Abstract: Market forces and/or planned intervention in many metropolitan areas are transferring urban form from mono-centric to more dispersed or, poly-centric structure where firms cluster outside city center and where location and trip patterns tend to vary amongst cities. As study area, distribution of employment, and related commuting and residential location preferences in Tokyo metropolitan area have been investigated by grouping zones into four tiers and analyzing associated trip lengths, mode shares employment destination zonal preference functions. Tokyo contributes to poly-centric city work (with huge literature on North America) by its extensive railways that mainly characterize urban dynamics. Results confirm that despite relatively higher decentralization between 1960s and mid of 1980s, Tokyo central area or highest ranked zones are accommodating half of total employment stock but jobs agglomerations have evidently evolved nearby major rail stations generating stable trip times over time and uniform mode shares over metropolitan area.

Keywords: Poly-centric employment; Accessibility; Decentralized concentration

1. INTRODUCTION

Ample evidence exists that especially since the 1970’s, economic development together with the population growth and motorization have led to de-concentration of economic activities with an outward movement of residents from the city core, and then, this was followed by exodus of jobs in many large and growing cities. Firms began to cluster re-concentrating in
new suburban agglomerations and forming a decentralized concentration form of spatial configuration (Archer and Smith, 1993), where urban dynamics are more complex than the case of mono-centric structures (Anas et al., 1998).

The defining characteristics of the non mono-centric city are CBD is still the strongest center, and its absolute growth is still evident, but loses its share of relative metropolitan employment. Non mono-centric trend can be classified into two main categories: dispersed employment; and locally centralized employment location (Gary, 1990). In the first category, economic activities are rather scattered and the employment density gradients are somewhat flat outside the CBD. In the second archetype, there is an urban pattern where firms and businesses are clustered, either in some sub-centers (poly-centric employment development), or along some major transportation corridors (rail or highway) where local density gradients are observed, or, indeed with both. Another possible classification is: (a) large concentrated centers; (b) decentralized by concentrated and compact settlements linked by public transport; (c) dispersal in self- sufficient centers as alternatives to the compact city - that is, a high dense center with clear and abrupt edges to the countryside (Frey, 1999).

The dynamics of non mono-centric formation, and associated trip profiles, will differ amongst the cities because of a number of factors such as economic development stage, size of the population, transport network, existing location policies, and geographical features. Existing empirical and theoretical studies, explaining the employment distribution, sub-center formation and land rents have been mostly limited to North American cities (For example, see McDonald and Prather, 1994; Giuliano and Small, 1999; Hansen, 1987; McMillen, 2001; Lee, 1982; Shukla and Waddel, 1991; White, 1999). Many of these case studies have demonstrated that sub-centers have added to the vehicle distances traveled over the years, especially those for the North American cities (Cervero and Wu, 1998, Guiliano and Small, 1999).

This paper, as a part of the EASTS International Collaborative Research Activity (ICRA) funded project “Asia Poly-centric employment collaborative – transport (APEC – TR)”, contributes to the research on decentralized concentration of employment by exploring the Tokyo metropolitan area with particular reference to its rail network development as its representative character. After the Second World War, railways have been improved rapidly and high density urban agglomerations have emerged by main railway stations. Today, rail lines carry 46 % of the total daily trips or, in other words railway commuting has been a long-standing habit. As one extreme case city, the study may also assist planning in developing cities that are encountering urban problems of high stress on their CBD, uncontrolled growth and insufficient transport infrastructure. (Morichi, 2005).

We first outline the history of relevant location and transport policy making experiences for
Tokyo (Section 2). Next, we empirically analyze how clustered employment distribution has been observed since 1960’s, describing four tiers of clusters (Section 3). The analysis further explores the associated residential location preferences and commuting trip profiles to address the affects of spatial distribution of jobs on commutes, notably, considering the tiers and spatial distribution of urban nodes (Section 4). Finally section 5 examines the job accessibilities by calculating traditional gravity-type accessibility indicators over time and among spatially defined employment agglomerations.

2. HISTORY OF POLICY-MAKING ON NON MONO-CENTRIC URBAN FORM

By rapid population growth and very rapid economic development starting at 1960s, Tokyo has become one of the few economic centers of the world (GDP per capita increased from $3,000 in 1963 to $38,000 in 2001). Today Tokyo capital region accommodates 40 million people with very mobile daily trip profiles and 19 million job opportunities. Tokyo is by far the largest agglomeration in the world, which can be mainly explained by its lower commuting costs due to its high developed network of suburban commuter railroads and obviously well connected subway system.

2.1 Location Policies for Growth outside the CBD

In 1956, first comprehensive plan for national and capital region development was established- describing Tokyo metropolitan area within 100 km radius from the core of Tokyo (including Tokyo-to, Kanagawa-ken, Saitama-ken, and Chiba-ken; part of Ibaraki-ken, Tochigi-ken, Gunma-ken, and Yamanashi-ken) (Figure 1). At the time, mono-centric structure and associated high stress on the city center, especially the congestion in central area railways was realized as a big problem. For this reason, the policy document envisaged policies to promote controlled decentralization restraining centralization and introducing “Green belt” to preserve large scale green area very similar to Greater London Plan. However, “Tokyo greenbelt plan” failed and the subsequent plan in 1968 abolished the green belt concept. Following second and third National regional capital region plans (1976 and 1986) both addressed the formulation of policies for “Suburban development area” around the existing built-up areas in order to develop balanced and well-designed hierarchical urban centers and to preserve green areas on a rather smaller scale. Notably, the plan was also not only limited to industrial and satellite cities but also academic, recreational and cultural facilities.
Fourth and fifth plans firmly designated “Business core cities”\(^1\) defined as the high density core settlements within Tokyo central area; and “Bases for large cooperation”\(^2\) defined as the large centers outside the Tokyo central area (Figure 2). Plans promulgate their primary aim as poly-centric spatial re-structuring within a circular development of stronger urban nodes outside the Tokyo central area to ensure self-reliance regions and to strengthen the regional network and co-operation and also to mitigate the stress on the central area (Kantouhokubu, Kantoutoubu and Nairikiseibu regions).

Complementary financial programs were also introduced in terms of bonuses to promote new developments especially in the underdeveloped regions such as tax exemptions from Co-operate enterprise tax or Business facility tax deduction. However, over the years despite the substantial efforts forwarded to promote multi-nucleus urban pattern, Tokyo continued to preserve its strong centralized structure, but rather at a macro scale. Nevertheless, looking at a micro scale within the central area, apparently there have emerged a number of urban spots near by the rail stations that can be quantified as Transit oriented development (TOD) settlements (Shinjuku, Harajuku, Ikebukuro). Urban re-generation plans have also been applied for non-core city development and one good example is the re-development plan for Roppongi, where multi-use 54 floor tower has been constructed near the rail station. Such

\(^1\) Yokohama, Kawasaki, Atsugi, Hachioji, Tachikawa, Oume, Kumagaya, Urawa Saitama, Tsuchiura, Ushiku, Tsukuba, Narita, Chiba, Kisarazu Tama, Sagamihara, Machida, Kawagoe, kasukabe, Koshigaya, Kashiwa.

\(^2\) Mito, Maebashi, Takasaki, Utsunomiya, Kofu
plans are not limited to the central area and also are adopted to foster the growth in designated urban nodes outside the city center. For example Tsukuba and Saitama have grown as densely populated urban nodes –large enough that can be defined as sub-center. Almost in all the cases, either micro or macro scale urban developments, they were well connected by a rail line, for example after the opening of “Tsukuba express” in 2005 the trip time to the city center reduced from 90 min to 45 min.

Figure 2: National regional development plans and multi-centric development

2.2 Transport Policies

Rail line improvement and linking land use development has a long history in Japan. For example even before the 1940’s, when the railway enterprises invested in new rail lines they also owned and developed the land parcels around the major stations. Since the 1960’s, Tokyo has developed its rail network, not only the central subway but also the urban railways connecting the suburban areas. After the 1970’s, along with the land use development policies, new rail lines connecting the business core cities and the center of Tokyo have been developed (Musashino-line in 1973, Hokusol- line in 1979, Tsukuba express connecting Tsukuba and Akihabara - central area - in 2005).

Council responsible for transport policy assists to develop the railroad network in Japanese metropolitan areas; it gives recommendations about certain construction and upgrading projects. Only if listed in the council’s report, the new construction of a railway line can be undertaken. The nineth report by the council in 1966 was the first document to address transit-focused development and necessarily construction of railroad network in the suburban
areas. In addressing the problem of rush-hour congestion (especially from east and north area) and long-distance commuting, the seventh report by the next Council published in 1985 defined its goals as to decrease the congestion rate from 220 % in 1980 to 185 % in 2000, and to ease long-distance commuting. For realizing these targets, acceleration of railway lines, provision of more frequent service, elongation of the vehicles, and construction of new lines were included in many plans. By 1998, 44 % of the planned railroad construction and improvement has been opened and 38 % was under construction. In addition, the importance of sub-centers and the cultivation of business core cities are strongly stressed.

3. EMPLOYMENT DISTRIBUTION PATTERN

Literature review has identified that a number of empirical studies on USA cities have classified census tracts to define the tiers of employment and to investigate the firm location dynamics and patterns (Cervero and Wu, 1997; Guilliano and Small, 1999). For Tokyo metropolitan area, as one case city of the EASTS (ICRA) awarded project APEC-TR, we will follow the analytical scheme proposed by APEC-TR research group for clustering the zones into four tiers by their employment density based on rank size distribution (See for analytical techniques of the ICRA paper of EASTS 2007 “Poly-centric employment formation in mega-cities: Analysis from APEC-TR collaborative research”, Alpkokin, et al, 2007). We will further explore commuting characteristics and residential location preferences of the trips over the last three decades by specifically considering the variations among the tires and changes over the time with the emergence of the clusters.

3.1 Cluster Analysis for Employment Location Dynamics

Plotting the rank size distribution for gross employment density on the y-axis and ranks on the x-axis over, 337 analysis zones for the years 1963, 1981 and 2001 allowed us, to some extent, to trace the dynamics among the tiers (Figure 3). Obviously there was no change in the shape of the tier I zones- specifically no upward or downward shift of the rank size curve- which are located in the core city. The cut offs for tier I and tier IV- low densely zones- more for 1981 and 2001 were apparent. Applying the criteria for classification of the zones instructed within the context of APEC-TR project and following the general tendency of defining the zones in to four tiers (Cervero and Wu, 1997), we have defined the four tiers as: Tier I: Old CBD and high density zones; Tier II: Agglomerations outside the core city; Tier III: Suburban zones that are likely to develop; Tier IV: Low density zones (Alpkokin, et al, 2005). Table 1 represents the characteristics of four clusters in terms of employment and the share of the employment over the total and the changes between 1963, 1981 and 2001.
Both Table 1 and Figure 3 witness the primary role of tier I type of zones accommodating approximately half of the total employment stock with almost no change over the last three decades (from 56 % in 1963 to 53 % in 2001). This is rather a different pattern compared to those of large North American cities, where notable dynamics have been occurring outwards and the old CBDs have been loosing their shares over the total. In one of these studies, notably highly depends on the definition of CBD, it was reported that share of CBD is only 7.4 % at average in a number of large American cities. (Heikkila, et al, 1989; McMillen and McDonald, 1998; Giuliano and Small, 1999)). Between 1963 and 1981, Tokyo has shown a fairly concentrated decentralized pattern with a substantial increase in the tier II type of zones. These zones increased their total employment stock by 155 % and share of metropolitan total from 26.3 % to 32.6 %. But, there has been more moderate increase between 1981 and 2001 in tier II zones followed by tier III type of zones. Over the years, tier IV has very little share giving an understanding that there did not much occur unnecessary dispersion. One traditional and visual way to identify agglomerations evolving outside the CBD is to plot the density gradients for the selected urban nodes with the distance from the CBD (Figure 4). The
gradients show that the density decline towards the periphery but not so steeply without very obvious peaks in the suburbs—comparably to the North American cities (Small, et al., 1994; Cervero and Wu 1998).

Figure 4: Employment density gradients for Tokyo Metropolitan Area (1963, 1981 and 2001)

Figure 5 portrays a different way of displaying the clustering dynamics of employment by showing the increase / decrease in the ranks of the zones, defined by the rank size distribution, and the designated areas for either new or re-development zones represented by the arrows. Comparably higher shifts in the ranks between 1963 and 1981, then those for between 1981 and 2001 also witness the stronger pattern of decentralized concentration, mentioned earlier. This way of visualization may be used as a tool to monitor how successful multi-centric relevant policies for promoting sub-centers have been. To our knowledge, there has not been such a way of mapping applied to any other case cities on the purpose of exploring poly-centric spatial re-structuring. Upon examining the increase in the ranks, some of the zones with remarkable shifts in rank have been strongly consistent with the land use development plans designating these urban nodes as sub-centers.

Figure 5: Clustering rank dynamics (1963-1981 and 1981-2001)
4. COMMUTING PATTERNS

Research on decentralized firm location preferences and their likely impacts on residential choices, commuting average time and mode shares are contradictory and mostly limited to the metropolises of America. In a poly-centric urban form, average commutes may decline or may remain stable although employment and population scatter, if exists a tendency that the workers may prefer to reside around a sub-center to get the advantage of likely decreasing trip time so called cross commuting. This is defined within the context of “Travel time budget theory” implying that the people tend to maintain a total travel time budget and adjust their trip diaries accordingly (Garrison and Ward, 2000). A similar argument on the undesirable impacts of sub-centers is that they add more to the vehicle-distance kilometers and unbalanced mode share favoring longer kilometers by automobiles. But this may not be the case in every city taking a non mono-centric form. Gordon (1991) found somehow shortened automobile commuting times for 20 USA cities. Alpkokin, et al., (2005) has shown a 12 minutes decrease of rush hour average trip time between 1985 and 1997 in the metropolitan area of Istanbul. In contrast, Cervero and Wu (1998), exploring the average trip distance and time for San Francisco between 1980 and 1990 has proved that the metropolitan average commuting distances and times increased by 12%, and 5%, respectively. Tokyo is one the cases that serves as the evidence for the existence of travel time budget theory because the average trip time over whole metropolitan area has been rather stable with only very slight variations (42 min in 1968, 43 min in 1988, 44 min in 1998).

A more analytical way of grasping the residential location preferences and associated commute distances for a given employment center is to plot graphically the destination specific employment preference functions, based on a form of the intervening opportunity model. The estimation of the shape of the zonal preference functions requires data for the zonal number of resident workers, the zonal number of job opportunities, the destination–origin pattern of traffic, and the inter-zonal transport impedance matrix. For each employment zone, residential zones are ranked according to increasing distance, or better, transportation travel time, by either car or public transportation, or a weighted combination of the two away from that zone. The number of residential workers living in each zone is a proxy for housing opportunities. By plotting the cumulative distribution of residential workers reached, on the x-axis and the cumulative workforce captured on the y-axis, a housing opportunity surface around that employment zone is constructed. Simply, steep gradients imply a nearby choice of residential location; shallow gradients around a sub-center imply a broader, metropolitan-wide, spatial labor market.

Such spatial extent of trips attracted to five selected zones in 1968, 1988, 1998 was investigated in Tokyo based on the given idea of employment location-specific preference
function (Figure 6). The notable feature of Figure 6 is the different patterns in the zonal preference functions, the outer zones (Odawara, Hachioji) capture a very higher proportion of workers from very nearby residences indicating a minimizing approach to the journey to work by commuters. On the other hand, for core city zone (Shinagawa), least trips among the other five zones examined, are attracted from nearby residential opportunities. When examining the change over the time for the same zones, there was almost no change for the central area zones; on the other hand the outer zones slightly tended to attract more trips from closer residential locations (Odawara, Kawasaki). This may be accepted as the evidence that the non CBD zones may attract, to an extent, shorter trips as they emerge.

![Figure 6: Employment preference function for five selected zones (1968, 1988 and 1998)](image)

To discuss the balance or imbalance of the spatially distributed mode shares or, simply the variations between the city core and outlaying areas, we plotted the maps for the zone specific mode choice ratios. CBD of Tokyo, served by intensive rail network, attracts public transport trips by 80%. With the distance from the CBD, public transport mode share decrease but not as dramatically as in many other cases, particularly in North American cities, that even the outer zones attract as much as 50% public transport trips (Figure 7).

![Figure 7: Public transport mode share distribution (1988 and 1998)](image)
Similar results were evident for Istanbul metropolitan area, where does not exist any efficient railway system but is served by a very extensive bus network, did not also produce much mode choice variations between the CBD and outskirts of the city. Contrary to Tokyo and Istanbul, Cervero and Wu (1997) in their study for the San Francisco Bay Area examining the center specific modal shares, found huge variations between primary tier and the other lower density zones with the distance from the CBD. The mean public transport share for primary centers was 28%; whereas it was 8%, 4% and 2% for the second, third and fourth tiers, respectively. Referring to the three cities (San Francisco, Istanbul and Tokyo), it is not wrong to conclude that the existence of a metropolitan area wide public transport network would be a very important factor that if this is the case, the suburban centers do not necessarily and always attract/ produce car dependent longer trips.

5. CLUSTERING EMPLOYMENT AND ACCESSIBILITY

Accessibility has long been acknowledged in urban planning starting with Hansen (1959). Accessibility indicators are useful tools representing the efficiency or ease of reaching urban activities or simply, tools for indicating the potential for reaching opportunities. In considering the very likely linkage between employment decentralization and accessibility of jobs, Giuliano and Small (1999) Cervero and Wu (1999) similarly calculated the accessibility in San Francisco area exploring spatial and temporal variations. In this general context, we computed trip-end simple gravity-type, in its general exponential form (Equation 1), to represent any linkage between the clustering of employment opportunities and accessibility variations over the time, where: \( A_i^t \) is the accessibility of zone \( i \) in question; \( L_j \) is the labor force in zone \( j \); and \( t_{ij} \) is the impedance function between zone \( i \) and \( j \) in terms of trip time.

\[
A_i^t = \sum_j L_j \exp(-\beta t_{ij})
\]

(1)

By selecting twenty four representative zones from different tiers, the changes in the tier-type, ranking and the accessibility for each zone in consideration are presented in Table 2. We particularly considered choosing representative zones for the urban nodes that are designated as “Business core cities” and “Bases for large co-operations” (Figure 8). Upon examining the variations in accessibility indices by time, significant increases were evident over the twenty years between 1968 and 1988, where there has been more decentralization (Section 3, Cluster analysis). Increases in the accessibility indices, not completely but to an extent, were explained by the increases in the tiers or ranks. Among the twenty four zones, twelve were showing a fair increase in the accessibility, either between 1968 and 1988 or 1988 and 1998, and six zones out of the twelve are consistent with a notable increase of their ranking (Kashiwa, Narita, Atsugi, Koshigaya, Sagamihara, Kasukabe).
Additionally, zones gaining more accessibility tend to be shifting from tier III to tier II, (most of them are the surrounding zones of the central Tokyo). Such decentralized concentration pattern of job distribution and associated labor force accessibility variations may be explained by two important reasons: one is the decentralization of both jobs and people's tendency of residing closer to where they work, particularly in outlaying and emerging job agglomerations. The general idea is that jobs have been following the decentralization of people in many large American cities (Glaeser and Kahn, 2000) but there also exists contrary arguments. Within the context of this paper, we do not aim explore in detail such a relation for Tokyo area, but to our
knowledge, the strong mono-centric characteristic of firm stock has started to cluster outside the core area of Tokyo after the high population growth and dispersed pattern of residential market. Obviously, the other reason is the firm location choices in line with the job development of the rail network, namely the transit oriented development by the improvement of railways and strong habit of commuting by trains in Japan. The three maps in Figure 9, showing the accessibility computed via only the rail systems, also reveal remarkable increase of accessibility increases along the rail lines.

Figure 9: Rail network and job accessibility (1968, 1988 and 1998)

One particular interest of any possible statistical relation between accessibility and ranking of zones, we further plotted Figure 10, where y-axis is the logarithmic accessibility over the whole trips and x-axis is the rank of zones. Preliminary visual inspection demonstrates that early in 1960 there was a more linear relation, but starting from 1980 and in 2000 noticeably, a cut off around 150 ranked zones appeared representing a linkage between decentralized concentration and a desirable upward shift in the accessibility. More detailed discussion will be published elsewhere, but we only discuss here as a way of evaluating the efficiency of firm clustering trend and the potential for reaching these agglomerations.

Figure10: Accessibility and the employment density ranking (1960, 1980 and 2000)
6. CONCLUSIONS

Since 1980s, there has been growing interest in the poly-centric spatial configuration as an alternative solution in large and growing cities. Abundant studies, overwhelmingly on the North American cities, have empirically shown the decentralization process and its impacts on housing and commuting patterns. One motivation of writing this paper is to contribute to the research by exploring Tokyo metropolitan area with its distinct and representative characteristics of vast rail development after the Second World War in line with the rapid economic growth as one very important factor that created a habit of daily urban railway trips.

Besides, Tokyo metropolitan area constitutes one good and extreme case and contributes to ongoing EASTS ICRA awarded project APEC-TR which aims to provide an understanding and further guidelines for the mega-cities of the developing world, experiencing decentralized concentration, that in case there exists public transport services combining city center and outer agglomerations, this may provide preferably good solutions in some cases, that is the poly-centrism may not necessarily be phenomena any more.

Despite the land use developments and the re-generation plans that have been addressing multi-centric structure over the whole metropolitan area in order to mitigate the stress on the city center and to ensure a balanced growth, the central area is still strongly dominating. As one consequence of economic boom during the 1970’s and 1980’s, a considerable amount of jobs located in the second tier zones - a pattern of concentrated decentralization but rather more uniformly. However micro-scale poly-centric settlement has been more evident with vast amount of firms and offices nearby major rail stations both within and outside the central Tokyo.

Examining the spatial extent of commuting trips, particularly considering the variations between the core and the outer city over the time, we have found that decentralized concentration structure of Tokyo metropolitan area does not produce strong unbalanced results. Notably, this is contrary to the empirical findings from many large poly-centric American cities. The average commutes have tended to remain stable and there is to some extent uniform modal share of public transport throughout the whole metropolitan area. The zones surrounding the very center of Tokyo - most of which are second-ties zones have gained accessibility due to both decentralization of population and rail network improvement. Interestingly, outlaying and emerging zones are likely to attract more trips from near by zones witnessing the individual tendency to reside closer to where they work when there is more housing opportunity closer to the non CBD firm agglomerations.
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