Urban Mobility and Employment Accessibility in Bangkok: Present and Future

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Abstract

Many large cities are evolving to be multi-nucleated cities, which are believed to reduce car dependency, relieve traffic congestion, lessen suburbanization, etc. Bangkok has also been developing with many urban policies and implementations. It is still unclear to what extent those actions are appropriate. This paper examines the present status of urban mobility and job accessibility in Bangkok, both on private and public transport modes. The spatial distribution of employment is explored by the cluster analyses based on employment density and job accessibility. The associated travel-to-work patterns are examined by the location-associated travel preference function, which indicates the attractiveness of an area in capturing workers from its neighborhood. It is found that the central areas receive workers from the city-wide while the satellite areas receive workers from its nearby areas. The commuting patterns of different employment clusters are significantly different. Finally, the recently committed mass transit network is evaluated by comparing the improved mobility and accessibility with the base case for the future year 2025.

Keywords: Mobility, Accessibility, Employment Cluster, Bangkok

1. INTRODUCTION

Rapid population increase, suburbanization, economic growth, motorization, and car dependency are common urban problems experienced by many growing cities around the world. The situations are more severe in the developing countries. Most of their previous developments were undergone disorderly and unsatisfactorily. This resulted in terrible traffic congestion and critical level of urban air pollution. They are mainly stem from inefficient urban structure and suburbanization, which are caused by rapid population and high economic growth. In such a situation, residential areas are developed in the outer area, which reduces the inner density. Residents and households are moving out of the city, and some business firms will look for more accessible locations to serve them. This has often brought an urban sprawl that induces people to travel farther and longer in heavy traffic, to spend more money for transportation, and unavoidably to consume more fuels. This also caused other problems such as urban heat island, environmental degradation, low quality of living, etc. In order to alleviate these, the city growth must be properly controlled with a well developed urban plan. This requires a thorough understanding of the urban structure and characteristics, which are likely different for cities of different age, population, transport and development policies. Literature reviews found several theoretical and empirical studies to identify employment distribution pattern, sub-center formation mechanism in a metropolis, e.g., (Giuliano and Small 1999) and (Cervero and Wu 1998).
1.1 Objectives

This study has objectives to examine the present status of urban mobility, job accessibility, and travel pattern in Bangkok and to evaluate some transport policies. Mobility and accessibility on private and public transport modes will be determined. The spatial distribution of employment is explored by cluster analyses based on employment density and job accessibility. The associated travel-to-work patterns are examined by the location-associated travel preference function, which indicates the attractiveness of an area in capturing workers from its neighborhood. It is found that the central areas receive workers from the city-wide while the satellite areas receive workers from its nearby areas. The commuting patterns of different employment clusters are significantly different. Finally, the recently committed mass transit network is evaluated by comparing the improved mobility and accessibility with the base case for the future year 2025. The remainder is organized as follows. The next section describes the study area, the data, and the transport model used. Section 3 shows the present status of urban transportation with hazard map and accessibility map. Section 4 presents the distribution of employment clusters. Section 5 presents the pattern of travel to work as generated by the location of residence and employment in the form of the location-associated travel preference function. Section 6 presents a policy evaluation with scenario test. Finally, Section 7 concludes the paper.

2. THE STUDY AREA

The 7,758 sq km. area of Bangkok Metropolitan Region (BMR), Thailand, covers the large core so-called Bangkok Metropolitan Area (BMA) and five surrounding areas, namely Nonthaburi, Pathumthani, Samut Prakarn, Samut Sakorn, and Nakorn Pathom. BMR has undergone rapid urbanization and industrialization since 1960. Population growth is so dramatically rapid due to extensive investment in road network and the rapidly growth of real estates. However, from 1987 to 2000, population of the inner area has declined, but the outer area increased. The inner area population density decreased from 15.27 to 11.09 thousand/sq.km. (3.25 to 2.36 million people) while the outer increased from 0.77 to 1.28 thousand/sq.km. (0.67 to 1.12 million people). Recently in 2005, the total population in BMR accounts for 16.8% of the country population and produces 44.2% of the country’s GDP. This shows that BMR is a major economic center of the country, where every economic activities can be found in various area such as high-density business districts, high-density residential areas, heavy industrial estates, etc.

Regarding the transportation, major travels in Bangkok are based on road transport; mostly by private vehicles. In 2005, private mode share is approximately 53%; while public mode is only 44%. The fact is that private mode is far superior to public transports, mostly are public bus. Although there are over 404 bus routes, they are not enough to accommodate travel demand, especially from/to the suburban areas. For rail transport, from recently the urban rail transit is introduced. In 1999, the 23-kilometer elevated urban railway called BTS, standing for Bangkok Transit System, started its service in two lines. BTS is presently receiving over 400,000 daily passengers. Five years after BTS opened, a 20-kilometer urban subway line (called MRT) operated by Mass Rapid Transit Authority has started its service in 2004. There are three transfer points between the two systems. In addition, there are also suburban railway lines of SRT, standing for State Railway of Thailand, mainly on sub-urban and inter-city routes. Although the rail services of BTS, MRT, and SRT have accommodated some portions of urban travel demand, but still not enough.
2.1 Data and Model

The population, household, employment, land use, and transportation data used in this study is obtained from the official transportation planning data, which is responsible by the Office of Transportation Policy, (Office of the Commission for the Management of Land Traffic 2000). In 2005, total population is 10,661,047 and total employment is 5,962,497. The distribution of population and employment are shown in Figure 1. It is clear that population and employment are mostly concentrated in the inner core; only some portions are scattered to the northern and eastern parts.

These data are obtained and used in the official Bangkok’s transport demand model, named e-BUM, which is built on the CUBE proprietary software (Office of the Commission for the Management of Road Traffic 1997). The multi-modal transportation network consists of urban highway, bus lines, taxi services, ferry lines, mass transit lines, intercity railway lines, and non-motorized transports. The model is used in this study to calculate the inter-zonal travel time, mode share, and accessibility.

3. URBAN TRANSPORTATION

It is well accepted that transportation infrastructure, such as highway or transit service, will alter the spatial form of land development by increasing the accessibility of land (through the introduction of new access or improvement of existing access), enhancing the mobility of land users, lowering transportation costs, and ultimately encouraging land development of various types. Changes in land use in turn generate activities that create a demand for travel. Then increased travel generates the need for new transportation facilities, which in turn increase accessibility and attractiveness of further development. This is known as land use/transport interaction. This section determines the present status of transport service as well as urban development by looking at its mobility and accessibility.

3.1 Mobility

Mobility measures how ease travelers can move from a certain place to their final destination, which may be represented by travel time, travel speed, average delay, or level of service, etc. This paper presents a so-called Travel Hazard Map as shown in Figure 2a and b for private
and public modes respectively. It is the travel time in minutes to the city center, named Silom (zone 131), computed by the travel demand model as mentioned in Section 2. It is shown that travelling to the center from the outer residential area like Don Muang, Nonthaburi, Phutthamonthon, or Bang-Na (the red areas in Figure 2a), would take about two hours on private cars; but would take longer on public transport (becoming pink in Figure 2b). Recalling that residents are sprawling (Figure 1a) but employment are concentrating at the center (Figure 1b), those people living in the outer area have poor mobility on public transport comparing with private cars, so they will never choose to take public transport but prefer to drive into the center. This generated a lot of travel demand on private mode and causes severe traffic congestion, particularly during rush hours.

![Figure 2 Mobility in 2005 a) Private mode b) Public mode](image)

### 3.2 Accessibility

Accessibility measures the opportunity to complete certain activity at other locations at a distance away. Regions with well-developed transportation networks generally have high degrees of accessibility. A typical accessibility measure has two components. One is related to the destinations and is commonly called the attractions portion of the measure. For example, attractions measures for shopping may be number of employees, amount of sales, or square feet of space. The second component describes the ease of reaching those attractions. Since difficulty increases over distance, this component is commonly called the impedance factor. Typical impedance factors include distance to the attraction, the amount of time it takes to reach the attraction, or cost of traveling to the attraction. Expression of accessibility measures vary from simply minimum-travel-time indices, cumulative opportunities within specified time thresholds (Srour et al. 2002), to more complicated measures of various forms (Kim and Kwan 2003). This study employed a simple gravity-type expression, (Hansen 1959), to determine job accessibility from each area in the city: 

\[
A_i = \sum_j \frac{Emp_j}{t_{ij}}
\]

where \(A_i\) is the employment accessibility of zone \(i\), \(Emp_j\) is the number of employment or workforce available in zone \(j\); \(t_{ij}\) is the inter-zonal travel times on private and public modes. The resulting job accessibility will be that on private and public modes as shown in Figure 3a and b respectively. It is obvious that job accessibility on the private mode is far larger than on the public mode. This confirms that public transport service is inadequate, considering that people...
are living around the city and most of them are commuting to work in the city center. Again, the large numbers of people living outside with low job accessibility on public transport would have no choice other than using private modes of transport for their commuting trips.

Moreover, it is noticed that the areas with high accessibility (the dark areas in Figure 3b) are on the corridors of the two urban railway lines and have very rapid increase in land value as well. This shows that the impact of transport on land development potential is quite strong.

4. EMPLOYMENT CLUSTERS

The preceding sections have shown that employments in Bangkok are concentrated at some locations or along corridors with high accessibility. The concentration of activity evolves to form a sub-center in longer time. It is, therefore, important to understand the spatial distribution of employment because location of business activities, retail stores, and industrial establishments derives the travel patterns in the city, especially the journey-to-work trips, which largely contributes to the daily travel demand. This section examines the pattern of distribution based on the cluster analysis as described in (Alpkokin et al. 2005; Alpokin et al. 2007). It is one of several ways to analyze the spatial distribution of employments; ranging from simple statistical analysis to explicit consideration of land market mechanism in discrete choice modeling (Miyamoto et al. 2004).

4.1 Density Clustering

It is simple to cluster zones in the study area based on the employment density in each zone by plotting the logarithmic density against the rank size. That is, the gross employment density is plotted on the vertical axis and its rank on the horizontal axis, as shown in Figure 4a. The relatively steep curve implies that there is large difference of employment intensity among zones; i.e., the high-ranked places have large employment intensity such as CBD; while some area have low employment intensity such as the outer residential area. The zones are classified into groups; or so-called clusters. This study classifies the employment zones into four clusters. The cutting points chosen between Cluster 1, 2, 3, and 4 are the logarithmic employment density value of 9.5, 7.0, and 5.0 respectively. The distribution of clustered zones is shown Figure 4b, which also represents the degree of employment agglomeration. Detail discussion of the clustered area can be found in the earlier papers (Alpokin et al. 2007; Vichiensan 2007).
4.2 Accessibility Clustering

Since the employment opportunity can be measured by the job accessibility, the clustering of employment may also be defined based on its accessibility. The similar way of clustering by plotting rank-size distribution and plotting the spatial distribution is conducted. The results are shown in Figure 5a and b respectively.

As previously, the areas with high accessibility are the areas with high potential to form a sub-center. It is clear that the cluster-one zones are the area along the mass transit corridor surrounding by cluster-2, cluster-3, and cluster-4 zones respectively. Clearly, the cluster-1 area, are in the inner core while some are locating at the high accessibility area such as the end terminal of the BTS line on the south-eastern area, or Minburi location on the eastern side of Bangkok. These areas have high potential to form a sub-center where employment opportunity is high and attractive to the workers who can travel to work by using urban railway. The cluster-2 areas are presently known as the large inner core of Bangkok with moderate employment opportunity in the mix residential and commercial setting. The area is also known the covered area of the inner ring road, namely Ratchadapisek road. The cluster-3 zones have low employment opportunity because it is mainly residential area. The Cluster 4 zones are the rest sub-urban area and/or the preserved green area, which are less developed as well as less accessible. In a spatial perspective, the clustering pattern based on accessibility in
Figure 5b is much smoother than based on density in Figure 4b. It will not be wrong to conclude that clustering based on job accessibility will be more interpretable and understandable; so such clustering will be used in the subsequent analysis.

5. WORK TRIP PATTERN

Although it is well accepted that Bangkok is a monocentric city where most of the urban activities are concentrated in the large inner core, the city is evolving time to time where many activities are moving to concentrate at some locations. In general sub-center is defined as the area where the activities such as working, living, pleasuring activities are self-contained at a closer distance. In order to examine which area has such characteristics, this paper present an analysis of the location-associated travel to work pattern by looking at some specific workplace locations. It is to plot a location associated travel pattern at some large employment nodes namely Don Muang, Jatujak, Bangrank and Sathon, shown in Figure 6.

![Location Associated Travel to Work Pattern](image)

For an employment zone, it is to plot the cumulative proportion of workers on the vertical axis for each increment of travel time on the horizontal axis. Thus, the values on the vertical axis will range from 0 to 1, as it is the proportion number; the values on the horizontal axis will range from 0 to the largest travel time to that employment zone from the farthest zone. For example, at Sathon employment zone in Figure 6, there are about 20% (0.2 portions) of workers coming from the area within 40 minutes of travel; while there are about 70% (0.7 portion) of workers coming from the area within 100 minutes of travel. Therefore, an employment area with a steep curve would have workers coming from nearer area while an employment area with a flat curve would have workers coming from farther area. As a result, a sub-center would be characterized by a relatively steep curve where workers choose residence around the area within a short duration of travel to work. From the graph, it is clear that people who work in the central area such as Sathon and Bangrak are coming from all parts of the city, which is shown by the relative flat curves; while people working in the outer employment areas such as Jatujak or Don Muang are coming from shorter distance area, showing by a steeper curve. To illustrate this, only about 50 percent of Sathon workers are coming from the area within 80 minutes travel time to Sathon; while almost 90 percent of Don Muang workers are coming from the area within 80 minutes travel time.
In order to ease the presentation, the raw plot is fitted by a quadratic equation and so-called a location-associated travel preference function; that of some zones of each cluster are shown in Figure 7. It is obvious that the functions of zones in each cluster are different. Cluster 1 zones have mild gradient or rather flat curves, implying that workers are living across the city. Cluster 2 and 3 zones have relatively steeper curves, implying that they have captured workers from nearby residences.

![Figure 7 Location Associated Travel Preference Function](image)

This result confirms the way of clustering presented in Section 4 in that Cluster 1 is the area in the inner core having large size of employment and high accessibility, so its workers are coming from different area of the city; while Cluster 2 and 3 are the areas having moderate size of employment and level of accessibility.

6. FUTURE DEVELOPMENT

Having known that some certain areas have high potential to form sub-center especially along the mass transit corridors, focus of developments are given to the mass transit network. Recently, the government has committed a master plan to construct a 291-km urban and suburban railway network covering the whole Bangkok Metropolitan area. Lines of service are shown in Figure 8.
Figure 8 Full Mass Transit Network
a) Base scenario (only the present two lines)    b) Full mass transit network

Figure 9 Travel Hazard Map in 2025
a) Base scenario (only the present two lines)    b) Full mass transit network

Figure 10 Accessibility Map in 2025
This study evaluates the impact of the mass transit network from the viewpoint of mobility and accessibility improvement by comparing two scenarios: Base scenario (only the present two lines) and full mass transit network scenario. The mobility in the future year 2025, represented by a travel hazard map is shown in Figure 9. It is again the travel time in minutes to the city center named Silom. The accessibility in the future year 2025 is shown in Figure 10.

It is obvious that the full network has significantly changed the mobility and accessibility of Bangkok comparing to the base case with only the three lines of BTS & MRT. In words, for the base case where the full mass transit network is not available, the city will be severely congested. That is, it will take very long time to travel into the city center, as shown by the widely scattered pink area in the Travel Hazard Map in Figure 9a. On the other hand, with the full network, the areas of each color in Figure 9b are larger, showing that within a certain time budget, people can move farther. From the accessibility viewpoint, the full network scenario gives an area more opportunity to be reached, resulting in the increased level of accessibility, shown in Figure 10b.

7. CONCLUSION

This paper presented an analysis to show the present and the future of transportation in Bangkok focusing on travel to work trips, which are the largest portion of travel in rush hours. Mobility is shown by a travel hazard map. Accessibility map is also constructed to illustrate the distribution of employment opportunity. It is found that public transport is inadequate especially for the outskirt areas. The area clustering based on employment density shows the pattern of concentration based on size of the activity. It is found that employments are mostly concentrated at the large inner core area. The clustering based on job accessibility shows the pattern of employment opportunity, which indicates the tiers of development potential of cluster 1, 2, 3, and 4. In addition, the travel to work pattern is examined. It is found that most of workers are travelling across town to come to work, which mainly causes severe traffic congestion presently. At the end, the recently committed mass transit network is evaluated. Comparison of the mobility and accessibility in the future year 2025 confirms the necessity of the project. However, the scenario test has an inherent assumption that land use in the future is a given condition and not different for each scenario. In the other words, the effect of transportation to land development is implicitly neglected; which definitely limits the discussion. This may be delimited by employing an integrated land use/transportation model in the analysis, which is remained for the further study.

REFERENCES


