# MODELING RESIDENTIAL LOCATION CHOICE, WORKPLACE LOCATION CHOICE AND MODE CHOICE OF TWO-WORKER HOUSEHOLDS IN METRO MANILA

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**Abstract**: This study uses disaggregate modeling approach to investigate the spatial behavior and mode choice behavior of two-worker households in Metro Manila. Results confirm the existing pattern of suburbanization in the metropolis as more households are willing to tradeoff longer distances and hence commuting time in their residential location choices.

Key Words: Location choice, Mode choice, Two-worker households, Nested logit

# **1. INTRODUCTION**

Metro Manila's present urban spatial structure is a product of varying degrees of urbanization and suburbanization over the decades. Because of ineffective land use control and weak political will, the metropolitan's ever changing landscape and land use patterns sadly, has been in response to socio-economic demands of the growing population and not necessarily according to plan. Although, the government has noticed the region's self-evolving and expanding urban structure, it has failed to cope and address the risks associated with its urbanization.

At present, the continuous influx of migrants seeking employment opportunities expanded the urbanized area of the metropolis unto its adjoining provinces. Suburbanization and leap frog developments are observable in the outer fringes, where local governments are generally unprepared. And if even so, city/municipal expenses have increased and provision of public services became more limited to these areas. On the other hand, employment opportunities have not followed the pattern of urban sprawl. Most primary businesses and commercial establishments are still located in the inner urbanized core of the metropolis. Meanwhile, as population increases, so does the demand for travel. Transportation infrastructures are now insufficient to cope with the increase in travel demand, increasing commuting time and making the distribution and movement of goods inefficient.

With more and more households preferring to live in the outskirts of the metropolis, together with an increasing population and travel demand, longer commutes and journeys will be unavoidable. This in turn raises the consumption of fuel and energy which causes increase in air pollution and degradation of the environment.

Given the present conditions, an analysis of the underlying causes that shape the urban spatial structure of Metro Manila therefore is suggested. Since household location preferences play

an important part in urban development patterns, this study shall be focusing on household location choice behavior. In particular, we will try to investigate how the household trade off location attributes as well as the effect of transportation in their choice behavior in a disaggregate manner. Special attention shall be given to two-worker households to give us an insight on how workers in the household assess each worker's disutility when relocating. The study uses multinomial and nested logit models to examine the nature of household choices of residential location, workplace location and mode choice to work in Metro Manila. Initial findings support spatial trends and patterns or urbanization.

# 2. REVIEW OF RELATED LITERATURE

# **2.1 Residential Location Preferences**

The choice of residence of households generally involves trade-offs among several factors which give the household the highest possible utility. Several researches that studied these factors found out that cost and size of dwelling unit, and proximity to activity centers were the most influential. The choice is also found dependent on household demographics such as household size, life cycle and income.

The studies done by Weisbrod et.al. (1980) and Hunt et.al (1994) provide good insight on how households assess the benefits inherent to a potential residential location. In Hunt's study, respondents were asked to rank hypothetical residential location options which include monthly house rent, travel time to work and proximity to rail. They hypothesized that aside from house characteristics, the relative travel times and ease of access provided by roads and public transport systems present in a particular area contributes to the location's degree of attractiveness. Their study concluded that there exist two (2) types of households when choosing a residential location: first, are those households that use public transport and believe that public transport influences the quality of the residential location while the second type are households who do not intend to use public transport and consider the degree of attractiveness of public transport insignificant to the location. Meanwhile, households belonging to the second type prevailed in the study done by Weisbrod et.al. for the city of St. Paul in Minnesota. Bus travel time proved to be less significant on location demand when compared to private car travel time. These studies

Households also value their neighborhood or their immediate environment. On a study done by Gayda (1998), she discovered that residents in Brussels are attracted to urban residential neighborhoods which are quiet, safe and have very low traffic volume. Children being able to play in the street were also considered important by the residents.

Metro Manila residents are not different as well. Although no direct study was made with respect to home location choice preferences, average to high-income household earners have a tendency to dwell in neighborhoods structured or planned as villages or subdivisions. Similar to the condition in Brussels, residents prefer to live in these type neighborhoods because of the security and the peaceful atmosphere these places offer. This is evident in the study done by Nishioka et.al. (1993) which is concerned about how the village system in Metro Manila came into existence.

#### **2.2 Modeling Developments**

Von Thünen was the first to conceive an analytical model of the relationships between markets, production and distance. His model lies on land's fertility with accessibility as the determinant of agricultural land rent. The model consisted of an isolated city wherein land is uniform, the terrain is entirely flat and there are no available transportation infrastructures such as roads or rivers. In addition, a single market place exists where farmers trade or sell their goods located at the center of the city – a type of arrangement commonly known as monocentric. From these assumptions, he theorized that the relative costs of transporting different agricultural commodities to the central market determined the agricultural land use around the city producing a concentric spatial pattern. Crop or livestock activities which are most productive or those goods that are the most costly to transport will thus compete for the closest land while activities not productive enough will locate farther. Furthermore, since lands near the center will definitely have lesser transport costs, land rent here will be highest and decreasing with distance farther from the center

McFadden (1978), on the other hand, based his location choice model on the utility enjoyed by an individual or household. Based on random-utility theory, he then developed a multinomial logit residential location choice model, on the premise that consumers will choose a particular property that will maximize their utility compared to other properties.

Von Thünen's monocentric city concept was extended by several researchers in the field of urban economics such as Mills (1985) who included competition for lands for both businesses and households and Simpson (1980) who allowed simultaneous choosing of residential and workplace location and also incorporated job search and the effect of commute distance. Furthermore, Simpson discovered that a model comprised of workplace and residential location explains urban commuting distances better than models of residence or workplaces alone. Watterson (1994), in conjunction with Simpson's, also stated that the work commute is defined by both residence and workplace locations. He proved this by using household panel data to examine changes of home and workplace locations over time. He found evidence that households transfer to other locations or change their work locations in order to minimize commuting distance and travel time. His result clearly supports the results of DeSalvo et.al (1996), in which they determined that the variation in location patterns is the effect of the differences in the cost of commuting by different modes available.

The weaknesses and limitations of fixed work locations such as the monocentric city assumption for location choices was criticized and assessed by Waddell (1993) in his paper. He pointed out that because of the rise of suburban employment centers, the monocentric city assumption may not be anymore accurate. Based on this premise, he stated that the extent, to which residence location is driven by workplace location or the opposite, may vary with the degree to which workplace locations are spatially dispersed. He then created a model utilizing random-utility theory, specifically a nested logit specification in order to characterize the choice of home, workplace and tenure choice of households.

His results clearly showed that the assumption of fixed or exogenous workplaces in residential location choice models is no longer valid and should be reconsidered. Several years later, he discussed the deficiencies of previous studies regarding some of the typical assumptions and methods being employed by researchers. He commented on the non-behavioral foundation of models such as the assumptions of exogenous workplaces, single-worker households, cross-sectional application of models and the absence of land or housing

markets. Eventually, all of the mentioned shortcomings were later resolved in Waddell's latest operational urban economic model UrbanSim (Waddell 2001).

Abraham et.al. (1997) made an improvement on Waddell's (1993) model by including transport mode choice as part of the household' location choice decision process. They were also able to consider all working members of the household in the model. This addition made the modeling procedure complex but was able to capture the influence of each household member to household's overall utility.

There were also studies made that focused entirely on the case of two-worker households, in particular differences of female and male utilities. Sermons and Koppelman (2001) found out that females are more sensitive to travel time compared to males by developing a discrete residential location choice model as a function of male and female commute times and other factors. Meanwhile, Freedman and Kern (1997) discovered that a woman's welfare affect both the husband's choice of workplace and the home location of the household.

# 2.3 Accessibility and Residential Location Choice

Accessibility has long been identified as the central influence in urban theory of residential location (Waddell 1996). It is a major factor that influences attractiveness of a certain location aside from the area's physical characteristics. It is argued that the reason why most people prefer to live in city centers and built-up areas because of accessibility –potential for a variety of activities aside from being near to work. This notion explains why accessibility has been always present in most location choice models.

Handy et.al. (1997) stated that accessibility is determined by the spatial distribution of potential destinations, the quality and character of the activities of each destination. In other words, access is defined by the ease of getting to a particular location and by the location's characteristics.

Several researches done on residential location choice show that accessibility has influence but not very significant. Molin et.al. (2003) summarized the various case studies about residential location choice in Brussels and found that the results of those studies suggest that regardless of the study area and the model specification, accessibility considerations are significantly less important than housing attributes and attributes related to the neighborhood. They explained that as long as people have the opportunity to afford flexible means of transport, the impact of accessibility on their residential choice behavior is relatively limited, but might be different on households who rely on public transport.

# **3. STUDY BACKGROUND**

A multinomial and nested logit model is proposed to examine the nature of household mobility choices of residential location, workplace location and mode choice to work of two-worker households.

The specific objectives are as follows:

- a. To determine the various factors that affect home location, workplace location and mode choice to-work of households.
- b. To examine the constraints imposed of having a second worker present in the location choice decision.

An advantage of the discrete choice approach is that it is based on microeconomic random utility theory, which states that households trade-off different location attributes when choosing their location that maximizes their utility (Sermons and Koppelman 2001). The approach also has the ability to include in the utility functions other variables such as air quality, crime rate etc.

Note that our goal here is to understand the household's location and other related choices and not the whole interaction between employment and residence location. The latter would require simulation of markets since households generally do not have control over availability of homes, employments and travel modes.

# 4. STUDY AREA

Metro Manila is chosen as the study area for the empirical analysis. It has an area of about 636 km<sup>2</sup> and a total population of 12 million in 2000. It is composed of 14 cities and 3 municipalities. Radial and circumferential roads comprise its road network. For convenience, we will adopt the zoning system used in MMUTIS 1999, so that our geographic level of analysis shall be similar with the latter. All in all, Metro Manila contains 265 traffic analysis zones (TAZ) (Figure 1).

In 1996, total daily trips in the region are about 30.3 million in which 24.6 million are motorized trips. To-work daily trips are around 3.6 million. The share of public transport is very high at 78%. 20.1% of Metro Manila residents are car-owning households.

The metropolis has three major CBD's, two are located in the southern part: Makati and Binondo, while one is located in the eastern part: Ortigas. It also boasts of having numerous medium to large scale commercial centers situated in different parts of the region.

More households are now living in the outskirts if not outside Metro Manila, increasing the spatial separation of workplace and schools. These outer urban areas are generally unprepared for the influx of new land developments and migrants.

# **5. DATA DESCRIPTION**

The main data used in this study is derived from the MMUTIS 1999 HIS database. This database contains pertinent household demographics such as income, age, occupation type, employment sector, zone of residence and workplace. It also contains person trip data, a one-day trip diary in which the origin, destination, trip purpose and travel mode used is recorded. A total of 550 samples were extracted from the database according to model requirements of: (1) households having only two workers, (2) trips made by workers are to-work and (3) households that moved into a new home two years prior to the survey.

Distances from home to workplace were calculated using shortest path criteria using ArcInfo software. Network travel times were determined by making use of JICA STRADA's trip and transit assignment program. An approximation of trip cost for each mode is done by making the cost as a function of the distance and travel time.



Figure 1. The Study Area, Metro Manila

Location attribute data for each zone came from the MMUTIS database, data from the census of population and housing as well as land valuation data from the internal revenue bureau. These sources were integrated and were correspondingly assigned to each traffic analysis zone. Some of the zonal attributes include are: population, land values, number of new houses and number of workers.

#### 6. THE PROPOSED MODEL

We assume that households use a rational sequence and method for making the choice, in order to allow us to use a random utility joint-choice model to calculate the probability of a given households choosing a bundle. Thus, households select among choice bundles that are composed of home and workplace location and mode of travel to work that maximizes their utility. The utility of a two-worker household n is given by this equation:

$$U_{n} = H + \sum_{w=1}^{2} (W_{w} + M_{w})$$
(1)

Where: H = residence characteristics

W = workplace characteristics

M = transport mode characteristics

This form of the equation allows us consider the disutilities of both workers which in turn affect the total utility of the household and as well as the interaction of household or worker characteristics to the choice attributes. The different variables used in the utility function are shown in Table 1. We assign worker 1 as the person who has a highest income among workers in the household.

Each worker in the household shall have 265 possible residential location choices and 265 possible workplace location choices. However, in a stricter sense, all 265 zones as possible location choices are possible but not probable. Some zones are to be restricted as an alternative location choice because of several reasons such as: the zone is purely a shopping center, a CBD, government-owned lands such airports or seaports which are not appropriate as a residence location.

Transportation modes that are considered in this study are car, bus and jeepney. Rail is not included because modal share is low and has limited coverage. Also, rails in other corridors were not operational during the survey. Those households that have workers who are private car users have 3 travel modes to in their choice set (first commuter mode – second commuter mode): car-car, car-jeepney and car-bus. On the other hand, PUV using households will have 4 alternative modes: jeepney-jeepney, jeepney-bus, bus-jeepney and bus-bus (Figure 2). The distribution is as follows:

From Figure 2, it is shown that residential location and workplace location is jointly determined. This is consistent with the recommendation of Waddell (1993). In reality, most residential choice location decisions are based on present location of workplace or the other way around. However, for long-term predictions of household locational patterns it is important to examine both workplace location choice and home location choice (Abraham et.al. 1997).



Figure 2. Nested Logit Model for Two-worker Households

In this study, we shall estimate two (2) alternative model structures. The first one is a multinomial logit structure of the joint choice of residential location, workplace and mode choice. The second one is a two-level nested logit structure with residence and workplace as the joint conditional choice and mode choice as the marginal choice.

Considering that there are 265 traffic zones used for Metro Manila, most of which are potential residential and workplace locations, a simple random sampling of approach is not necessarily an efficient method to use. It is possible that some of the alternatives may have very small choice probabilities for a decision maker who faces a large choice set. So we make use of stratified importance sampling of alternatives:

Residence:

The chosen zone (1 sample)
 All other zones (2 samples)
 Three (3) residential location choices.

Workplace:

- 1. The chosen zone (1 sample) 3 zones for 1st worker x 3 zones for 2nd worker = Nine
- 2. All other zones (2 samples) (9) choices

Therefore, a household has  $3 \times 9 \times 7 = 189$  possible alternatives

# Accessibility

Handy et.al. (1997), defined three (3) types of accessibility: cumulative, gravity and logsum. For this study, we shall use the second type which is the gravity-based form of measure. This type is derived from the denominator of the gravity model for trip distribution. It weights opportunities (quantity of an activity) by impedance, generally a function of travel time, distance or cost. In mathematical form:

$$A_{i} = \sum_{j} a_{j} f(t_{ij})$$
<sup>(2)</sup>

Where:

 $\mathbf{a}_{\mathbf{j}}$  = activity or attraction in zone  $\mathbf{j}$ 

 $\mathbf{t}_{ij}$  = travel time, distance or cost from i to j

 $\mathbf{f}(\mathbf{t}_{ij})$  = impedance function

The above equation simply states that the closer the opportunity, the more it contributes to accessibility and the larger the opportunity, the more it contributes to accessibility. The impedance function  $f(t_{ij})$  has many forms; the most common is the negative exponential.

$$f(t_{ij}) = \exp(-t_{ij} \cdot b)$$
(3)

Where:

**b** is a factor = 
$$\begin{cases} 0.9839 & \text{for to - work trips using public mode} \\ 0.7309 & \text{for to - work trips using private car} \end{cases}$$

The coefficient  $\mathbf{b}$  is determined by calibrating a trip distribution choice model. Ours are adopted from the MMUTIS 1999 gravity-based trip distribution model.

# 7. MODEL ESTIMATION RESULTS AND DISCUSSION

BIOGEME, an open source software, designed for the maximum likelihood estimation of Generalized Extreme Value (GEV) models was the program used to estimate the parameters.

Earlier estimation results show that the nested logit specification has a lesser negative loglikelihood value that its joint logit counterpart. Also, estimated nest parameters are significant at the 95% confidence level, Thus, our final model is based on the two-level nested logit specification. Table 1 shows the results of the estimation process as well as descriptions of the variables included in the model.

Variable	Value	t-test
accessibility index for to-work trips	-0.000981	-2.168
population density	-0.759605	-0.270
zonal land value	-0.002808	-0.206
percent low income	-0.009572	-2.227
total number of housing units	0.000203	10.190
distance between workplaces (car_users)	-0.230661	-5.212
number of workers at workplace of worker 2	0.000058	8.324
number of workers at workplace of worker 1	0.000056	7.967
travel cost to work for worker 2	-0.026322	-8.605
travel cost to work for worker 1	-0.024744	-8.872
travel time to work for worker 2	-0.070835	-13.055
travel time to work for worker 1	-0.074159	-12.799
dummy. zone is a commercial complex/CBD	0.423172	1.551
nest parameter	2.240	5.390
scale parameter	1.0	fixed
Sample size	550	
Null log-likelihood	-2552.73	
Final log-likelihood	-1906.32	
Likelihood ratio test	1292.82	
Rho-square	0.276209	

Table 1. Parameter Estimation Results for Nested Logit Model

\* Significant at the 95% confidence level

It is first noticed that some of the variables relating to location characteristics for both residence and workplace are slightly below the 90% confidence level threshold and some are even too low compared to variables concerned with distance and travel. However it was decided that these variables remain in the model for illustrative purposes. On the other hand, the latter result implies that travel cost and travel time is given more priority by workers while location characteristics remain secondary in their choice decisions.

Moving on, we can see that land values have a negative impact on the choice preferences of households though it was found to be not significant. However, the sign of the coefficient gives support to the fact that households to locate to the outskirts of Metro Manila where land, housing or rent is cheaper compared to places located in the core of the region and land value could be a possible driving force for them to do so. The negative and weak value for

accessibility supports the latter statement. It suggests that households are willing to trade-off proximity to their employment to cleaner, safer environments and larger open spaces.

Population density is found to be negative and has weak influence on the location choice. The fact that there is not much decrease in population in the inner core of the region even though the outer fringes of the metropolis are experiencing suburbanization, could possibly explain why density has little influence on the utility of the household.

We can also see that individuals all else being equal do want to work in areas where there is a large population of workers. A large worker population could also mean more job opportunities for individuals. The result of the latter statement combined with the a positive and significant CBD dummy variable could mean that people are more likely to be employed in commercial centers and business districts.

Travel time and travel cost have expected signs and are all significant – a striking contrast to the preferences of households to live in neighborhoods far from their workplaces. It also observed that for car-owning households, distances between the workplaces of the two workers is minimized. This could mean a possibility for shared rides during to-work or to-home trips.

Lastly, it can be observed that in general, that the value of the coefficients for worker 1 are not higher compared to worker 2 as expected. This means that the hypothesis that the utility of worker 1 is given more priority in the location choice decision does not hold true for this case. Note that we assigned worker 1 as the person who has a highest income among workers in the household. The result implies that the degree of disutility is shared both by the two workers and no priority is given to either one.

# 8. CONCLUSIONS AND RECOMMENDATIONS

A disaggregate residential location choice, workplace location choice and mode choice for two-worker households has been developed for Metro Manila. This study allowed us to determine the factors which affect location and mode choice, particularly how two-worker households assess benefits and disbenefits between associated with each worker. It also showed that we can analyze land and transport decisions in a disaggregate manner.

The data that we used in this study is quite old and may be rendered obsolete. There are significant changes in the transportation conditions in Metro Manila that need to be considered. The introduction of two new rail systems is believed to have great influence on the spatial behavior as well as mode choice behavior of Metro Manila residents. In line with these new developments, a new HIS survey is currently being conducted. The new data shall be utilized to update our model.

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