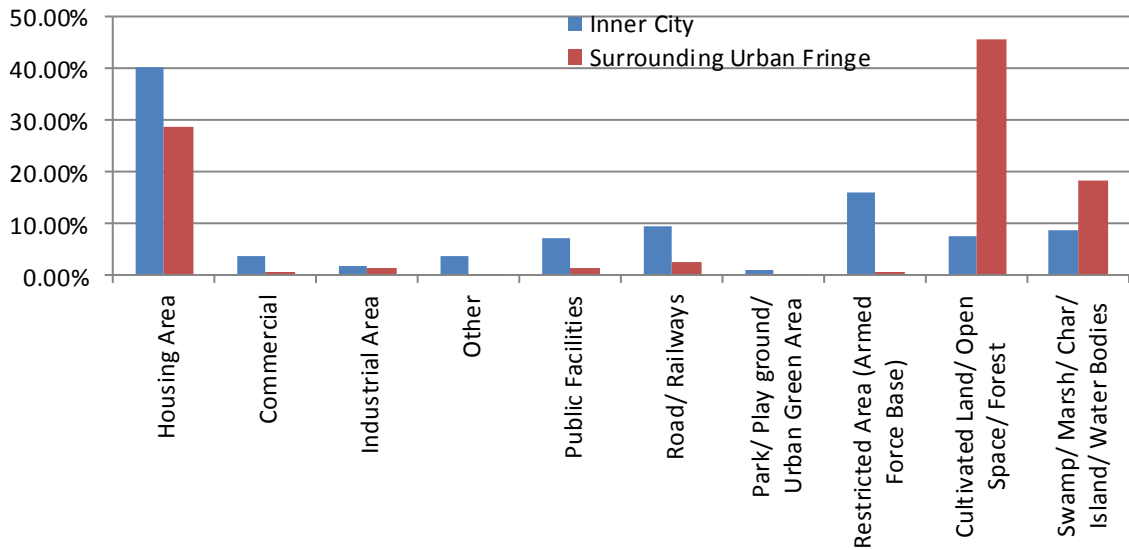


Figure 1: Land-use split Dhaka City and the Surrounding Area

(Source: Final Report: Dhaka Urban Transport Network Development Study, DHUTS, 2010)

The detailed data used in this study is collected from faculty members of two universities in Bangladesh, Shahjalal University of Science and Technology (SUST) and Dhaka University of Engineering and Technology (DUET). SUST is located around 6 km (around 40mins) from the city center of Sylhet, the 5th largest city in Bangladesh and about 300 km (around 6 hours) from the capital city Dhaka. DUET is located in Gazipur, a small town around 40km (around 2 hours) from Dhaka (Figure 2).

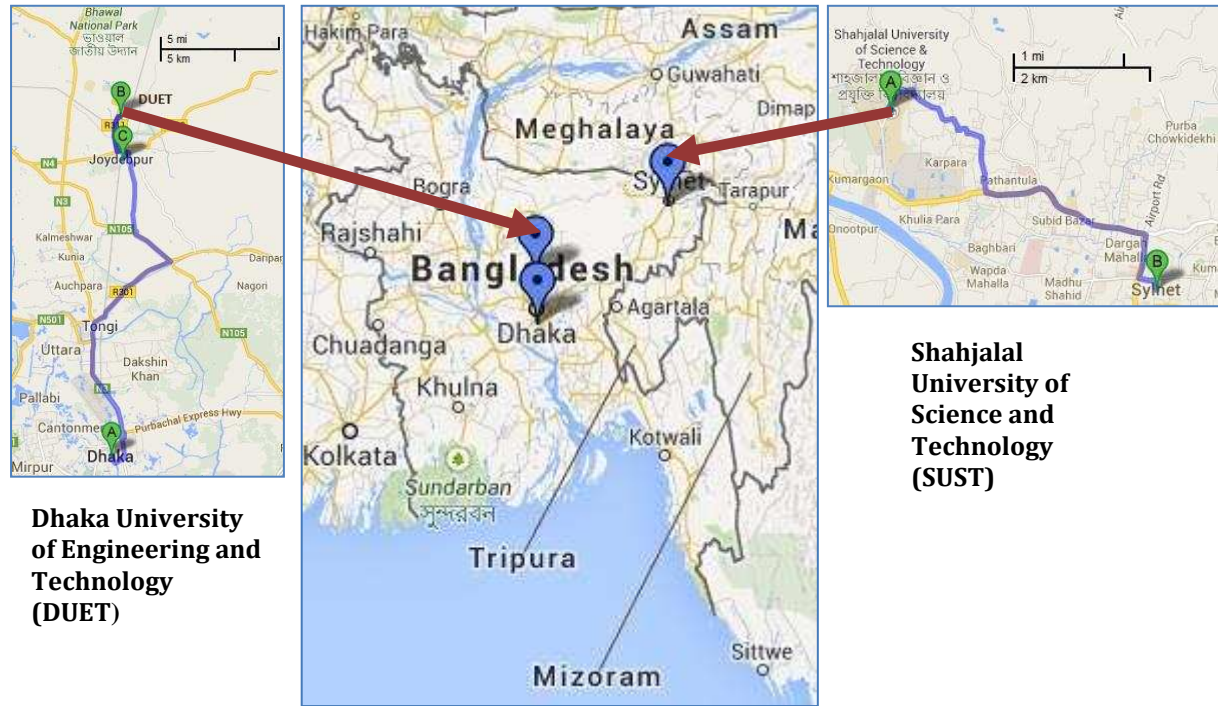


Figure 2: Locations of the case studies
(Source of Map Data: Google, AutoNavi)

SUST and DUET have 282 and 95 faculty members respectively¹. In both cases, on-campus residential facilities are available for the faculty members of the universities, but both universities have high proportions of faculty members who are either commuting long-distances on a daily basis (around 67% and 33% respectively²) or maintaining split-families (around 32% and 30% respectively). It may be noted that such residential location patterns (long commutes from the major cities and maintenance of split families) are quite typical among the middle class and upper middle class residents of other sub-urban universities and other white-collar workers³ of other offices as well.

The current research focuses only on the middle and upper-middle class segments of the population who have wider affordability in terms of residential location choice and can afford to own private vehicles (e.g. cars or motorcycles). People from lower income groups, who also very often maintain split families (where the earning member is based on the capital city and the rest of the family members are based on rural areas), are not included in the study as their choices are constrained by affordability and also because they are unlikely to have access to private vehicles

¹Excluding faculty members currently on study or research leave

²These numbers are based on the survey results presented in Section 3 since no actual statistics was available

³ White collar workers constitute of 13.1% of the total population and 19.4% of the urban population of the country (47)

and tend to use public transport for their weekly/monthly/ occasional visits to the family homes.

In terms of transport access, both universities provide shuttle services to the nearby large cities, but private cars are popular choices of many of these long-distance commuters, particularly those travelling between DUET and Dhaka.

In this paper the reasons behind these choices are explored. In particular, the paper attempts to answer the following questions:

1. Why on-campus residential facilities and areas closer to workplaces are not being chosen?
2. Are there systematic differences in residential location choices among different demographic groups (e.g. age, family structure, gender) and different universities?
3. What are the relative contributions of transport attributes compared to other attributes in the choice of residential locations?
4. What incentives may be effective to induce people to live closer to their workplace?

The differences of the results between the two universities and potential for transferability of the model parameters have also been analyzed.

3. METHODOLOGY AND SURVEY DESIGN

The SP survey has been conducted in two stages. In the initial stage, respondents have been interviewed in person and asked open ended questions regarding their residential choices. These surveys helped in identification of choice sets, important attributes and appropriate ranges which have been used in the second stage (main survey). In the main SP survey, respondents are presented with hypothetical scenarios regarding mode and residential location choice. The data from the main survey are used for developing discrete choice models. The surveys are detailed below.

3.1 Initial Survey

In this survey 50 participants (25 from DUET and 25 from SUST) have been interviewed in person and asked open ended questions about their choice of residential location and reasons behind their choices as well as the details about other options that were feasible for their respective cases (i.e. unchosen alternatives and their attributes). Questions about their current travel pattern and socio-economic status (e.g. age, family income, number of family members⁴, marital status, number of children, etc.) have also been asked.

Analysis of the initial survey data revealed similarities as well as differences between the choices made by the respondents of the two universities. In both cases, the respondents stated quality of schools, job opportunity of their spouse, scopes of consulting opportunities, rent and safety and security as the top 6 reasons for their current choices. The key details associated with these influencing factors are presented below.

- i. Quality of schools: The quality of schools, high schools in particular, are considered as the most important factor for respondents having school going children (or having school going dependant siblings). In particular, many of the respondents opting to live in Dhaka or have other family members based in Dhaka mentioned the proximity and access to several reputed public and private schools as the main

⁴ May include parents and siblings as well as spouse and children

reason behind their choice⁵. It may be noted that, most of the reputed public and private schools, which often have several branches, are located in the capital or the major cities. There are no school district systems in place though (i.e. people regardless of their residential location can attend that school if they qualify in the admission test and can afford the tuition fees).

- ii. Job opportunity of the spouse at or near the university: The job options in the sub-urban areas are quite limited and specialized. Therefore, married faculty members who have a spouse pursuing an academic or other career, tend to prefer to live in the capital cities or big cities where there are better job opportunities for their spouses.
- iii. Scope of consulting and other part-time teaching jobs: Scope of additional income and experience through consulting and/or part-time lectures in private universities are very limited outside the capital city which prompts many to live in Dhaka city.
- iv. Rents: Current rents of on-campus houses are higher than similar off-campus options around the campus (particularly in case of SUST). The high rent is often an important issue for not choosing on-campus housing facility.
- v. Safety and security: The on-campus housing facilities are gated communities and the enhanced security offered by the on-campus residential facilities has been found to be a prime reason for selecting on-campus accommodation.
- vi. Access to other improved services: Proximity to improved healthcare, shopping and recreational facilities has also been mentioned as important factors behind residential location choices.

It may be noted that though some of these influencing factors are similar to the factors affecting choices in residential location in developed countries, some are quite unique (e.g. iii, v and vi). Interestingly, travel time (a significant factor in residential location choice in developed countries), is not among the top reasons.

In terms of residential location, some differences have been observed in the top choices for the two universities. The three common categories are living on-campus, living off-campus but still locally (in Gazipur in case of DUET and in Sylhet in case of SUST) and living on-campus and maintaining split-families. But in case of DUET, living in Dhaka and commuting everyday has also been identified as a popular option whereas in case of SUST, living off-campus in Sylhet and maintaining a split-family in Dhaka is also mentioned as a viable choice. A summary of the choice-set defined by the respondents is presented in Table 1.

⁵In the public schooling system in Bangladesh, there are options to study either in English or Bengali versions of the curriculum. English versions are preferred by students planning to compete for admission in premier public universities. In addition, there is a private schooling system (commonly known as English Medium Schooling) where students follow the British Curriculum and participate in GCSE and GCE A Level exams administered by the British Council and get degrees which are recognized worldwide. The English medium schools are much more expensive compared to public schools and mainly preferred if the ultimate aim is to study or work abroad.

Table 1: Feasible choices

Choice	Description	DUET	SUST
On-campus Family	Lives in University residential facilities with family	✓	✓
Off-campus Other	Lives locally with family (in Gazipur/Sylhet but not in university facilities)	✓	✓
Off-campus Dhaka	Lives in the capital city with family and commutes long distance every day	✓	Infeasible
On-campus Split	Respondent lives in university facilities. Family lives elsewhere.	✓	✓
Off-campus Split	Respondent lives locally (in Gazipur/Sylhet but not in university facilities). Family lives elsewhere.	✓*	✓

* Though feasible, this option is not mentioned as the currently chosen alternative by any of the respondents in the main survey

These observations shaped up the design of the main survey presented in the next section.

3.2 Main Survey

3.2.1 Survey organization

The main survey consisted of four sections.

Questions on the socio-economic status of the respondents are presented in the first section. These include questions on job designation, age, gender, marital status, number of family members, occupation of the spouse, number of children and their current education levels, monthly family income, and car ownership. The second section consists of questions on the current residential location of the respondents and the prime reasons behind the choice. The third section includes questions about the current travel pattern of the faculty members, the job location of their spouse (if applicable) and his/her travel pattern, and questions about the travel pattern of children (if applicable). The SP scenarios are presented in the last section.

3.2.2 Design of SP Survey

The survey design for the research work is conducted using the Choice Experiment (CE) technique. In the CE approach, respondents make choices among hypothetical choice scenarios where multiple attributes can vary. Compared to other SP techniques (e.g. rating and ranking exercises), the trade-offs among various attributes of a product or service can be captured relatively easily with the CE technique [44, 49]. The steps of the SP survey design are detailed below.

Defining attribute levels

The attribute levels are chosen to be as realistic as possible so that it is easy for the respondents to compare the hypothetical alternatives with the current condition and there is less cognitive incongruence. Table 2 details the different attributes and their respective levels used for the SP design.

Table 2: Attributes and their levels

Attributes	Number of Levels	Levels
School Facilities	4	Same as now Branches of reputed Bengali Medium Schools (examples listed) Branches of reputed English Version Schools leading to SSC and HSC level public exams (examples listed) Branches of reputed English Medium Schools leading to GCSE and A levels (examples listed)
Job opportunity of spouse	2	Same as now Preferential appointment at DUET/SUST
Professional work scope	2	Same as now Same scope of consultancy, part-time job etc. in Gazipur/ Sylhet as in Dhaka
Additional Utility	3	Same as now Big shopping malls (examples listed) Excellent medical facilities (examples listed)
Rent of university residence	4	Same as now 20% less than now 30% less than now 40% less than now

Creating SP scenarios

The respondents are presented with three SP scenarios (each showing different levels of the five attributes associated with the on-campus facility) and are asked which alternative (residential location) they will select in each scenario.

The profiles of the hypothetical on-campus housing scenarios are generated with the statistical software SPSS (50) using fractional factorial design. From the generated profiles, unrealistic ones are discarded and extreme/dominant combinations (where one option is better than the other option in terms of all attributes) are excluded.

Examples of SP choice scenarios are presented in Table 3.

Table 3: Examples of SP choice scenario

a. DUET

Attributes	Future scenarios at or near DUET	Dhaka/other cities
Children's school & college facilities	Same as now	Same as now
Rent of university residence	Same as now	
Job opportunity of spouse	Will get preferential appointment at DUET	
Professional work scope	Similar scope of consultancy, and part-time job etc. in Gazipur as in Dhaka	
Additional utility services	Branches of reputed hospitals (e.g. Apollo, Square, Popular, etc.)	

What type of residential option will you choose in Scenario 1?

a. Commute from Dhaka	b. Live On-campus with family
c. Live On-campus, but family lives in Dhaka	d. Live Off-campus in Gazipur with family

b. SUST

Attributes	Future scenario of or next to SUST	Sylhet/other cities
Children's school & college facilities	Branches of reputed Bengali Medium Schools close to SUST campus	Same as now
Rent of university residence	20% less than now	
Job opportunity of spouse	Will get preferential appointment at SUST	
Professional work scope	Same as now	
Additional utility services	Same as now	

What type of residential option will you choose in Scenario 1?

a. Live On-campus with family	b. Live On-campus, family lives in Dhaka
c. Live Off-campus with family	d. Live off-campus in Sylhet, family lives in Dhaka

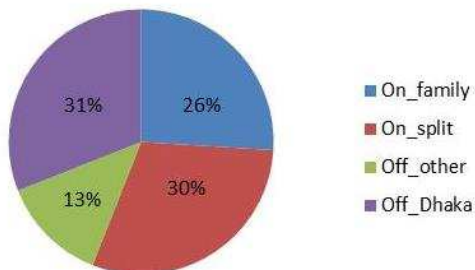
3.2.3 Data

The main survey has been conducted among all faculty members of DUET and SUST. Almost all data have been collected with the assistance of surveyors. Those who were not available for face-to-face interviews have been given the paper questionnaire. The responses collected without the surveyor's assistance have been checked carefully and all invalid responses have been discarded from the data set. 81 and 169 valid responses were obtained from DUET and SUST respectively (85% and 60% of the active faculty members respectively). There are four observations per respondent: one RP and three SP observations. Comparisons of the socio-demographics of the respondents are presented in Table 4.

Table 4: Comparison of socio demographic characteristics

		DUET (%)	SUST (%)
Designation	Lecturer	42	41
	Assistant Professor	26	31
	Associate Professor	10	13
	Professor	22	15
Age	25-30 years	45	36
	31-40 years	32	45
	41-50 years	16	16
	>50 years	4	2
Gender	Male	86	81
	Female	14	19
Marital status	Married	73	72
	Unmarried	27	28
Job status of spouse	Employed	26	39
	Homemaker	31	40
	Not mentioned	43	21
School going children	Yes	33	43
	No	67	57
Car ownership	Yes	17	14
	No	83	86

(a) Residential Status of DUET Respondents



(b) Residential Status of SUST Respondents

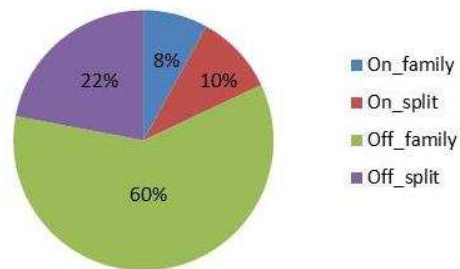


Figure 3: Current residential status of the respondents

The current split of residential locations of the respondents is presented Figure 2. As observed in the figure, in DUET, out of the 44% respondents who live off-campus, 31% commute from Dhaka on a daily basis. In case of SUST, 82% respondents live off-campus. The proportion of respondents maintaining split families is around 30% for both universities.

The current commuting VMT of off-campus faculty members of DUET and SUST are calculated and analyzed (Figure 4). In the questionnaire, the travel times to the workplace on a typical day and the number of commuting co-passengers in case of travel by private vehicles (if any) have been recorded and these have been converted to VMT using the average speed of different modes in the two contexts [47,51]. The analyses have been conducted using two-way daily commuter VMT and does not include the VMT contributed by split-families.

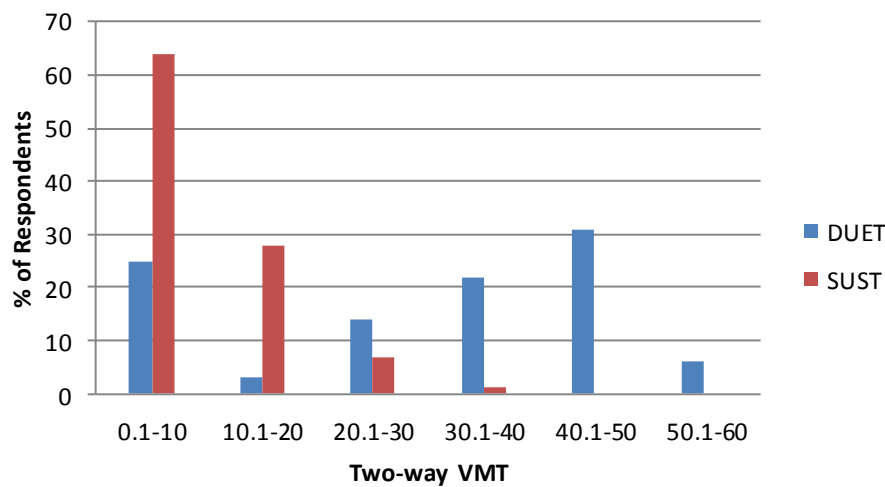


Figure 4: Current Commuting VMT of Faculty Members

4. MODELS

In this section, the model structures are developed and the model parameters are estimated using data from the main survey. A discrete choice framework is used and the model parameters are estimated using the maximum likelihood estimation (MLE) technique within the software package BIOGEME (52). The utility associated with a residential location (U_{in}) can be expressed as follows:

$$U_{in} = \alpha_i + \sum_K \beta_i X_{in}^k + \vartheta_n + \varepsilon_{in} \quad (1)$$

Where, α_i is the alternative specific constant associated with alternative i , X_{in}^k is the k^{th} explanatory variable associated with alternative i and individual n , ϑ_n is the individual-specific error term for respondent n ($\vartheta_n \sim N[0, \sigma^2]$) and ε_{in} is the random error term associated with the utility (assumed to have a Gumbel distribution).

In SP, the on-campus options are presented with improved or ‘same as now’ facilities. In addition to the attributes (Table 2), socioeconomic variables are also likely to affect the choices of location and tested for inclusion in the model specification. Different Multinomial (MNL) and Nested Logit (NL) model specifications for panel data have been tested and the final models are chosen based on informal (i.e. signs and values of parameter estimates) and formal tests of

statistical significance (e.g. t-tests and Likelihood-ratio tests). The goodness-of-fit measures are compared using the adjusted rho-square value which explicitly accounts for the number of variables.

$$\rho_{\text{adj}} = 1 - \frac{\text{LL}(\hat{\beta}) - k}{\text{LL}(0)} \quad (2)$$

Where, $\text{LL}(\hat{\beta})$ is the log-likelihood at the estimated parameter values; and $\text{LL}(0)$ is the log-likelihood when all the parameter values are set to zero.

Since initial statistical analysis of the data revealed significant differences in the choice-set and the choice patterns between the faculty members of DUET and SUST, separate models have been developed for each university rather than pooling the data. However, spatial transferability of the individual parameters is checked by testing whether or not there is a significant difference between the parameter estimates of equivalent variables in the two case-studies (Equation 3). Minimum and maximum t-ratio values of -1.96 and 1.96 corresponding to the 95% confidence are taken as the critical values.

$$t_{\text{diff},k} = \frac{\beta_{\text{trans},k} - \beta_{\text{appl},k}}{\sqrt{\left(\frac{\beta_{\text{trans},k}}{t_{\text{trans},k}}\right)^2 + \left(\frac{\beta_{\text{appl},k}}{t_{\text{appl},k}}\right)^2}} \quad (3)$$

Where; $\beta_{\text{trans},k}$ and $\beta_{\text{appl},k}$ are the estimates for the k -th parameter in the transferred and application areas; $t_{\text{trans},k}$ and $t_{\text{appl},k}$ are the respective t ratios of the parameter estimates; and $t_{\text{diff},k}$ is the t-ratio for the difference between parameters.

4.2 Estimation Results

Nested Logit Models with On-campus and Off-campus nests has been found as the best structure to model the choices both for DUET and SUST. The alternatives within the On-campus nests are same for both contexts, but the Off-campus nest for DUET includes Off-campus Dhaka and Off-campus Other (Figure 4a-ii) while the Off-campus nest for SUST includes Off-campus Family and Off-campus Split alternatives (Figure 4b-ii). The estimation results are presented in Table 5.

It may be noted that for comparison purposes, the coefficients which are statistically significant at 95% level of confidence in at least one context, have been retained in both models.

In Table 5, $\alpha_{\text{OFF_DHAKA}}$, $\alpha_{\text{OFF_OTHER}}$, $\alpha_{\text{ON_SPLIT}}$, $\alpha_{\text{OFF_SPLIT}}$ and $\alpha_{\text{ON_FAMILY}}$ represent the alternative specific constants for residential location choice alternatives: Off-campus Dhaka, Off-campus Other, On-campus Split, Off-campus Split and On-campus Family respectively (defined in Table 1). β_{school} , $\beta_{\text{prof_work}}$, β_{rent} , $\beta_{\text{spouse_job}}$, β_{female} and $\beta_{\text{car_ownership}}$ represent the coefficients of the variables related to school facilities, scope of consultancy and other professional opportunities, house rent, job opportunity for spouse, female dummy and car-ownership dummy respectively. In order to reflect reality, it has been assumed that the reputed schools and spouse's job opportunity are always available for Off-campus Dhaka, and Off-campus and On-campus Split Family alternatives and the scope for professional work is always available for Off-campus Dhaka alternative. For On-campus alternatives (both Family and Split), the professional work scope presented to the respondent in that particular scenario has been taken into account. For On-

campus family alternatives, the reputed schools and spouse's job opportunity presented to the respondent in that particular scenario have been taken into account. It may be noted that the school related variables have only been included in the utility functions of the faculty members who currently have school going children. Similarly, the job opportunity of the spouse related variable has been taken into account only for faculty members who stated that their spouses are currently employed in an Off-campus location.

Table 5: Estimation results of the final model of DUET and SUST

Parameter	Affected alternatives	DUET		SUST		t-stat difference
		Estimate	t-stat	Estimate	t-stat	
$\alpha_{OFF-DHAKA}$	Off-campus Dhaka	-6.01	-1.15	-	-	-
$\alpha_{OFF-OTHER}$	Off-campus Other	-26.0	-2.58	-1.84	-4.46	-
$\alpha_{OFF-SPLIT}$	Off-campus split	-	-	-4.02	-6.55	-
$\alpha_{ON-SPLIT}$	On-campus split	-3.33	-7.40	-2.40	-4.53	1.09
$\alpha_{ON-FAMILY}$	On-campus family	0	fixed	0	fixed	-
β_{rent}	All alternatives	-0.273	-2.84	-0.225	-4.59	0.15
β_{school}	All alternatives	1.67	2.85	0.637	4.88	-1.33
β_{prof_work}	All alternatives	0.158	0.42	0.377	2.53	0.35
β_{spouse_job}	All alternatives	0.866	1.98	0.244	1.37	-0.91
β_{female}	On-campus alternatives	2.87	3.03	0.165	0.28	-2.38
$\beta_{car-ownership}$	Off-campus alternatives	-0.573	-0.40	2.11	2.48	1.83
σ^2	All alternatives	3.08	7.33	3.79	4.28	0.65
$\mu_{OFF-CAMPUS}$	Off-campus alternatives	0.0428	3.54	3.34	2.09	1.09
Number of estimated parameters		11		11		
Number of individuals		81		169		
Number of observations		243		507		
Null log-likelihood		-336.87		-702.851		
Log-likelihood at Convergence		-202.38		-389.254		
Adjusted rho-square		0.367		0.431		

As seen from the estimation results (Table 5), it can be inferred that all else being equal, On-campus Family housing is the most preferred housing location, both for DUET and SUST. For DUET, the Off-campus Other (living in Gazipur with family) and for SUST Off-campus Split (living alone in Sylhet, while family lives in Dhaka) are the least preferred options.

In terms of attributes of the alternatives, faculty members having school going children tend to have a significant preference for locations with reputed schools in the proximity which is in agreement with the findings of the initial survey. However, when the differences in preference for different types of schools are tested separately (e.g. preference for reputed Bengali and/or English schools leading to Public examinations and reputed Private English Medium schools), the sensitivity is not found to be significantly different. This indicates that faculty members having school going children have a significant preference for reputed schools, but they are indifferent about the exact type of school. In terms of professional work scope, as expected, the utilities of alternatives increase if there are opportunities for consulting and/or part-time teaching jobs in private universities in the vicinity, but the effect is not significant for faculty members at DUET. On the other hand, in terms of work scope for spouses, in both universities, the utilities of alternatives increase if there are job opportunities for spouses (preferential job opportunities at the university establishments or vicinity in case of the hypothetical on-campus facilities), but the effect is not statistically significant for SUST. It may be noted that for Off-campus locations, this variable has only been considered if the spouse is currently working. As expected, house rent has a significant disutility for both groups of respondents. The effect of additional amenities like improved medical facilities and improved recreational facilities are not found to have a significant effect on the choice of locations in any of the contexts.

In terms of respondent characteristics, female faculty members of both universities have a preference for On-campus alternatives (which offer enhanced safety and security as well as shorter commute), but the effect is not statistically significant for SUST. In case of SUST, faculty members who own one/more cars have an increased propensity to live Off-campus. However, this was opposite in case of faculty members at DUET which may be due to the slightly better public transport options available in the Off-campus locations (Dhaka and Gazipur). The effects of age, marital status, home-ownership, family size and income have not been found to be significant in any of the universities.

The nest coefficients associated with Off-campus nests relative to On-campus nests are found to be statistically significant for both universities. It may be noted that they are not directly comparable because in case of DUET, the Off-campus nest includes living in Dhaka and commuting every day and living in an Off-campus location in Gazipur; whereas, in case of SUST, the Off-campus nest includes living in Sylhet either with family or without family (in which case the family is likely to be based in Dhaka).

The intra-respondent heterogeneity is found to be significant indicating significant correlation in error terms of the same individual.

Analysis of the difference in t-statistics ('t-stat. diff' presented in Table 5) reveals that most of the parameter estimates are not statistically different from each other (at 95% level of confidence) which indicate location independence of the preferences of the respondents and potential for wider applicability of the estimation results.

The estimated equations can be used to predict the probabilities of shifting to on-campus facilities in response to a certain policy change (e.g. establishment of a branch of a reputed English medium school, x% reduction of house rent, etc.). These probabilities can then be used to calculate the corresponding changes in VMT.

5. COMPARISON OF RESULTS

Findings from both surveys confirm that the quality of schools and rents are the main determinants for the residential location choice in these specific cases. Other factors for living far from the workplace include job opportunities of spouse, opportunities for part-time consulting and other professional works and access to better healthcare, recreation and shopping facilities (though the last factor has not been found to be significant in the quantitative analysis). These choices are found to be almost constant across almost all demographic groups. Exceptions are: additional inclination towards On-campus facilities for female respondents, preference for reputed schools for respondents with school going children and preference for spouse's job opportunity for respondents whose spouses are currently employed.

Comparing these findings from the previous studies, there are both similarities and differences. For example, the rent and affordability issues have been found to be a dominant factor in choice of location and tenure, both in developing and developed countries [e.g. 9,15,16,17,23,36,37]. However, the contribution of transport attributes (e.g. travel time, travel cost, accessibility, etc.), which typically play dominant roles in the context of developed countries [e.g. 9,11,15,16,18,22], has not been found to be significant. The gender effect (i.e. females being less prone to commute long distances), which is the single most utilized and consistent variable in relation to commuting behavior both in the developed and developing countries [18, 19, 20, 21, 23,24,25, 26], has been found to be significant in one location only. The finding regarding the propensity to commute longer travel distances among dual career households is also in agreement with the previous studies in the context of the developed countries [30,31]. In the context of developing countries, this effect has not been directly addressed in previous research. Rather, the effect has been captured indirectly as number of working members in the household [34] and found to have a similar effect as the current study. Factors like access to better education, healthcare, recreation and shopping facilities have not been explored in detail in the previous studies. This is expected in the context of developed countries where the qualities of these facilities have lower variance between urban, semi-urban and rural areas. However, in the context of the developing countries, where these factors are intuitively expected to have significant effects, there appears to be a research gap which the current paper fills in.

6. CONCLUSION

In this research, residential location choices of faculty members of two public universities (DUET and SUST) in Bangladesh have been analyzed. A framework for modeling residential location choice has been developed in this regard to quantify the relative importance of factors that affect the choices of residential location (and ultimately the commuter VMT) in the context of a developing country. The model results are cross-compared with the qualitative findings from an initial survey as well previous research findings in the context of developed and developing countries.

The model results indicate that there is substantial potential to encourage people to live closer to their workplace by university level initiatives (e.g. subsidizing rent or introducing preferential appointment of spouses within the university establishment), Private initiatives (e.g. opening branches of reputed schools⁶ and Government initiatives (e.g. decentralization to increase scope of consulting opportunities in smaller cities). The findings of the study may help university authorities and policy makers in formulating policy guidelines to promote On-campus housing.

There are several limitations of the research though which need to be addressed in future research: the study is based only on SP data (since the attributes of all the unchosen alternatives are not available and/or inferable from existing data sources), applicability of the results in other contexts (e.g. wider income groups) have not been explored, and detailed policy analysis has not been done as part of this research. These issues need to be explored in future.

The similarity of the model parameters across the two universities is however very encouraging in terms of generalization of the results. The full-scale generalization or testing the transferability of the model results in other developing countries is beyond the scope of paper. However, though the results may or may not be directly transferable, the developed model framework can provide as guidance to researchers and practitioners in other developing countries who are interested to tackle similar problems especially since many developing countries are experiencing rapid population growth and high urbanization, yet details of residential location choices in the context of developing countries is quite an unexplored area.

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⁶ Currently most of the reputed schools have several branches, but all within Dhaka city

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