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Spatial Structure and Spatial Impacts of the Jakarta Metropolitan Area: a Southeast Asian EMR Perspective

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***Abstract*—**This paper investigates the spatial structure of employment in the Jakarta Metropolitan Area (JMA), with reference to the concept of the Southeast Asian extended metropolitan region (EMR). A combination of factor analysis and local Getis-Ord (Gi*) hot-spot analysis is used to identify clusters of employment in the region, including those of the urban and agriculture sectors. Spatial statistical analysis is further used to probe the spatial association of identified employment clusters with their surroundings on several dimensions, including the spatial association between the central business district (CBD) in Jakarta city on employment density in the region, the spatial impacts of urban expansion on population growth and the degree of urban-rural interaction. The degree of spatial interaction for the whole JMA is measured by the patterns of commuting trips destined to the various employment clusters. Results reveal the strong role of the urban core of Jakarta, and the regional CBD, as the centre for mixed job sectors such as retail, wholesale, services and finance. Manufacturing and local government services, on the other hand, form corridors radiating out of the urban core, reaching out to the agriculture zones in the fringes. Strong associations between the urban expansion corridors and population growth, and urban-rural mix, are revealed particularly in the eastern and western parts of JMA. Metropolitan wide commuting patterns are focussed on the urban core of Jakarta and the CBD, while relatively local commuting patterns are shown to be prevalent for the employment corridors.

***Keywords*—**Jakarta Metropolitan Area, Southeast Asian EMR, spatial association, spatial statistics, spatial structure.

I. Introduction

RAPID urban expansion of the JMA, prior to the economic crisis that hit Asia in 1997, had been mainly driven by foreign and domestic investment. Foreign direct investment (FDI) inflows to the JMA had been increasing steadily in the late 1980s and early 1990s; USD 0.6 billion, 2.56 billion, and 3.03 billion respectively [1]. Between the period 1990-1994, the cumulative foreign direct investment (FDI) in JMA reached USD 8.46 billion [2]. Channelled by trunk transport corridors connecting the urban core of Jakarta to the east, west and southern parts (and beyond) of JMA, the investments, which had focused primarily on manufacturing, services, finance and the property sectors [2], had brought about substantial impacts on the spatial arrangement of employment in the JMA. Manufacturing seemed to be among the first benefitting from increased access to investment. Backed by the non-oil export oriented policy, began in the 1990s, outlying manufacturing sites were soon developed along the three transport corridors for cheap land and good access to export/import points (i.e., Tanjung Priok port and Cengkareng airport, located in the northern part of JMA). As quoted by Soegijoko [3], in 1985 and 1989 manufacturing already accounted for the largest share of GDP (26.8% and 27.2%, respectively) in the JMA's municipalities and regencies outside Jakarta. The region (i.e., JMA minus Jakarta) is commonly referred to as Bodetabek, standing for Bogor, Depok, Tangerang and Bekasi. The JMA itself is interchangeably termed Jabodetabek (Fig. 1).

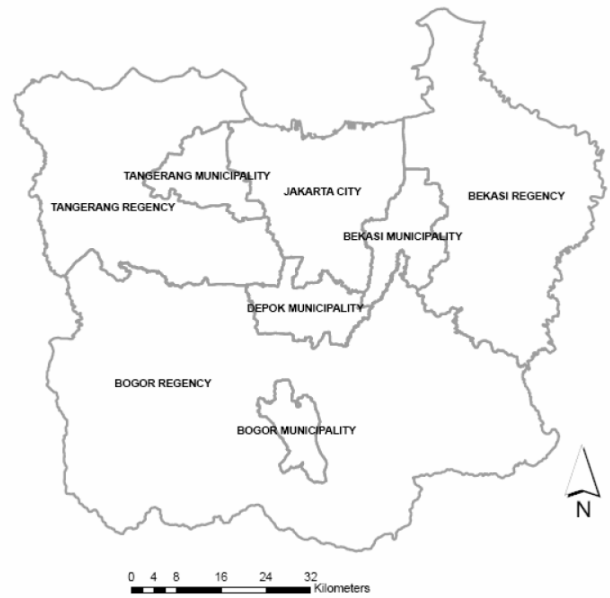

Fig. 1 Jakarta Metropolitan Area (JMA)

In the property sector, large scale housing development, commonly referred to as the "property boom" [4], had penetrated the peri-urban areas of JMA. Such large scale housing projects have been developed many kilometres away

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from the Jakarta urban core, mainly along the radial trunk transport corridors. Winarso [5] noted that between the 1970s and 1990s, private developers had converted 16,600 hectares of rural lands in JMA into housing areas. Investment in the finance sector had been equally influential in urban expansion. While investment in this sector had been focused within the central business district (CBD) of the Jakarta urban core, it had been directly attributable to the increasing demand for land in the CBD, which in turn boosted land prices and put enormous pressure on residents, including those living in inner city *kampungs*, to give up their lands and move outside the city [6]. The spurts of growth in housing in peri-urban areas, particularly that for medium and high income classes, were soon followed by retail and shopping centers [1] and other amenities such as schools, hospitals, golf courses and amusement parks. Within the period 1990-2000, the population of Bodetabek grew rapidly at a rate of 3.7%, while the population of Jakarta city grew only by 0.2% [6].

Along with this rapid urban expansion, the predominantly rural areas in Bodetabek, including the paddy fields areas, came under sustained and significant development pressure. In fact, manufacturing sites had been attracted to locate in JMA's peri-urban areas not only for cheap land prices and good transport access, but also for the availability of labour and lower labour costs, supplied from the relatively densely populated rural areas [7]. It was around these outlying manufacturing sites, and later probably the outlying housing estates, where there has emerged a co-existence of urban-rural activities. This urban-rural mix of activities, under the Southeast Asian extended metropolitan region (EMR) concept [8], is referred to as *desakota*, a term popularised by McGee [9] and dubbed from the Indonesian words *desa* (rural) and *kota* (urban). The Southeast Asian EMR, that is interchangeably termed a mega-urban region (MUR), is a type of urbanisation proposed originally by McGee [9] to explain the pattern of urban expansion experienced by Southeast Asia's major cities. The Southeast Asian EMR is defined by McGee & Robinson [8] as follows:

"Extended metropolitan development tends to produce an amorphous and amoebic-like spatial form, with no set boundaries or geographic extent and long regional peripheries, their radii sometimes stretching 75 to 100 km from the urban core. The entire territory – comprising the central city, the developments within the transportation corridors, the satellite towns and other projects in the peri-urban fringe, and the outer zones – is emerging as a single, economically integrated 'mega-urban region,' or 'extended metropolitan region.' Within this territory are a large number of individual jurisdictions, both urban and rural, each with its own administrative machinery, laws, and regulations. No single authority is responsible for overall planning or management."

Jakarta, Manila and Bangkok are the most prominent examples of EMR but the EMR concept is quite prevalent in the Southeast Asian region so that similar patterns are also noticed in the subsequent large cities of Bandung [10], Surabaya and Medan [11], and Ho Chi Minh, Cebu City and Chiang Mai [8]. For the case of Jakarta, the whole JMA covers a vast area of 6,580 square kilometers, consists of the urban core of Jakarta and the surrounding municipalities and regencies of Bogor, Depok, Tangerang and Bekasi, and can reasonably be considered as an EMR [12], [13].

Following the 1997 economic crisis, urban expansion in JMA has been halted or at least has slowed down. Now, ten years after the crisis, the economic recovery is still taking place very slowly. FDI in 2007 was estimated at "only" around USD 0.87 billion (Table I), less than one-third (in absolute term) of the 1992 level. Combined with domestic investment, the cumulative investment in the region in 2007 was about USD 1.3 billion, with Bekasi Regency sharing more than 60% of this total. There is no clear evidence that in the post-crisis period JMA would take a different path of urbanisation. In fact, the era of regional autonomy, which followed shortly after the crisis, has given the municipalities and regencies more motivation to pursue their economic interests through foreign and domestic investments. A recent example was the kick-off for the 36 hectare "Movieland" project, resembling that of the US' Hollywoodland, in Cikarang, Bekasi Regency, about 40 kilometers east of Jakarta [14]. Such a project seems to simply conform to features of the Southeast Asian EMR, an urbanisation pattern that JMA had mostly followed during the pre-crisis era.

TABLE I
FOREIGN AND DOMESTIC DIRECT INVESTMENT IN JMA*, 2007 (in USD)

Municipality/Regency	Foreign Direct Investment	Domestic Direct Investment
Jakarta City	4,676,900	282,015,076
Bogor Municipality	825,000	0
Bogor Regency	131,188,467	19,113,420
Depok Municipality	32,282,383	1,274,021
Tangerang Municipality	16,832,000	2,017,199
Tangerang Regency	53,175,000	6,716,286
Bekasi Municipality	9,105,067	0
Bekasi Regency	622,936,971	153,248,649
JMA	**871,021,788**	**464,384,651**
JMA Cumulative	**1,335,406,439**	

* Data is for 2007 realisation, except for Tangerang Municipality and Tangerang Regency, which are 2006 approval
Source: Official websites of BKPM, BPPMD West Java, BKPMD Banten

Whether JMA will follow the same urbanisation pattern as that of the pre-crisis era can be questioned because Southeast Asian EMRs, besides the economic benefits they have offered locally and nationally (Bangkok and Manila as the urban cores of EMRs shared 37% and 24% respectively, of their corresponding national GDPs [15], and JMA contributed 21.8% to Indonesia's GDP in 1995 [1]), have also been associated with various concerns about urban sustainability. These include, among others, land use conflicts [16], [17], [18], and [19], housing provision insufficiencies [20], [21], social segregation [22], [23], water supply crisis [18], [21], [24], [25], rapid increases in motorisation and the dominance of motor vehicles [26], [27], [28], traffic congestion [17], [20], [25], [29], and air pollution [27], [30], [31], [32].

Despite its prevalence and serious consequences on urban sustainability performance, the Southeast Asian EMR, in terms of its spatial structure, has not been empirically investigated in any detail. Spatial structure in this study refers to "*the kind, location, and density of activities as they are distributed across space in an urban area*" [33]. The study is focussed particularly on the spatial structure of employment in the Southeast Asian EMR; it is contended that identification of employment clusters would allow further investigations within the context of the Southeast Asian EMR itself, such as spatial impacts of the clusters on their surroundings and the degree of spatial interaction within its vast region. A review of literature confirm that the finest analysis of the Southeast Asian EMR's spatial structure available up to date had only divided the enormous region into three broad zones, namely the urban core, the middle ring, and the outer zone [6], [16], and [34], limiting further analysis to only a very coarse level. Moreover, all these studies relied on census data for identifying the spatial location of employment. For the case of Indonesia, the result will be biased because the census only records information on place of residence, not place of work. The purpose of this paper is to identify employment clusters within the EMR context and to conduct further investigations on their spatial impacts or spatial associations [35] with aspects of their surroundings and the degree of spatial interaction for the whole EMR region (using JMA as the case study).

II. Method and Data

Identification of employment clusters has gained increasing importance in empirical investigations of urban spatial structure given the pervasiveness of suburbanisation of employment and the formation of subcenters outside the CBD in many cities in the world. The most common method used to identify employment clusters is the one proposed by Giuliano & Small [36], which involves the application of thresholds of employment density and the level of employment to decide whether certain groups of zones in an urban area can be categorised as a subcenter. Despite its popularity, the method has been criticised for its arbitrariness of the choice of thresholds [37]. Alternative approaches have been developed to avoid such arbitrary cut-offs. An example is the work by Baumont et al. [38] who used exploratory spatial data analysis (ESDA) to identify clusters of employment in the Ile-de-France area. The method is appealing in another sense because it takes into account spatial autocorrelation and spatial heterogeneity of spatial data [39].

The use of ESDA in cluster identification has gained momentum since the extension of global measures of spatial autocorrelation to the local ones. These include local Moran's I (Local Indicators of Spatial Association - LISA) and local Getis-Ord Gi*, developed by Anselin [40] and Ord & Getis [41], respectively. Local Gi* is used in this study, yet with a slightly different approach. Instead of using employment density or the level of employment directly to calculate the Gi* statistic, co-location of jobs and industry across the region is first identified by applying factor analysis to the zonal percentage of total employment in the JMA for each of the eight job industry categories. The resulting factor scores are then used in the calculation of the Gi* statistic to identify hot-spots, i.e., clusters of zones with high factor scores. This method seems to be particularly helpful in identifying clusters for the case of the Southeast Asian EMR where employment tends to locate along trunk transport corridors radiating out of the urban core. When using the ordinary approach, delineation of clusters would be problematic since the cluster results will be contiguous and connected to the urban core. Another issue is that it is unlikely that clusters of agricultural industry can be identified directly using the ordinary approach because this type of industry tends to have very low employment density and zonal levels of employment. The modified method proposed would delineate clusters based on job industry co-location tendencies and identify agricultural areas simultaneously. Some of the resulting clusters, however, can be overlapped because some zones may return high Gi values under more than one factor.

This study relies on the Home Interview Survey, conducted as part of the Study on Integrated Transportation Master Plan (SITRAMP) for Jabodetabek in 2002 [42], as the main data source. The survey collected data from 166,600 households across the JMA. The data is organised into three datasets: *household dataset*, containing information on households' zone address, housing type, household monthly income, household monthly expenditure, vehicle ownership and the number of household members; *household member dataset*, containing information on household members' characteristics including age, gender, social activity (working, studying, jobless, retired), education level, workplace or school zone address, occupation, job industry, workplace facility type, individual monthly income and vehicle availability; *trip dataset* containing details of trips made by each household member including the trip's origin zone address, departure time, trip purpose, travel mode, arrival time, and destination zone address. In addition, the SITRAMP study also provided data in a geographical information system (GIS) format including the transport network, land use map and IKONOS aerial photo. Population data was obtained from the Population Census conducted in 2000.

III. Empirical Results

Prior to identifying hot-spots using the local Gi* statistic, factor analysis is applied to Z-scores of the zonal percentage of total employment in the JMA for each of the eight job industry categories; namely Agriculture, Forestry and Fishery, Manufacturing, Transportation and Communication, Finance, Whole and Retail, Central Government, Local Government and Services. There is no agreed upon criterion on deciding the number of factors to retain [43]. The scree plot (eigenvalue against factor) would suggest one to four factors to retain for high eigenvalues. Another approach would suggest five factors should be retained, for this is the point at which the scree plot starts to flatten; meaning that the addition of another factor adds only slightly to the explanation of variance within the data. It is decided however to retain six factors because the study needs more variations in spatial distribution and co-location of employment sectors allowing further analysis within the Southeast Asian EMR context. Table II presents the rotated component matrix for the six factors. Factor 1 and Factor 2 represent areas with a high degree of job industry mix. Factor 3 reveals the co-location tendency of manufacturing and transport and communication infrastructure. Factor 4 represents the CBD, where finance and central government services co-locate. Factor 5 and Factor 6 represent agricultural areas and local government zones, respectively.

TABLE II
ROTATED COMPONENT MATRIX FOR JOB INDUSTRY

	Component					
	1	2	3	4	5	6
Wholesale & Retail	**0.911**					
Services	**0.781**	0.317		0.380		
Central Government		**0.836**		0.328		0.310
Transport & Communications	**0.555**	**0.703**	0.274			
Industry			**0.978**			
Finance	0.343	0.291		**0.879**		
Agriculture, forestry, fishery					**0.991**	
Local Government	0.305	0.355				**0.864**

Note: Component loadings with absolute values less than 0.2 are not shown

The six factor scores then enter separately in the Getis-Ord (Gi*) hot-spot analysis to identify clusters corresponding to each factor. A spatial contiguity (first order) weight matrix is used for the hot-spot analysis. For 1,485 zones, the Bonferroni-type test method sets Z (Gi*) to 4.16 for the 95% level of confidence. It has been argued however that a Bonferroni-type test is too conservative, especially when the analysis involves a large number of zones (as in this case). In addition, for exploratory research, a Bonferroni-type test may not be used strictly as false negative results of the hypothesis are more of a concern [44]. Hot-spot analysis results for both Z(Gi*) 1.96 and 4.16 (the former is adopted in cluster definition) for the six factors are presented in the Appendix.

Due to some zones having high scores on more than one factor, clusters are not necessarily mutually exclusive, especially the ones within the Jakarta urban core where the degree of job diversity is higher. For the purpose of further investigation, the clusters are delineated as follows: First, Factors 1 and 2 are used to delineate the Jakarta urban core. A few clusters identified from Factors 5 and 6 within the urban core are neglected. Clusters from Factor 1 in Bogor Municipality are also blended to Factor 4. Next, as cluster results clearly show a corridor type of employment (which conforms to the Southeast Asian EMR theory), further delineation is performed based on the factor and spatial location of clusters. There are 14 clusters that are used, as shown in Fig. 2. Basic characteristics of the clusters including job density and centroid to centroid distance from the CBD are presented in Table III.

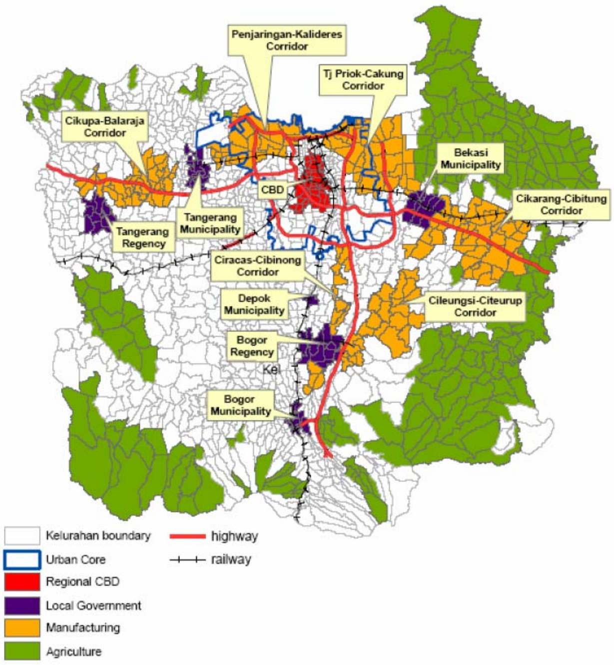

Fig. 2 Employment clusters

TABLE III
EMPLOYMENT CLUSTERS' CHARACTERISTICS

	Employment Cluster	Area (sq km)	Distance from CBD (km)	Number of Jobs	Job density (jobs/sq km)
1	Urban core	504.7	0.0	2,868,768	5,684
2	CBD	51.2	0.0	869,775	16,991
3	Tj. Priok-Cakung	178.4	11.6	615,043	3,447
4	Penjaringan-Kalideres	110.5	12.6	348,631	3,155
5	Cikarang-Cibitung	209.0	31.2	306,130	1,465
6	Cikupa-Balaraja	105.9	32.0	198,676	1,876
7	Ciracas-Cibinong	74.4	26.2	150,679	2,025
8	Cileungsi-Citeurep	127.0	28.1	157,240	1,238
9	Bogor municipality	14.4	43.0	79,166	5,505
10	Bogor regency	43.6	29.7	66,480	1,526
11	Depok municipality	5.0	20.9	11,947	2,412
12	Tangerang municipality	25.1	21.6	85,332	3,401
13	Tangerang regency	30.8	39.8	11,830	384
14	Bekasi municipality	35.2	20.1	78,354	2,226

Having identified the clusters, investigation is continued into the spatial associations of the clusters with their surroundings [35], [45]. The CBD is investigated in terms of the extent of its influence on employment density in the JMA. Instead of using the commonly chosen National Monument (Monas) as the point of reference, the CBD centre is identified using the weighted mean centre based on the number of jobs. Setiabudi, which is the zone within the new Golden Triangle CBD, is identified as the center of the CBD cluster. Spatial association of the CBD with the rest of JMA on employment density is calculated using increasing distance from Setiabudi. The result shows that the CBD's influence on employment density extents up to 51 km (GiZ > 4.16). The changes in GiZ values over distance from Setiabudi are shown in Fig. 3.

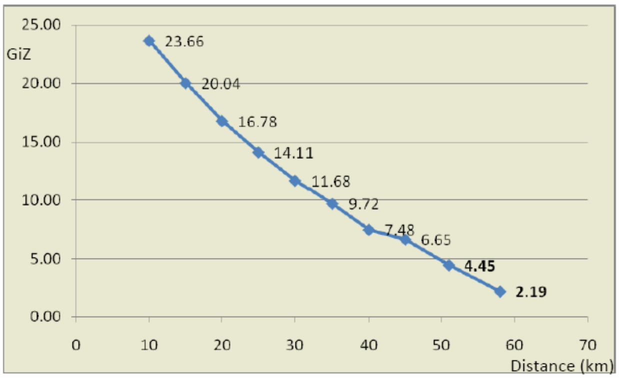

Fig. 3 Spatial association of CBD on employment density

Another interesting spatial association to test is the impact of clusters on population growth [45]. The dimension of spatial association used is percent change of zonal population within the 1990-2000 period. This is measured from manufacturing clusters located in the east-west direction of JMA (Cikarang-Cibitung and Cikupa-Balaraja), where development has been encouraged [46], and compare it to another cluster in the south, Depok Municipality, where development has been discouraged. The results show that the influence of manufacturing clusters in the east and west direction are quite large, i.e., 31 km and 26 km respectively (GiZ > 4.16) while the impact of Depok Municipality is much shorter, i.e., 17 km (GiZ > 1.96, which is not significant when a Bonferroni-type test is used). Fig. 4, 5 and 6 show the changes of GiZ over distance for the three clusters, respectively.

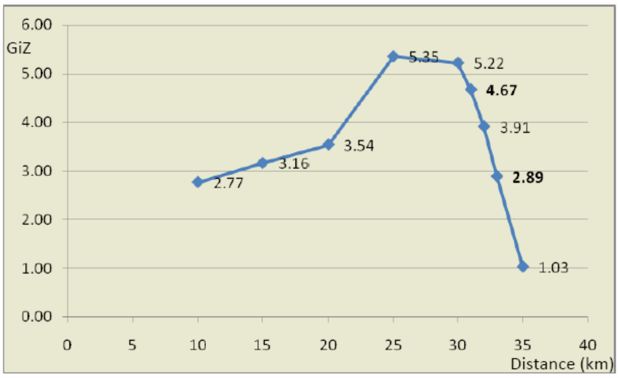

Fig. 4 Spatial association of Cikarang-Cibitung manufacturing corridor on population growth

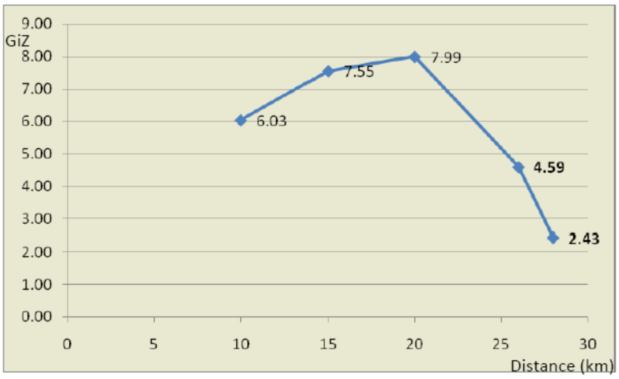

Fig. 5 Spatial association of Cikupa-Balaraja manufacturing corridor on population growth

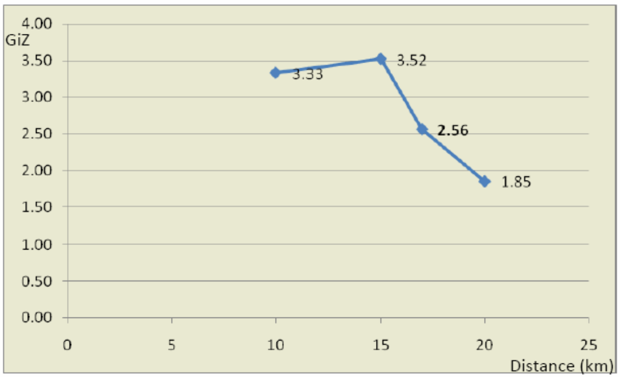

Fig. 6 Spatial association of Depok Municipality on population growth

The last investigation on spatial association is to test the impact of clusters on urban-rural mix, which is closely related to the theory of the Southeast Asian EMR. Here the extent of urban-rural interaction is investigated through distance impacts of east and west manufacturing clusters on the zonal percentage of households having family members working in manufacturing and agriculture. While it may be premature to regard the outcomes as the extent of the *desakota*, results (Fig. 7 and 8, respectively) show that the influence of those two manufacturing clusters on urban-rural mix is quite substantial, i.e., around 25 km (GiZ > 4.16).

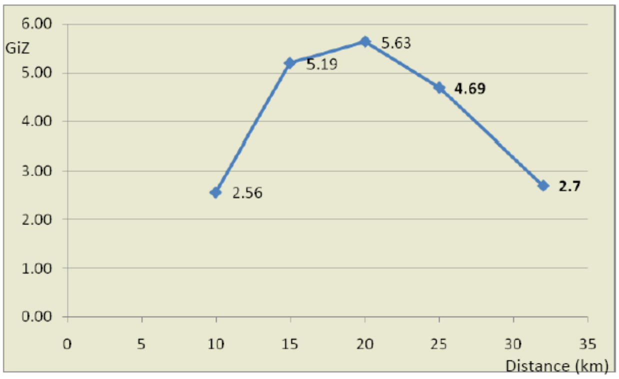

Fig. 7 Spatial association of Cikarang-Cibitung manufacturing corridor on urban-rural mix

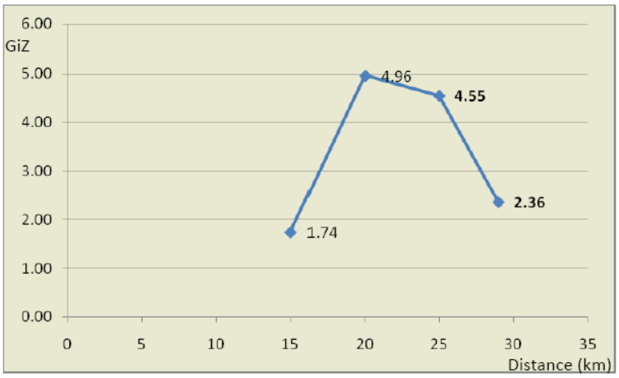

Fig. 8 Spatial association of Cikupa-Balaraja manufacturing corridor on urban-rural mix

Spatial interaction is one of the main components of urban structure [47]. Examinations of the patterns of exchange of work trips in the JMA can contribute to understanding the degree of spatial interaction in such a vast and complex region. This is investigated by drawing desirelines of home to work trips (one-way commuting) destined to each of the clusters identified previously. Figs. 9 to 12 present the results of this analysis (only desirelines of more than 300 trips are shown). Desirelines show that the CBD attracts commuting from almost every corner of the JMA, while the other clusters outside the urban core seem to attract relatively local commuting trips. The extent of the *desakota* around Cikarang-Cibitung and Cileungsi-Citeurep corridors is reflected from commuting trips that originate from the agricultural areas surrounding them.

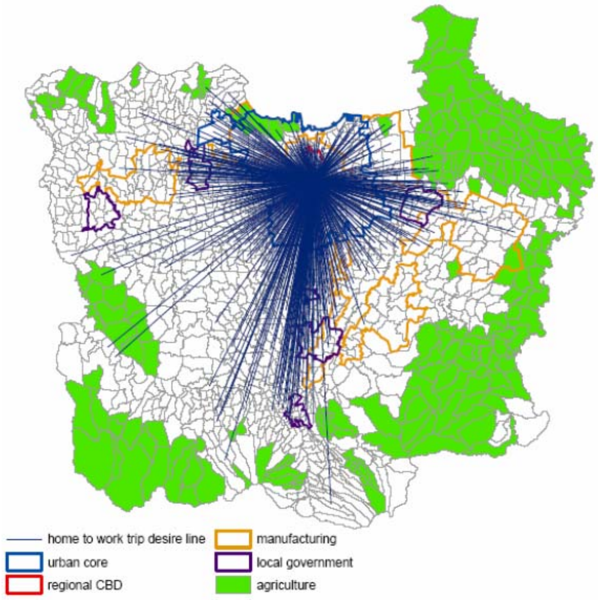

Fig. 9 Desirelines of commuting trips to urban core

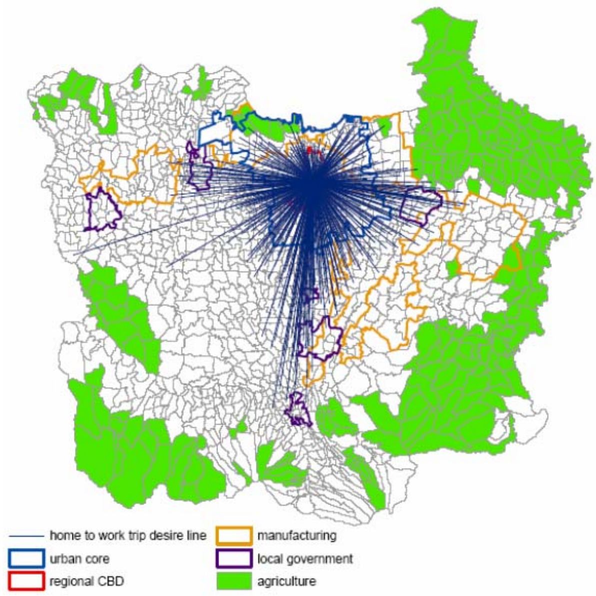

Fig. 10 Desirelines of commuting trips to CBD

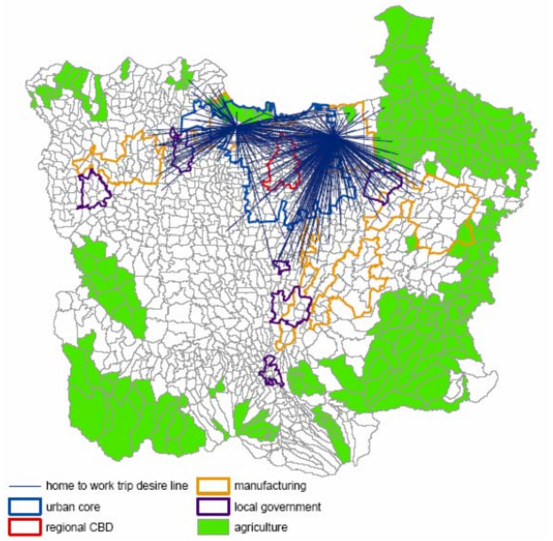

Fig. 11 Desirelines of commuting trips to Penjaringan-Kalideres and Tj. Priok-Cakung manufacturing corridors

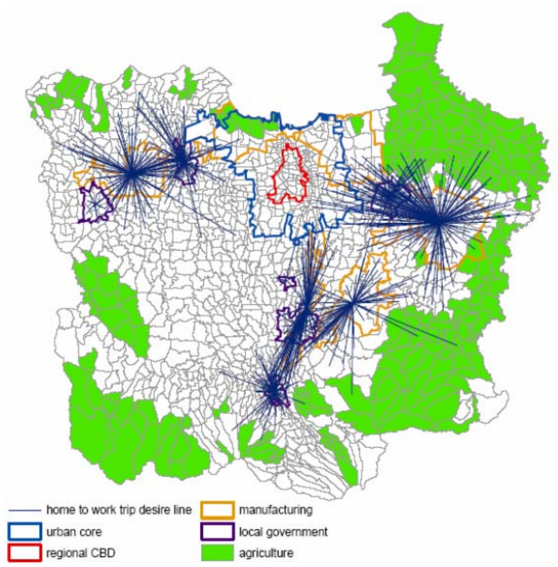

Fig. 12 Desirelines of commuting trips to centers outside urban core

IV. CONCLUSION

The combination of factor analysis and ESDA is quite promising in identifying clusters of employment for the case of the Southeast Asian EMR, as it allows identification of both urban and agricultural sectors at the same time and offers ease of delineation of clusters, which tend to be contiguous along trunk transport corridors radiating out of the urban core. The spatial structure in general does not seem to fit neatly to either monocentric or polycentric patterns as recognised in Western cities. The urban core of Jakarta and the CBD at its centre, are almost solely the zones of higher diversity of urban jobs in the JMA. Manufacturing forms the sprawl of employment corridors outside the urban core, while local government services (municipalities and regencies) have not been developed as subcenters (in terms of high job diversity) to the urban core and CBD. Rapid urban expansion during the pre-crisis period, mainly in the form of manufacturing and housing development, seems to have converted significant proportions of agricultural land, with small portions left particularly in the northeastern and eastern part of the JMA. These parts may represent a *desakota* feature of the Southeast Asian EMR, as suggested from results of spatial association analysis.

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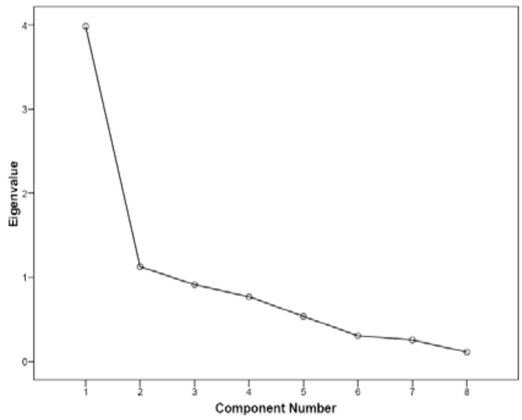
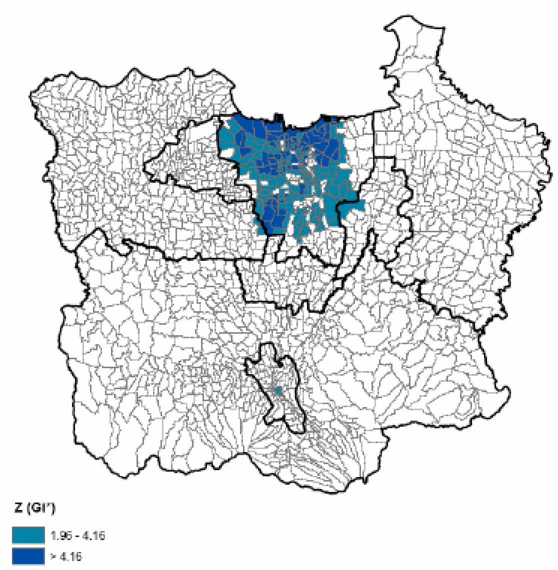
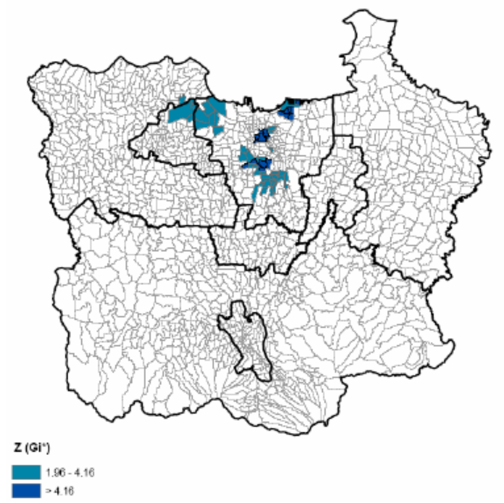
APPENDIX



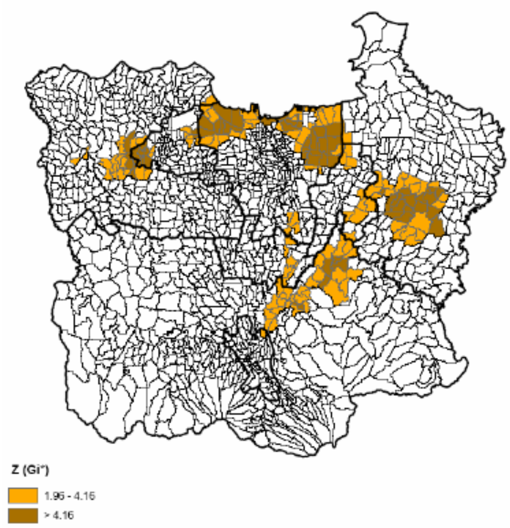
Screen plot of factor analysis



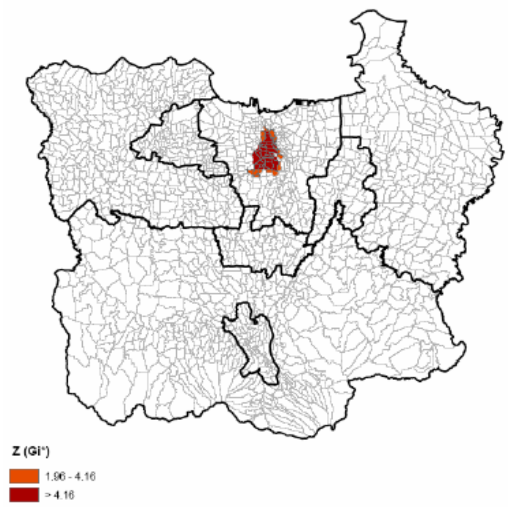
Hot-spots for Factor 1



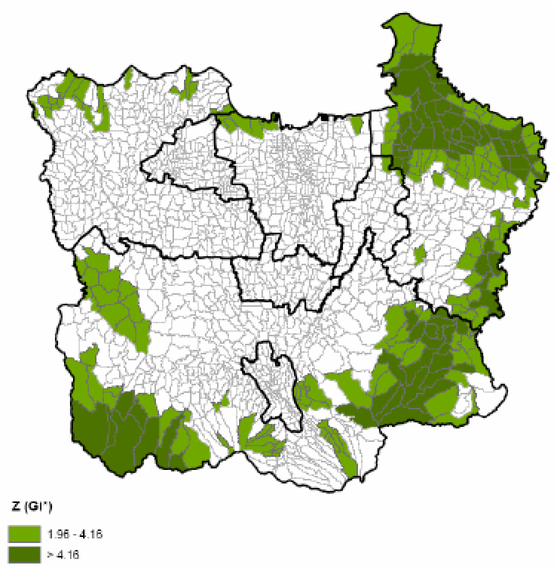
Hot-spots for Factor 2



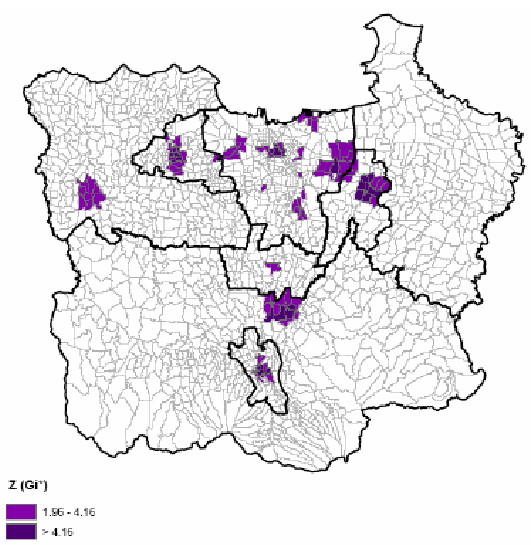
Hot-spots for Factor 3



Hot-spots for Factor 4



Hot-spots for Factor 5



Hot-spots for Factor 6