Spatial dispersion of Jobs in an African city: Evidence from Kampala

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Arti Grover Goswami and Somik V. Lall

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Abstract:

Research on urban spatial structure reveals that the location of jobs in a city may take various forms. Starting with the early monocentric structures to the modern urban form of polycentricism, cities in developed countries are increasingly de-concentrating. However, little is known about urban morphology in cities from developing countries. In this paper, we examine the pattern of spatial dispersion of employment in Kampala using census data from 2001 and 2011. Our analysis suggests that, one, employment in Kampala is increasingly in non-tradable services and this share has increased in the past decade; two, most jobs in Kampala are rather created by young and small establishments; three, the predictions of monocentric model in terms of a negatively sloped employment density gradient is followed only up to 3 kilometers of central business district (CBD). Beyond this radius, jobs in Kampala are spatially dispersed. Four, non-parametric estimations of the employment density in the city of Kampala suggests that although there are 5 distinct potential subcenters in each of the two census years, none of them appear to be significant centers of economic activity. Our findings have important implications for policy makers seeking to integrate people with jobs, such as those on investment in transit operations and that on land use regulations.

JEL Classification: R12, R13, R14, R3, R52

Key Words: jobs, urban, spatial, monocentric, polycentric, mixed land use

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I. Introduction

In response to differences in economic conditions, cities around the world have adopted varying forms of urban structures. Some cities such as Chicago, New York, Boston, in the US, Barcelona and Paris in Europe or Bogota in Columbia have evolved from a city with one central business district to a city with multiple centers of economic activity (e.g. Anas et al.,1998 and Clark, 2000). Contrarily, some smaller cities in the US such as Milwaukee in mid-west or Buffalo in up-state New York remain largely monocentric while others like South Florida, Dallas and Detroit have shown a pattern of urban development with dispersed employment (e.g., Lang, 2003; Gordon and Richardson, 1996). The literature on internal structure of cities suggests that the observed urban form of a city depends on centrifugal and centripetal forces of which the cost of commuting, population size, costs of congestion and the rate of spatial decay of production externalities seem the most relevant.[1] Most of the research on urban spatial structure of a city, however, focuses on cities in developed country. The purpose of this paper is to identify the spatial distribution of employment in the city of Kampala in Uganda.

Studies on urban spatial forms argue that decentralization is only normal and the declining role of central business districts is very much real in modern cities (e.g. Mills, 1972). For most cities around the world, it is observed that as they grow in size, the original monocentric structure of large metropolises tends to dissolve progressively into a polycentric structure. The central business district (CBD) loses its primacy, and the city transforms into a polycentric structure with clusters of activities spread within the built-up area (Bertaud, 2003). For instance, Kenworthy and Laube (1999) study cities across the world and find that the share of jobs in the CBD declined significantly from 25.4% in 1960 to 16.2% in 1990. However, this decline is not equally observed across all the cities in the world. The same study reveals that in Tokyo, in fact, the share of jobs in CBD increased by 2% during the same period. In the recent years, Angel and Blei (2015a) report that for the 50 largest metropolitan areas in the U.S. in the year 2000 the average share of jobs in the CBD was 10.8±3.1%. It varied from a maximum of 21% in Austin, Texas, and Las Vegas, Nevada, to a minimum of 4% in Los Angeles, California.

Research on urban spatial structure reveals that as CBDs de-concentrate, sub-centers emerge.[2] Based on the spatial organization of American cities, Angel and Blei (2015a) propose that besides the monocentric and polycentric models, there are three other theoretical forms of spatial organization of cities. (i) Maximum Disorder model, where workers' homes and their jobs are randomly distributed in the city. (ii) The Constrained Dispersal model, where a small number of sub-centers exist outside the CBD and attract workplaces to each other or to shared public infrastructure and amenities. In this form,

[1] See for example Fujita (1988), Lucas and Rossi-Hansberg (2002), Berliant et al. (2002), Berliant and Wang (2008), Fujita and Ogawa (1982) and Chatterjee and Eyigungor (2014).

[2] On average, each of the 50 largest American cities contained 8±2 subcenters. The average share of jobs located in these employment subcenters outside the CBD 13.8±2.0%, varying from a maximum of 34% in Los Angeles, California, to a minimum of 2% in Providence, Rhode Island (Angel and Blei, 2015a)

both workers and firms adjust their locations to remain within a tolerable commuting range of each other. (iii) The Mosaic of Live-Work Communities, where workers and firms are all within walking or bicycling distance of each other. According to this research most American cities follow the constrained dispersion model, given that there are significant subcenters and yet a large proportion of the employment is spread out throughout the city. Our paper seeks to answer how the configuration in an African city looks like and why so.

Cities in developed countries have presented different patterns of urban evolution. The evolution of a monocentric city can be traced back to the history of development of transportation routes. Prior to 1840s, most cities were tied to waterways such as harbors, rivers, and canals or railway networks. Locating closer to these terminals created accessibility advantages and favored the growth of a single manufacturing district. The high cost of intra-urban communication motivated concentration of manufacturing within CBD for cities such as New York.[3] Similarly, in late nineteenth-century, four-fifths of the Chicago's jobs were compactly located within four miles of State and Maddison streets.[4]

After the World War II, large scale construction of inter-state highways and the creation of suburban rail terminals reduced the cost of trucking and travel. These changes enabled manufacturing to switch out from CBD to the suburbs. Manufacturing in CBD was now increasingly replaced by service and office centers.[5] Cities such as Chicago, New York and Los Angeles have evolved from monocentric structures to polycentric spatial forms while smaller cities like Milwaukee in mid-west or Buffalo in up-state New York remain largely monocentric. Chicago started as a monocentric city way back in 1850s but had 9 subcenters in 1970. The number of subcenters in Chicago increased to 13 in 1980, 15 in 1990 and 32 in 2000 while more than 30 subcenters were identified in New York and Los Angeles in a 2003 study.[6]

However, little is known about the pattern of spatial development in cities from developing countries. This paper examines the pattern of employment in Kampala across various sectors, firm size and firm age. Additionally, our descriptive also cuts across the gender dimension in each case. Our analysis suggests that one, firms in Kampala are increasingly involved in non-tradable services and this share has increased in the past decade; two, most jobs in Kampala are rather created by young and small establishments. Finally, the 2001 census indicates that the participation of women is largely in non-tradable services while the 2011 census suggests that these are also the sectors with largest share of female owned establishments.

Next, we test the basic prediction on employment density of a monocentric model by fitting a linear regression of log of employment density on distance to the CBD. Our results here suggest that while employment density declines with increase in distance from the CBD, it has a reasonable R-square for only up to 3 kilometers and thereafter the R-square declines to below 0.08. This holds true for both across the two census years of Uganda Business Registry (UBR) data as well as for more sophisticated

[3] Chinitz (1960)
[4] Fales and Moses (1972)
[5] Being much older, European cities have evolved somewhat differently. Central parts of many of such cities are allocated to mixed use. Nevertheless, these cities have also witnessed massive suburbanization and the emergence of edge cities.
[6] McMillen and Lester (2003); McMillen and Smith (2003)

linear, and cubic splines fit of the monocentric model. These results suggest that whilst the CBD in Kampala is important, however, the city is not monocentric. Our findings indicate that there are pockets of dispersed employment in most parts of the city.

Next, we identify potential subcenters of employment in the city of Kampala using the geographically weighted regressions (GWR) suggested in McMillen (2001). The GWR technique basically produces a smooth function of the employment density by placing more weights on nearby observations. By definition, potential subcenters are cites with significantly higher employment density that neighboring sites. This regression identifies subcenters as clusters of sites with positive residuals. Using the contiguity matrix approach suggested in McMillen (2003), we identify 5 potential subcenters in Kampala in both the 2001 as well as 2011 over and above the CBD. However, given the concentration of employment in all subcenters is extremely low, we are inclined to believe that Kampala does not have any one pocket of economic activity besides the CBD. In fact, it appears that most land, besides the one occupied by firms in CBD, is being used for mixed purposes, that is, residential as well commercial.

Using the census of business establishment data from 2001 and 2011 our results show that Kampala has a very concentrated CBD contributing to 22.3% of total employment in 2001. However, as in the case of cities in the US, this contribution declined in the last decade to 17.6%. Further, the contribution of potential subcenters in Kampala's employment is below 2.5% in each of the census years. Individually, none of the potential subcenters have over 2500 employees in 2011 while potential employment centers in 2001 have a maximum of 1500 employees. These figures suggest that none of the potential sub-centers in Kampala are significant employment centers.

The evolution of urban morphology can be explained in terms of public policy, such as those on housing land use and transportation, or changes in the cost of commute through technological innovations in communications as well as economic restructuring that impact the agglomeration economies at different spatial scales. For instance, changes in economic structure may be such that the benefits of proximity decline so much that employment clusters become an increasingly less significant aspect of the urban landscape. Alternatively, the cost of commute may be such that workers choose to co-locate with firms to economize on these costs. In such cases, mixed land use pattern emerges. This paper opens up these issues and sets the stage for future course of research.

Urban spatial structure has profound implications for the efficiency of a city. An understanding of the urban morphology of a city is important to inform our ideas about what can and should be done—in terms of public plans and investments in transport infrastructure and in terms of regulatory reform—to improve their land use patterns and their transportation systems in the coming years. For instance, Angel and Blei (2015a) find that in American cities more than three quarters of the jobs are located outside the CBD and the subcenters. In such an situation, the continued productive edge of cities is largely dependent on the ready availability of public transit and private automobiles that allow workers to travel to work by car—usually beyond walking and biking range to reach the better paying, more productive jobs available to them in the metropolitan area. They suggest that policies that increase overall regional connectivity and those that permit speedier commuting, and for longer rather shorter commuting to take advantage of metropolitan wide economic opportunities would play a positive role in making the city productive. Policies that remove impediments to the locational mobility of residences and workplaces for all income groups need to be supported so that they can easily relocate to be within tolerable commute range of each other.[7]

The paper beyond this point is organized as follows: Section 2 describes the empirical strategy while section 4 discusses the data requirements for this study. Section 5 presents some descriptive data analysis and the results on potential employment subcenters identified for Kampala. Finally, the last section concludes with some policy suggestions and areas of future research

Section 2: Empirical Strategy

Sub-centers in the city can be identified, to begin with, using the McDonald and Prather (1994) approach which rests on the assumption of the city being monocentric. This approach mainly involves looking for clusters of significant positive residuals from a simple regression of the natural logarithm of employment density on distance from the CBD.

$$\ln(n_i) = \alpha + \beta_1 x_i + \varepsilon_i \qquad (1)$$

Where $ln(n_i)$ is the logged value of employment density of a village *i* and x_i is the distance of village *i* from the CBD. Linear and Cubic Splines are other attractive versions of the monocentric model which have been used in, say, Anderson (1982). In this approach, the distance variable, x, is split into intervals and a separate linear or cubic function is applied to each region. The function is constrained to be smooth at the boundaries between regions (which are known as "knots"). For example, in the empirical section of this paper distance from the CBD is divided into three intervals. The minimum value of distance from the CBD is x_0 the boundaries between regions are $x_1 = 3$, $x_2 = 6$ and $x_3 = 9$. Since the closest village to the CBD is only 200 meters away from CBD, we begin with $x_0 = 0$. A simple estimating equation for a linear spline model with one knot at 3 km is given as:

$$\ln(n_i) = \alpha + \beta_1 min(x_i, x_1) + \gamma_1 (x_i - x_1) * D_1 + \varepsilon_{i,3} \qquad (2)$$

Where $ln(n_i)$ is the logged value of employment density of a village *i*, D_k terms are dummy variables that equal one when $x_i \geq x_k$ and $\varepsilon_{i,1}$ is the stochastic error term. In the next version, this model is built to include 3 knots at $x_1 = 3$, $x_2 = 6$ and $x_3 = 9$ and the following linear spline equation is estimated.

$$\ln(n_i) = \alpha + \beta_1 min(x_i, x_1) + \gamma_1 min(x_i - x_1, x_1 - x_0) * D_1 + \gamma_2 min(x_i - x_2, x_2 - x_1) * D_2 + \gamma_3 (x_i - x_3) * D_3 + \varepsilon_{i,4} \qquad (3)$$

The interpretation of the coefficients is simple: β_1 is the slope coefficient for distance from CBD between 0 – 3 km; γ_1 is the slope coefficient for distance from CBD between 3 – 6 km and so on.

The estimating cubic spline equation with three knot is expressed as:

$$ln(n_i) = \alpha + \beta_1 min(x_i, x_1) + \beta_2 min(x_i, x_1)^2 + \beta_3 min(x_i, x_1)^3 + \gamma_1 min(x_i - x_1, x_1 - x_0)^3 * D_1 + \gamma_2 min(x_i - x_2, x_2 - x_1)^3 * D_2 + \gamma_3 (x_i - x_3)^3 * D_3 + \varepsilon_{i,6} \qquad (4)$$

[7] Angel and Blei (2015b)

Other alternatives for estimating a monocentric model include nonparametric estimators and semiparametric estimators such as that used by McMillen (1996), however, these far more difficult to use and have few advantages when nonlinearity is confined to a single variable.

Besides the method of examining the residuals from a monocentric model, Giuliano and Small (1991) suggest that subcenter can be identified by visual inspection of maps by defining a subcenter as a set of contiguous tracts each having a minimum employment density of 10 employees per acre and, together, having at least 10 000 employees. Their method have been adopted by Anderson and Bogart (2001), Bogart and Ferry (1999), Cervero and Wu (1997, 1998), Small and Song (1994) and in the first stage of the study by McMillen and McDonald (1998).

Other statistical procedures for identifying subcenters have been proposed by Craig and Ng (2001), Giuliano and Small (1991), McDonald (1987), and McMillen (2001). In these models, a reasonable value of employment density is chosen based on the local knowledge of the city. In general, the employment density required for sub-center status is likely to be higher in areas with higher overall density levels. Instead of relying on arbitrary cut-offs that requires local knowledge of an area, we use a non-parametric technique to identify sub-centers of employment in Kampala. Sub-centers are defined as areas with significantly higher employment density than neighboring sites.

McMillen (2001) non-parametric technique for identifying subcenters does away with such arbitrariness. He uses a geographically weighted regression (GWR) to detect potential sub-center sites. GWR places more weight on nearby observations when estimating a predicted value for the natural logarithm of employment density at a target site. The only explanatory variables needed for running a GWR are the geographical co-ordinates of the target sites. This procedure returns an estimate of the employment density at each site which can be used to identify the potential subcenters of a city. Sub-centers are those sites that have densities significantly greater than the initial smooth. Statistically, this implies that a site where: $\frac{n(x)-\hat{n}(x)}{\hat{\sigma}(x)} > c$ is a potential subcenter.

Where $\hat{n}(x)$ is the GWR estimate of employment density at site *x,* $\hat{\sigma}(x)$ is the estimated standard error for the prediction; and c is the critical value for a normal distribution. Critical values associated with 5 per cent, 10 per cent and 20 per cent significance levels are 1.96, 1.64 and 1.28. Clearly, the number of potential subcenter sites increase as c falls. Since we use data at a village level (rather than at the finest geographical scale used in McMillen, 2001, that is, enumeration area in Kampala would be comparable to a tract in a US city), we choose with a lower value of *c* of 1.28.

In McMillen (2001), the second-stage regression of employment density on distances from the city center and subcenter employment peaks identifies statistically significant local rises in employment density. Local peaks that are statistically significant may nonetheless have trivially small overall employment levels. Furthermore, the procedure does not provide a direct measure of the geographical area covered by a subcenter. A combination of the Giuliano and Small (1991) and McMillen (2001) approaches provides a potential solution to these problems. Giuliano and Small approach suggests that a subcenter is a group of contiguous tracts (or villages in our case) with significantly positive residuals, in which total employment exceeds a critical value.[8] The critical value for total employment again introduces an arbitrary element to the subcenter definition. However, the critical value for total employment is less arbitrary than Giuliano and Small's cut-off point for minimum employment density and is less likely to require variation across cities or within a metropolitan area. The McMillen approach has three advantages over the other approaches. First, it produces reasonable results even when the researcher is unfamiliar with the study area (for e.g. no minimum density cutoff is required). Second, it can be automated (e.g. does not require requires visual inspection of maps to identify clusters of positive residuals). Three, it does not generate a symmetric density function of employment and the estimated density gradients can vary by direction from the CBD. For example, estimated densities can decline more rapidly on the north side of a city than on the south side.

Once we identify the set of potential subcenters, we retain only those subcenters which have the highest predicted log-employment densities among all observations with significant positive residuals in a 2 km radius. For the subcenters identified in central Kampala, we group them together as part of CBD if they within a 3 km radius because activities around the CBD is considered a spin-off from CBD employment (McMillen, 2001).

Section 3: Data

The only data required for identifying subcenters are total employment for small tracts, tract area, and geographic coordinates. Employment by establishments and their geographical coordinates are extracted from the Uganda Business Registry in the 2001 and 2010 Census of Business Establishments (COBE). COBE is a nationwide census that the government of Uganda has taken three times since 2001. The 2001 wave of the census –UBR 2001 henceforth - covered nearly 163,321 business enterprises across the country of which 55,448 belong to Kampala. Comparatively, UBR 2010 covered about three times as many enterprises –at a little over 458,106 of which 1,33,663 belong to Kampala. These additional establishments in the recent census reflect not only the scale of net business formation since 2001, but they could also be accounted by the additional coverage of all commercial farms and micro agribusinesses in the 2011 census.[9]

For each enterprise in the registry, UBR provides information on the official name and identity of the enterprise, its exact location (in terms of GIS coordinates), description of its main activity in terms of a four digit International Standard Industrial Classification (ISIC) code, the number of persons engaged in the enterprise on the date of the census and the date that the enterprise started operating. Additionally, the 2001 census separately provides the count of male and female employees in each establishment while the latest census offers information on the gender of the owner of the establishment. For identification of subcenters, we aggregate the counts of employment in each village for the two

[8] As in McMillen (2003), the task was simplified by defining two sites as 'contiguous' if they are within 1.25 miles (or approximately, 2.1 km) of one another. By contrast, Mcmillen (2001) retains only those subcenters which have the highest predicted log-employment densities among all observations with significant positive residuals in a 3-mile radius.

[9] In contrast to other sectors, only formal businesses activities were covered for the agricultural sector in 2001 census of UBR. The 2011 UBR covered both formal and informal agricultural businesses for the agricultural sector.

available UBR censuses. We then calculate the centroid of each village using the 2012 population and housing census maps.[10]

Section 4: Spatial pattern of employment in Kampala

Some Descriptive Facts

We begin by slicing establishment level data in the city of Kampala by industry to map the changes in allocation of establishments, entrepreneurship and employment over the last decade. Table 1 presents the firm and employment count and their respective shares, the density of firms and employment for each aggregate industry, namely, agriculture, manufacturing and services. Within services, we present these figures for most disaggregate services sectors. For 2001, we additionally show the split in employment by gender while the 2011 census allows us to infer the distribution of establishments that have female owners.[11] Our results for 2001 (panel A) and 2011 (panel B) UBR suggest that services contribute to close to 85% of employment and 92% of firm count in both waves of UBR census, of which retail trade, repair services and hotels and restaurants together account for about half of services employment and 70% of services establishment count. Over the last decade, the share of firms and employment in such non-tradable, low value add services has only increased, albeit marginally. By contrast, the share of employment in dynamics tradable services has declined from 13% to 8% during the period 2001 to 2011 census. Finally, the 2001 census indicates that the participation of women is largely in services (and agriculture) and within this broad category they are mainly working in the non-tradable retail trade and repairs hotels and restaurants sector. In these sectors, the participation of women is larger vis-à-vis men. In 2011 census, the table suggests that these are also the sectors with largest share of women owned establishments.

Table 1A: Disaggregation by Industry, 2011

		Count			Share			
Sub County	sector	Employment	Establishment	Establishments with Female Owners	Employment	Establishment	Female owned Establishments	Average Distance to CBD
Aggregate		379257	133663	66283	100	100	49.6	4.1
Agriculture		3363	484	135	0.9	0.4	27.9	3.9
Manufacturing		50873	10255	4146	13.4	7.7	40.4	4
Services		325021	122924	62002	85.7	92	50.4	4.1
	Retail trade and repair	108403	68948	38787	33.4	56.1	56.3	4.2
	Hotels and restaurants	51201	17144	12029	15.8	13.9	70.2	4.2
	Other Personal and Private Services	28832	13024	5322	8.9	10.6	40.9	4.1
	Financial, Real Estate and Business Services	24834	3258	484	7.6	2.7	14.9	4.1
	Sale and Repair of Motor Vehicles	23198	6203	993	7.1	5	16.0	4.2
	Education and Health Services	21608	2963	1160	6.6	2.4	39.1	4.2
	Public Admin Services	19445	2862	907	6	2.3	31.7	4.1
	Wholesale trade and repair	19119	5880	1939	5.9	4.8	33.0	4.2
	Transport and Communications	15751	2112	348	4.8	1.7	16.5	4.1
	Electricity, Water Construction	12630	530	33	3.9	0.4	6.2	4.1

[10] We are grateful to UBOS for promptly providing us with the 2012 census EA layer maps in GIS format.
[11] These establishments may be co-owned by other owners who may be males.

Table 1B: Disaggregation by Industry, 2001

Sub County	sector	Count: Employment	Count: Establishment	Gender Composition of Employment: Females, %	Gender Composition of Employment: Males, %	Share: Employment	Share: Establishment	Average Distance to CBD
Aggregate		180325	55448	41	59	100	100	3.9
Agriculture		928	432	30	70	0.5	0.8	6.1
Manufacturing		28870	4171	24	76	16	7.5	4
Services		150527	50845	44	56	83.5	91.7	3.9
	Retail trade and repair	50797	30461	54	46	33.7	59.9	4.3
	Hotels and restaurants	21153	7585	73	27	14.1	14.9	4.2
	Financial, Real Estate and Business Services	19318	1431	27	73	12.8	2.8	2.9
	Education and Health Services	14003	1675	54	46	9.3	3.3	4
	Other Personal and Private Services	12036	4941	41	59	8	9.7	4
	Sale and Repair of Motor Vehicles	11455	2710	15	85	7.6	5.3	3.7
	Transport and Communications	7812	629	24	76	5.2	1.2	3
	Electricity, Construction	7313	139	12	88	4.9	0.3	3.4
	Wholesale trade and repair	5088	1204	28	72	3.4	2.4	3.8
	Public Admin Services	951	55	34	66	0.6	0.1	2.4
	Extraterritorial organizations and bodies	601	15	33	67	0.4	0	2.2

Next, table 2 presents the size distribution of establishment and employee counts at sub-county level in the city of Kampala. This table describes how the share of large and small establishments as well as their employment density has evolved over time within the context of a sub-county in Kampala. The table suggests that in the central sub-county that constitutes the CBD, in the 2001 UBR small firms (below 5 employees) and large firms (over 100 workers) contributed almost equally to employment though the share of small firms in total firm count stood at 85% while this figure for large firms was less than 0.5%. By contrast, the share of large firms in employment declined remarkably over the last decade and their contribution to employment stood at 10%. This decline came at the expense of rise in share of employment across all categories of firm sizes, including the micro firms. This pattern is observed across all sub-counties in Kampala except Makindye where the share of large firms in employment increased slightly and in the case of Nakawa where the shares have remained largely unchanged over the last decade. It is also worth noting that female participation in employment, as indicated in the 2001 census of UBR, it higher than those of male workers only for micro and small establishments. Similarly, the 2011 UBR census finds that female entrepreneurs are more likely to form a small and micro enterprise.

Table 2A: Disaggregation by Sub-county and Establishment Size, 2011

Sub County	Establishment Size	Count: Employment	Count: Establishment	Count: Establishments with Female Owners	Density: Employment	Density: Establishment	Share: Employment	Share: Establishment	Share: Female owned Establishments	Average Distance to CBD
CENTRAL	Aggregate	181115	50421	22497	2988	832	100	100	44.6	1.8
CENTRAL	Less than 5 workers	70599	43167	21123	4659	2849	39	85.6	48.9	1.8
CENTRAL	5-20 workers	50751	6023	1293	3349	397	28	11.9	21.5	1.8
CENTRAL	21-100 workers	40565	1171	77	2677	77	22.4	2.3	6.6	1.8
CENTRAL	Over 100 workers	19200	60	4	1267	4	10.6	0.1	6.7	1.8
KAWEMPE	Aggregate	41388	18054	9527	336	146	100	100	52.8	5
KAWEMPE	Less than 5 workers	27076	16827	9227	878	546	65.4	93.2	54.8	5
KAWEMPE	5-20 workers	9335	1126	286	303	37	22.6	6.2	25.4	5
KAWEMPE	21-100 workers	3814	94	10	124	3	9.2	0.5	10.6	5
KAWEMPE	Over 100 workers	1163	7	4	38	0	2.8	0	57.1	5
MAKINDYE	Aggregate	52026	21811	11054	296	124	100	100	50.7	3.9
MAKINDYE	Less than 5 workers	31836	20538	10747	724	467	61.2	94.2	52.3	3.9
MAKINDYE	5-20 workers	9418	1144	290	214	26	18.1	5.2	25.3	3.9
MAKINDYE	21-100 workers	4135	105	14	94	2	7.9	0.5	13.3	3.9
MAKINDYE	Over 100 workers	6637	24	3	151	1	12.8	0.1	12.5	3.9
NAKAWA	Aggregate	51988	17573	9592	254	86	100	100	54.6	6.8
NAKAWA	Less than 5 workers	25018	16361	9253	489	320	48.1	93.1	56.6	6.8
NAKAWA	5-20 workers	8372	1000	294	164	20	16.1	5.7	29.4	6.8
NAKAWA	21-100 workers	7103	172	42	139	3	13.7	1	24.4	6.8
NAKAWA	Over 100 workers	11495	40	3	225	1	22.1	0.2	7.5	6.8
RUBAGA	Aggregate	52740	25804	13613	352	172	100	100	52.8	3.3
RUBAGA	Less than 5 workers	36926	24456	13317	985	653	70	94.8	54.5	3.3
RUBAGA	5-20 workers	9946	1220	263	265	33	18.9	4.7	21.6	3.3
RUBAGA	21-100 workers	4925	123	31	131	3	9.3	0.5	25.2	3.3
RUBAGA	Over 100 workers	943	5	2	25	0	1.8	0	40.0	3.3

Table 2B: Disaggregation by Sub-county and Establishment Size, 2001

		Count		Gender Composition of Employment		Density		Share		Average
Sub County	Establishment Size	Employment	Establishment	Females, %	Males, %	Employment	Establishment	Employment	Establishment	Distance to CBD
CENTRAL	Aggregate	88609	19932	37	63	4393	1406	100	100	1.7
CENTRAL	Less than 5 workers	28859	17071	51	49	5730	3295	32.6	85.6	1.7
CENTRAL	5-20 workers	20458	2480	38	62	4121	529	23.1	12.4	1.6
CENTRAL	21-100 workers	12670	322	31	69	2103	53	14.3	1.6	1.6
CENTRAL	Over 100 workers	26622	59	23	77	5896	16	30	0.3	1.8
KAWEMPE	Aggregate	30858	10246	44	56	1262	517	100	100	5.1
KAWEMPE	Less than 5 workers	15918	9617	56	44	1718	1017	51.6	93.9	5.1
KAWEMPE	5-20 workers	4517	558	32	68	574	73	14.6	5.4	4.9
KAWEMPE	21-100 workers	2182	60	25	75	622	15	7.1	0.6	5.2
KAWEMPE	Over 100 workers	8241	11	32	68	4049	8	26.7	0.1	5.8
MAKINDYE	Aggregate	19782	8855	46	54	1520	665	100	100	3.5
MAKINDYE	Less than 5 workers	13375	8404	54	46	2065	1273	67.6	94.9	3.6
MAKINDYE	5-20 workers	3180	403	34	66	676	88	16.1	4.6	3.5
MAKINDYE	21-100 workers	1709	43	21	79	948	21	8.6	0.5	3.3
MAKINDYE	Over 100 workers	1518	5	26	74	8055	23	7.7	0.1	4.4
NAKAWA	Aggregate	20277	7068	42	58	836	407	100	100	6.8
NAKAWA	Less than 5 workers	9937	6702	60	40	1067	694	49	94.8	6.8
NAKAWA	5-20 workers	2398	263	37	63	288	34	11.8	3.7	6.8
NAKAWA	21-100 workers	3485	82	22	78	555	13	17.2	1.2	6.7
NAKAWA	Over 100 workers	4457	21	17	83	2581	12	22	0.3	6.5
RUBAGA	Aggregate	20799	9303	50	50	996	431	100	100	3.1
RUBAGA	Less than 5 workers	14017	8778	57	43	1289	793	67.4	94.4	3.3
RUBAGA	5-20 workers	3930	477	32	68	553	66	18.9	5.1	3
RUBAGA	21-100 workers	1536	42	27	73	669	20	7.4	0.5	2.5
RUBAGA	Over 100 workers	1316	6	66	34	2881	10	6.3	0.1	2.4

Table 3 presents the age distribution of establishment and employee counts at sub-county level in the city of Kampala. This table describes the share of new and old establishments as well as their employment density within the five sub-counties in Kampala. One point noteworthy here is that not many firms reported their start year in the 2001 wave of UBR census. Thus, it is hard to make a comparison of how young and old firms have evolved over time. In the 2011 census, we note the following: One, the share of firms with over 25 years of age is only marginal across all counties. Two, in the central sub-county of Kampala that comprises of the CBD firms are almost equally distributed across all age groups (except those with over 25 years of age), however, other sub-counties record a slightly higher share of young firms (0-3 years of age). Three, the share of female owned enterprises is slightly larger in the young firms, said differently, a large proportion of new entrepreneurs are owned by women.

Table 3A: Disaggregation by Sub-county and Establishment Age, 2011

		Count			Density		Share			
Sub County	Establishment Age	Employment	Establishment	Establishments with Female Owners	Employment	Establishment	Employment	Establishment	Female owned Establishments	Average Distance to CBD
CENTRAL	Aggregate	181115	50421	22497	2390	665	100	100	44.6	1.8
CENTRAL	Less than 4 years	30678	13960	7063	2025	921	16.9	27.7	50.6	1.8
CENTRAL	4-10 years	46591	17188	7957	3075	1134	25.7	34.1	46.3	1.8
CENTRAL	11-25 years	48344	13957	6679	3190	921	26.7	27.7	47.9	1.8
CENTRAL	Over 25 years	4873	649	289	322	43	2.7	1.3	44.5	1.8
CENTRAL	Unreported	50629	4667	509	3341	308	28	9.3	10.9	1.8
KAWEMPE	Aggregate	41388	18054	9527	269	117	100	100	52.8	5
KAWEMPE	Less than 4 years	12796	6883	3784	415	223	30.9	38.1	55.0	5
KAWEMPE	4-10 years	13967	5765	2925	453	187	33.7	31.9	50.7	5
KAWEMPE	11-25 years	12619	4991	2636	409	162	30.5	27.6	52.8	5
KAWEMPE	Over 25 years	1055	201	105	34	7	2.5	1.1	52.2	5
KAWEMPE	Unreported	951	214	77	31	7	2.3	1.2	36.0	5
MAKINDYE	Aggregate	52026	21811	11054	237	99	100	100	50.7	3.9
MAKINDYE	Less than 4 years	16211	9110	4765	369	207	31.2	41.8	52.3	3.9
MAKINDYE	4-10 years	17208	6520	3161	391	148	33.1	29.9	48.5	3.9
MAKINDYE	11-25 years	15320	5654	2916	348	129	29.4	25.9	51.6	3.9
MAKINDYE	Over 25 years	1389	182	91	32	4	2.7	0.8	50.0	3.9
MAKINDYE	Unreported	1898	345	121	43	8	3.6	1.6	35.1	3.9
NAKAWA	Aggregate	51988	17573	9592	203	69	100	100	54.6	6.8
NAKAWA	Less than 4 years	13596	7175	4059	266	140	26.2	40.8	56.6	6.8
NAKAWA	4-10 years	15991	5308	2786	312	104	30.8	30.2	52.5	6.8
NAKAWA	11-25 years	13391	4655	2568	262	91	25.8	26.5	55.2	6.8
NAKAWA	Over 25 years	1656	152	90	32	3	3.2	0.9	59.2	6.8
NAKAWA	Unreported	7354	283	89	144	6	14.1	1.6	31.4	6.8
RUBAGA	Aggregate	52740	25804	13613	281	138	100	100	52.8	3.3
RUBAGA	Less than 4 years	17893	10659	5904	477	284	33.9	41.3	55.4	3.3
RUBAGA	4-10 years	16603	7721	3875	443	206	31.5	29.9	50.2	3.3
RUBAGA	11-25 years	15285	6680	3512	408	178	29	25.9	52.6	3.3
RUBAGA	Over 25 years	1186	204	110	32	5	2.2	0.8	53.9	3.3
RUBAGA	Unreported	1773	540	212	47	14	3.4	2.1	39.3	3.3

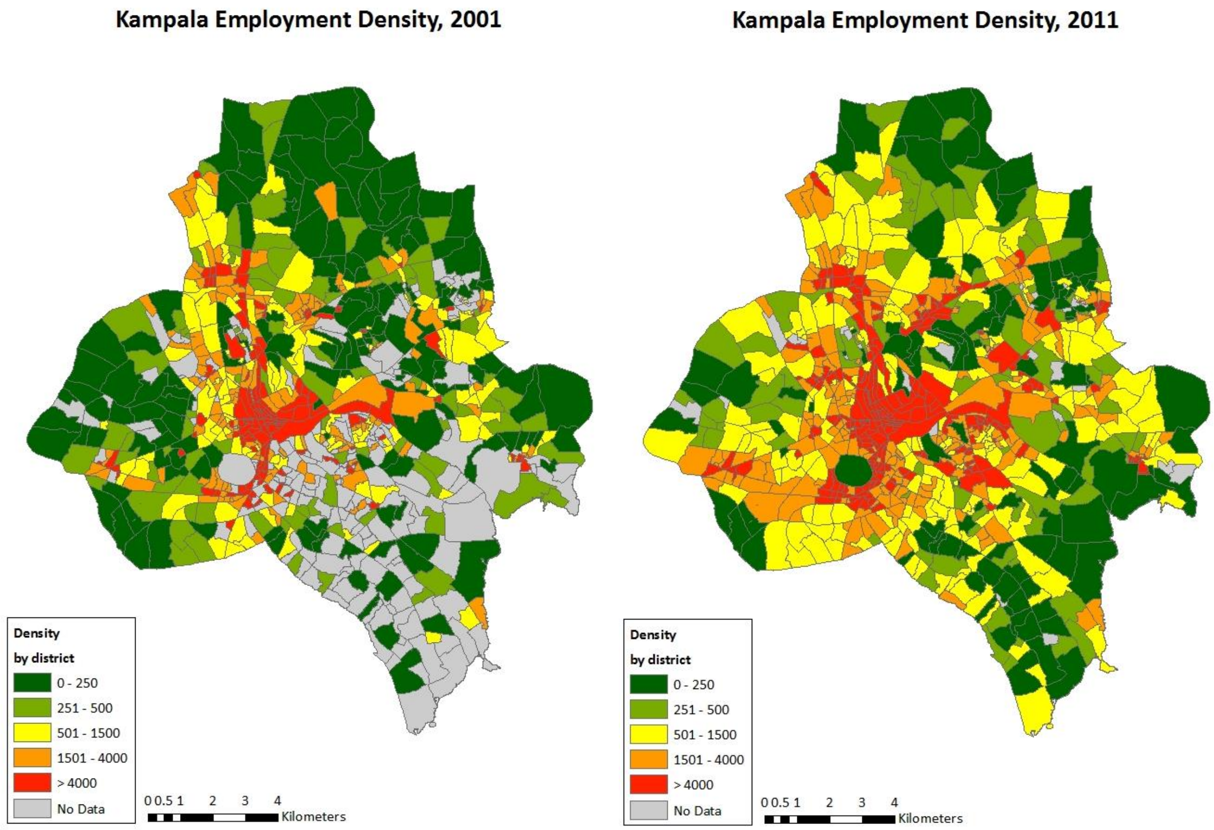
Table 3B: Disaggregation by Sub-county and Establishment Age, 2001

		Count		Gender Composition of Employment		Density		Share		Distance to CBD
Sub County	Establishment Age	Employment	Establishment	Females, %	Males, %	Employment	Establishment	Employment	Establishment	
CENTRAL	Aggregate	88609	19932	37	63	6226	1993	100	100	1.4
CENTRAL	Less than 4 years	2376	1071	48	52	2445	962	2.7	5.4	0.9
CENTRAL	4-10 years	4869	1361	36	64	2411	764	5.5	6.8	1.2
CENTRAL	11-25 years	980	138	34	66	973	143	1.1	0.7	1.2
CENTRAL	Over 25 years	147	19	21	79	428	53	0.2	0.1	0.5
CENTRAL	Unreported	80237	17343	36	64	9913	3172	90.6	87	1.7
KAWEMPE	Aggregate	30858	10246	44	56	798	327	100	100	5.2
KAWEMPE	Less than 4 years	4986	2043	47	53	508	223	16.2	19.9	5.3
KAWEMPE	4-10 years	4038	940	35	65	463	139	13.1	9.2	5.1
KAWEMPE	11-25 years	2198	301	41	59	362	70	7.1	2.9	5.3
KAWEMPE	Over 25 years	341	75	52	48	342	64	1.1	0.7	4.4
KAWEMPE	Unreported	19295	6887	46	54	1687	781	62.5	67.2	5.2
MAKINDYE	Aggregate	19782	8855	46	54	802	351	100	100	3.5
MAKINDYE	Less than 4 years	9440	5283	51	49	1479	814	47.7	59.7	3.6
MAKINDYE	4-10 years	4558	1609	40	60	688	258	23	18.2	3.6
MAKINDYE	11-25 years	1539	391	33	67	430	96	7.8	4.4	3.3
MAKINDYE	Over 25 years	276	61	21	79	143	32	1.4	0.7	3.2
MAKINDYE	Unreported	3969	1511	45	55	671	233	20.1	17.1	3.5
NAKAWA	Aggregate	20277	7068	42	58	476	232	100	100	6.9
NAKAWA	Less than 4 years	6613	3705	56	44	691	400	32.6	52.4	6.9
NAKAWA	4-10 years	4416	1212	38	62	310	126	21.8	17.1	6.9
NAKAWA	11-25 years	1089	296	39	61	162	66	5.4	4.2	6.9
NAKAWA	Over 25 years	912	35	16	84	472	31	4.5	0.5	6.5
NAKAWA	Unreported	7247	1820	34	66	584	279	35.7	25.7	7
RUBAGA	Aggregate	20799	9303	50	50	529	229	100	100	3.2
RUBAGA	Less than 4 years	9268	4866	52	48	810	412	44.6	52.3	3.3
RUBAGA	4-10 years	4286	1482	41	59	431	151	20.6	15.9	3.3
RUBAGA	11-25 years	1238	370	39	61	212	61	6	4	3
RUBAGA	Over 25 years	435	66	49	51	157	38	2.1	0.7	2.7
RUBAGA	Unreported	5572	2519	57	43	644	277	26.8	27.1	3.3

***Employment Distribution within the city*: Is Kampala Monocentric?**

We present the map of employment density for Kampala and here we see that it is mostly the villages in central region that show relatively higher employment density. There are very few villages outside the contiguous centrally located business district that have density higher than 4000 jobs per kilometer square in both the census years 2001 and 2011. The map suggests that Kampala has a very strong core of employment concentration but there are certain pockets with high job concentration. Moreover, the density of jobs does not seem to be falling monotonically with distance from the core. To test this more formally, we resort to standard monocentric model estimation.

Figure 1: Employment density Maps[12]



The monocentric model predicts that employment density declines smoothly as the distance from CBD increases. Further, increasing incomes and urban populations cause the slope of density gradient to be flatter over time (McMillen, 2006). One way to test the comparative-statics predictions of a monocentric model is to compare estimates for a single city over time or alternatively, we might compare estimates across cities at a given time if measures are available for income, commuting cost, population, and agricultural land values. Since it is more difficult to acquire data for a cross-section of cities than for a single city over time, the latter approach of comparing estimates across cities is far less common. We compare the gradient estimates of Kampala using six different specifications each for employment and firm density, defined as the employment per square kilometer and the number of firms per square kilometer respectively.

[12] A number of villages in the administrative boundaries map of 2012 population and housing census could not be found in the 2001 UBR data. This could be either because these villages indeed had no employment, or because there were certain changes in administrative boundaries, or names of villages from 2002 to 2012. In the latter case, we need to obtain a concordance between the two administrative units in the two census years.

In table 4 specification 1, we estimate the density gradient for Kampala using equation (1) for the 2011 UBR census. The slope gradient in 2011 suggests that with a 1 km decline in distance from CBD, the village employment density declines by 34% per square km. These estimates and the value of adjusted R-square are similar to those obtained by McDonald and Prather (1994) for Chicago in 1980 using 1196 urbanized tracts. Their estimates suggest that a 1 mile increase in distance decreased employment density by 13% per square mile (approximately 34% per square km). Another point worth noting here is that the average incomes of a household in Kampala has increased from 347,900 UGX in 2005-06 to 959,400 UGX in 2009-10 while that in Uganda increased from 70,800 to 303,700 UGX during the same period (UBOS, 2010). Similarly, the urban population (employment) in Kampala has increased from 1,189,142 (181,000) in 2002 to 1,516,210 (379,000) in 2012. Increases in income, decline in commute time and rise in urban population gradually lead to a decline in the density gradient (McMillen, 2006).[13] This is exactly what we observe in the case of Kampala where the density gradient in 2001 declined from -0.378 (see appendix table 1) to -0.341 in 2011 UBR census, although the decline is only marginal.

Model 2 shows the same regression as in model 1 but it includes only those villages that are located over 3 km of CBD. We note that although the density gradient is negative, distance from CBD has a very low explanatory power. Thus, beyond 3 km of CBD, the comparative static prediction of a monocentric model on a smooth declining density gradient does not seem to hold in the case of Kampala. This holds true for both the years of UBR data (see appendix table 1 for 2001 UBR estimation results). Our result is somewhat comparable with the results in McMillen (2006) for the case of Chicago where distance from the CBD no longer has much power in explaining the decline in floor area ratio gradient but this happens at a much higher cut-off of about 18 miles. Yet our results are different from

To explore this idea further, we estimate linear and cubic splines of employment density function. In the simple version of the linear spline model 3, we split the estimation of density gradient up to 3 km and the other section is beyond 3 km. We start with an estimating equation (2) for a linear spline with one knot at 3 km. This estimation results suggest that for the year 2011, the decline in density gradient is -0.91 in the range of within 3 km from CBD while it is merely -0.18 beyond 3 km from CBD, thus suggesting that most the decline in economic activity occurs within 3 km of CBD and beyond that distance there no significant centripetal or centrifugal force that agglomerates or de-concentrates activities.

[13] Comparing population density estimates for Baltimore, Milwaukee, Philadelphia, and Rochester for 1880–1963 Mills (1972) finds support for the argument that density gradient is flatter when cities have higher populations and incomes and lower commuting costs.

Table 4: Monocentric Model, 2011

	employment density, in logs						Firm density, in logs					
	All villages (1)	Villages over 3 km from CBD (2)	Linear Splines with one knot (All villages) (3)	Linear Splines, with 3 knots (All villages) (4)	Linear Splines, with 2 knot (for villages >3 km of CBD) (5)	Cubic Splines, with 3 knots (All villages) (6)	All villages (1)	Villages over 3 km from CBD (2)	Linear Splines with one knot (All villages) (3)	Linear Splines, with 3 knots (All villages) (4)	Linear Splines, with 2 knot (for villages >3 km of CBD) (5)	Cubic Splines, with 3 knots (All villages) (6)
distance_CBD	-0.341+++	-0.226+++					-0.303+++	-0.202+++				
	(0.023)	(0.036)					(0.024)	(0.037)				
min(x, 3)			-0.911+++	-0.924+++		-4.209+++			-0.846+++	-0.837+++		-6.347+++
			(0.075)	(0.082)		(1.049)			(0.083)	(0.091)		(1.133)
(x-3)*D(x>=3)			-0.180+++						-0.151+++			
			(0.032)						(0.033)			
min((x-3), 3)*D(x>=3)				-0.171+++	-0.308+++					-0.181+++	-0.349+++	
				(0.065)	(0.080)					(0.067)	(0.081)	
min((x-3), 3)*D(x>=6)				-0.118	-0.055					-0.020	0.058	
				(0.097)	(0.100)					(0.097)	(0.099)	
(x-9)*D(x>=9)				-1.791+++	-1.884+++					-2.125+++	-2.239+++	
				(0.564)	(0.569)					(0.616)	(0.623)	
$(\min(x, 3))^2$						1.669++						2.782+++
						(0.695)						(0.745)
$(\min(x, 3))^3$						-0.254+						-0.419+++
						(0.133)						(0.142)
$\min((x-3), 3)^3$*D(x>=3)						-0.032+++						-0.035+++
						(0.006)						(0.006)
$\min((x-3), 3)^3$*D(x>=6)						0.015						0.032+
						(0.016)						(0.016)
$(x-9)^3$*D(x>=9)						-0.062+++						-0.074+++
						(0.020)						(0.020)
Constant	8.766+++	8.088+++	9.970+++	9.987+++	8.424+++	11.700+++	7.656+++	7.066+++	8.800+++	8.790+++	7.677+++	11.676+++
	(0.108)	(0.204)	(0.177)	(0.183)	(0.368)	(0.442)	(0.118)	(0.210)	(0.202)	(0.208)	(0.375)	(0.475)
Observations	836	556	836	836	556	836	836	556	836	836	556	836
Adjusted R-squared	0.236	0.073	0.285	0.290	0.083	0.311	0.180	0.055	0.223	0.230	0.074	0.269

Notes: x refers to the distance from CBD, the knots are created at x1= 3, x2=6, x3=9

In the next specification, the linear spline model is extended to include 3 knots at $x_1 = 3$, $x_2 = 6$ and $x_3 = 9$ and the linear spline equation (3) is estimated. The interpretation of the coefficients is simple: β_1 is the slope coefficient for distance from CBD between 0 – 3 km; γ_1 is the slope coefficient for distance from CBD between 3 – 6 km and so on. Figure 2a presents a comparison of OLS estimates vis-à-vis linear splines and shows that although the OLS portrays a smooth decline in employment density as we move away from CBD, the splines show that the density gradient is much flatter beyond 3 km of CBD. Although, here again we notice the same trend. For instance, the 2011 UBR data, the decline in density gradient is -0.92 in the range of within 3 km from CBD while it is merely -0.17 between 3 -6 km from CBD. The slope coefficient between 6-9 km of CBD is not statistically significant at 10% level of significance while the coefficient for villages over 9 km of CBD stands low at -0.18. Thus, most economic activities de-concentrate within 0-3 km of CBD and employment in the rest of the city seems to be dispersing rather slowly.

The next specification model 5 estimates this equation but by considering only those villages that are over 3 km from CBD. Here, again we notice that R-square is very low and thus distance from CBD does not significantly explain the variation in employment density beyond 3 km of CBD. This result is mirrored in McMillen (2006) for the case of Chicago, however, in their case the cut-off distance is much higher. In their case, the R2 value of floor area ratio gradient is only 0.021 for a spline function with four equally spaced intervals from 15 miles from the CBD to the maximum value of 34 miles.

In the next model (specification 6) we estimate equation (4), the cubic spline equation with three knots at $x_1 = 3$, $x_2 = 6$ and $x_3 = 9$. The R2 value rises to 0.311 for the year 2011, and not all the coefficients for the additional explanatory variables are statistically significant. As in the linear spline case, the density gradient is not declining in a significant way between 6-9 km of CBD. Figure 2b presents a comparison of the fitted cubic spline with the fit of the OLS. The spline function's additional explanatory power comes from the sharp rise in employment density near the CBD.

Figure 2a: Linear fit versus linear splines

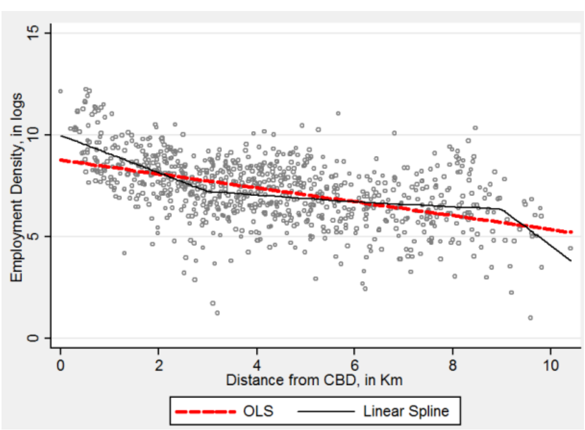
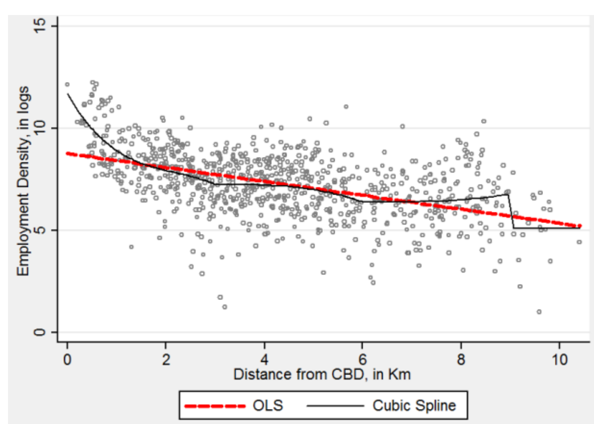


Figure 2b: Linear fit versus cubic splines



We make the further observations using results from tables 4 and appendix table 1. One, table 4 also presents the gradient estimates for firm density. The results on firm density are very much comparable to those on employment density. Two, the results across the two census years are very similar, both in terms of coefficient estimates of gradients as well as in terms of intercepts. This has happened in spite of rise in incomes and urban population of the city. What would be the explanation for obtaining almost identical results for the two censuses that are 10 years apart? Has the cost of commute and infrastructure system stagnated in the last 10 years? Has the composition of economic activity and employment remained unaltered in the past 10 years? Does this mean that the forces that motivate firms to agglomerate remained unchanged during the decade?

In sum, our results on employment density as well as firm density seem to suggest that Kampala has a very concentrated nucleus but the rest of the city is perhaps characterized by mixed land use. We believe this to the true because the monocentric model fails to explain the changes in the density gradient beyond 3 km of CBD. A caveat that needs to be noted here is that the monocentric model estimated here is not complete and there are deficiencies to fitting this sort of a simple model. For instance, evidence points to the static nature of the model when in fact the vintage effects manifested through age of buildings in a given village should be fundamental to explaining the density of employment (McDonald and Bowman, 1979; McDonald, 1979; Brueckner 1986; Anas 1978; Wheaton 1982). Given the lack of data on this variable, we next move to an alternative nom-parametric technique for identifying employment subcenters in a city.

Is Kampala Polycentric? A Non-parametric approach to subcenter identification

Identifying subcenters using Geographical Weighted Regression

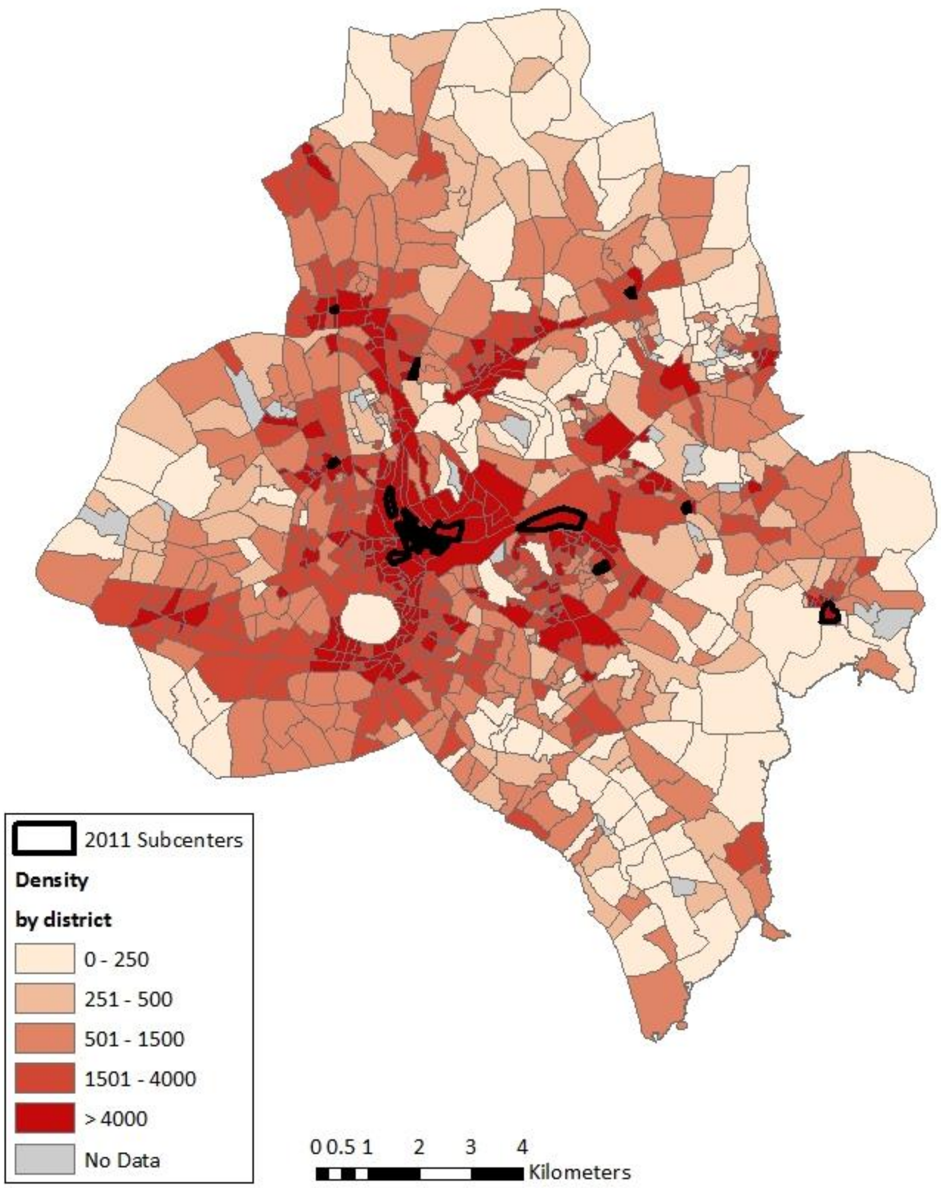
Using the monocentric model equation (1), McDonald and Prather (1994) suggest identification of subcenters as clusters of economic activity where the residual is higher than a given cut-off. Ranking the residuals by their size, we retain 27 subcenters in Kampala in the year 2011 UBR. Of these 27 potential subcenters, 18 belong to the central sub-county (and probably contiguous with the CBD) while the rest are in Nakawa and Kawampe. These sub-centers are listed in table 5.

Table 5: Subcenters identified using Monocentric Model, 2011

Sub-county	Parish	Village	distance CBD
CENTRAL	KAMWOKYA I	VILLAGE C	4.16
CENTRAL	KAMWOKYA II	MARKET AREA	3.94
CENTRAL	KISENYI II	MARKET VIEW	0.00
CENTRAL	NAKASERO III	NAKIVUBO ROAD	1.06
CENTRAL	NAKASERO IV	CITY HOUSE	0.70
CENTRAL	NAKASERO IV	HUSSEIN	0.78
CENTRAL	NAKASERO IV	KIYEMBE	0.47
CENTRAL	NAKASERO IV	NAKASERO MARKET	0.83
CENTRAL	NAKASERO IV	OWINO VIEW	0.35
CENTRAL	NAKASERO IV	SULTAN	0.50
CENTRAL	NAKASERO IV	UNIVERSAL	0.87
CENTRAL	NAKASERO IV	UTC	0.35
CENTRAL	NAKASERO IV	WILLIAM STREET	0.59
CENTRAL	NAKIVUBO-SHAURIYAKO	MUNNO A	0.72
CENTRAL	NAKIVUBO-SHAURIYAKO	REMAND A	0.71
CENTRAL	NAKIVUBO-SHAURIYAKO	SALOMPASI A	0.56
CENTRAL	NAKIVUBO-SHAURIYAKO	SHAURIYAKO A	0.51
CENTRAL	NAKIVUBO-SHAURIYAKO	SHAURIYAKO B	0.52
KAWEMPE	KAWEMPE II	SSEBAGGALA	8.08
KAWEMPE	MULAGO III	KALERWE	4.35
KAWEMPE	WANDEGEYA	KATALE	2.34
NAKAWA	BANDA	B 4	8.13
NAKAWA	BUGOLOBI	JAMBULA	5.67
NAKAWA	BUKOTO II	BBUYE CENTRAL	6.82
NAKAWA	KISWA	ZONE VI	5.27
NAKAWA	LUZIRA	KISENYI II	7.98
NAKAWA	LUZIRA	MAMBO BADDO	8.41

However, as noted earlier, a monocentric model is not very robust in identifying subcenters and hence the need to adopt a non-parametric method. Geographically weighted regression for the year 2011 identifies 27 subcenters shown in table 6.[14] These sub-centers are highlighted on the map of Kampala in figure 3.[15]

Figure 3: Subcenters identified using GWR, 2011



[14] GWR was estimated in the software GWR4 using an adaptive Gaussian type kernel. Although the subcenters are sensitive to the choice of bandwidth, cut-off significance level and the type of kernel chosen, we find that in most cases the subcenters identified outside of the central sub-county were consistently being drawn as sites of potentially higher employment density vis-à-vis neighboring sites. In the case finally selected, a cut-off of 1.28 is chosen (20% level of significance) to weed out non-significant potential subcenters.

[15] The subcenters identified for the 2001 UBR census data are marked in appendix figure 2.

In the case of cities in the US, such as Atlanta, Boston, New York, Chicago, and Philadelphia, McMillen (2003) defines two sites as 'contiguous' if they are within 1.25 miles of one another. Since Kampala is small relative to a city in the US, we define two villages as contiguous if they are within 1.25 km of each other. Appendix table 3 presents the contiguity matrix that tabulates the distance between each pair of the subcenters. This table suggests that all identified employment centers in the central sub-county are contiguous with each other and hence can be aggregated as a single CBD comprising of 21 villages. Contrarily, none of the identified potential sub-centers are contiguous with each other except the ones identified in Nakawa sub-county. Next we turn to subcenter characteristics to check the hypothesis that Kampala has multiple subcenters of employment.

Table 6: Subcenters identified using Geographical Weighted Regressions, 2011

Sub-county	Parish	Village	distance_CBD
CENTRAL	KISENYI II	MARKET VIEW	0.0
CENTRAL	NAKASERO I	KATONGA ROAD	2.0
CENTRAL	NAKASERO III	NAKIVUBO ROAD	1.1
CENTRAL	NAKASERO IV	CITY HOUSE	0.7
CENTRAL	NAKASERO IV	HUSSEIN	0.8
CENTRAL	NAKASERO IV	KIYEMBE	0.5
CENTRAL	NAKASERO IV	LUWUM STREET	0.9
CENTRAL	NAKASERO IV	NAKASERO MARKET	0.8
CENTRAL	NAKASERO IV	OWINO VIEW	0.3
CENTRAL	NAKASERO IV	SULTAN	0.5
CENTRAL	NAKASERO IV	TEMPLE	0.6
CENTRAL	NAKASERO IV	UNIVERSAL	0.9
CENTRAL	NAKASERO IV	UTC	0.4
CENTRAL	NAKASERO IV	WILLIAM STREET	0.6
CENTRAL	NAKIVUBO-SHAURIYAKO	MUNNO A	0.7
CENTRAL	NAKIVUBO-SHAURIYAKO	REMAND A	0.7
CENTRAL	NAKIVUBO-SHAURIYAKO	REMAND B	0.8
CENTRAL	NAKIVUBO-SHAURIYAKO	SALOMPASI A	0.6
CENTRAL	NAKIVUBO-SHAURIYAKO	SALOMPASI B	0.7
CENTRAL	NAKIVUBO-SHAURIYAKO	SHAURIYAKO A	0.5
CENTRAL	NAKIVUBO-SHAURIYAKO	SHAURIYAKO B	0.5
KAWEMPE	BWAISE II	KATALE	4.9
KAWEMPE	WANDEGEYA	KATALE	2.3
NAKAWA	BUGOLOBI	JAMBULA	5.7
NAKAWA	KISWA	ZONE VI	5.3
NAKAWA	LUZIRA	MAMBI BBADO	8.5
RUBAGA	NDEEBA	KASUMBA ZONE	1.9

Subcenter characteristics

The potential subcenters identified through the non-parametric approach within the central sub-county are contiguous and hence they are treated together as part of the CBD. Table 7 presents the aggregate contribution of CBD, potential employment subcenters and the remaining villages in the city of Kampala towards employment and firm share as well as their density in employment and firms. Panel A in this table present these results for 2011 UBR while panel B does the same for 2001 census (where potential subcenters are independently identified using GWR for the year 2001). The share of CBD in total employment seems to have declined from 22% to 18% while that in firms count has declined from 23% to 21%. The share of CBD in total employment is similar to that witnessed by large cities around the world during 1970s. For instance, Kenworthy and Laube (1999) find that the share of jobs in CBD in a sample of US cities declined from 25.4% in 1960 to nearly 22% in 1970; and again declined to 18% in 1980. Finally, the study reveals that this share has declined to 16.2% in 1990. Recently, Angel and Blei

(2015a) report that the average share of jobs located in the CBD for the 50 largest metropolitan areas in the U.S. in the year 2000 was 10.8±3.1%.

Table 7A: Contribution by regions within a city, 2011

	Aggregates			density		Share in		
regions	Total Employment	Firm Count	Area	Employment	Firm	Total Employment	Firm Count	Area
CBD	57501	27133	0.698	82404	38884	17.6	20.9	0.39
Potential Subcenters	7959	2641	0.232	34279	11375	2.4	2	0.13
Others	261809	99907	177.193	1478	564	80	77	99.5

Table 7B: Contribution by regions within a city, 2001

	Aggregates					density		Share in				
regions	Total Employment	Firm Count	Female Employment	Male Employment	Area	Employment	Firm	Total Employment	Firm Count	Female Employment	Male Employment	Area
CBD	40243	12720	17076	23167	0.9	44727	14137	22.3	22.9	23.1	21.8	0.51
Potential Subcenters	4465	1236	1527	2938	0.191	23402	6478	2.5	2.2	2.1	2.8	0.11
Others	135617	41493	55370	80247	177.033	766	234	75.2	74.8	74.9	75.5	99.4

In contrast to large American cities where employment subcenters contribute to about 15% of employment in 2000, the contribution of Kampala's subcenters to employment and establishments are abysmally small. It is not even clear if they deserve to be called subcenters because although the employment density in these villages is extremely high (higher than those in US cities) but the total contribution to employment and firms is very low.[16] Potential subcenters in Kampala contribute about 2% in employment and establishment count. The rest of the employment in Kampala, about 80% in 2011, is rather dispersed all across the city. This confirms our initial finding using monocentric model that Kampala is characterized by mixed land use pattern.

Evaluating the contribution of CBD and potential subcenters by sectors in table 8 panel A for the year 2011, we note that CBD contributes less to manufacturing employment vis-à-vis their contribution in services. Kampala's CBD accounts for 11% of manufacturing jobs while the central district contributes to about 18.5% of services employment. This was, however, not the case in 2001. Panel B of table 8 shows that in 2001 CBD contributed to about 27% of manufacturing employment while it accounted for 22% of services employment.[17] Thus, the contribution of CBD has declined remarkably in the last decade. By contrast, potential subcenters account for only about 2.5% of employment in each manufacturing and services sectors. The decrease in jobs share of CBD over the last decade has dispersed throughout the city rather than being apportioned to employment subcenters of Kampala.

In table 8, panels A and B clearly show that there is a marked difference between the average employment and firm density in CBD and potential subcenters on one hand and the remaining villages on the other. For instance, in 2011 the employment density in services sector in the potential

[16] Employment density is high in subcenters because the village area under consideration is very small. This is in line with the findings of Angel and Blei (2015a) who report that the average area of subcenters in American cities was 12.80±.260 km. By contrast, the average size of a village subcenter in Kampala is only 0.23 km square while that of CBD is only 0.70 km square.

[17] In terms of firm count, in 2011 CBD housed about 28% of manufacturing firms while 20.5% of services firms are located in CBD. This figure was slightly lower for manufacturing but higher for services, suggesting that smaller sized manufacturing firms are locating in CBD.

subcenters is about 24 times larger than those in the remainder villages (panel A of table 8). This ratio is 18 for the manufacturing sector. Similarly, in 2001 (see panel B) the average employment density in potential subcenters is 30 times larger vis-à-vis the remaining villages in the case of services sector firms.

Table 8A: Contribution by sectors and regions within a city, 2011

sector	regions	Employment	Firm Count	Area	Employment	Firm	Employment	Firm Count	Area
Agriculture	CBD	30	9	0.226	133	40	2.3	2.8	0.478
Agriculture	Others	1277	308	47	27	7	97.7	97.2	99.522
Manufacturing	CBD	3716	2706	0.614	6052	4407	10.8	27.6	0.418
Manufacturing	Potential Subcenters	864	100	0.232	3721	431	2.5	1	0.158
Manufacturing	Others	29830	7008	146	204	48	86.7	71.4	99.424
Services	CBD	53755	24418	0.698	77036	34993	18.4	20.4	0.393
Services	Potential Subcenters	7095	2541	0.232	30558	10944	2.4	2.1	0.131
Services	Others	230702	92591	177	1306	524	79.1	77.4	99.476

Note: The area of all villages that have employment in a given sector is aggregated to get the total area devoted to the sector.

Table 8B: Contribution by sectors and regions within a city, 2001

		Aggregates					density		Share in				
sector	regions	Employment	Firm Count	Female Employment	Male Employment	Area	Employment	Firm	Employment	Firm Count	Female Employment	Male Employment	Area
Agriculture	CBD	3	1	1	2	0.034	87	29	0.3	0.2	0.4	0.3	0.3
Agriculture	Others	925	431	275	650	10.118	91	43	99.7	99.8	99.6	99.7	99.7
Manufacturing	CBD	7754	1026	2383	5371	0.9	8618	1140	26.9	24.6	35	24.3	0.9
Manufacturing	Potential Subcenters	713	96	184	529	0.191	3737	503	2.5	2.3	2.7	2.4	0.2
Manufacturing	Others	20403	3049	4245	16158	94.096	217	32	70.7	73.1	62.3	73.3	98.9
Services	CBD	32486	11693	14692	17794	0.9	36106	12996	21.6	23	22	21.3	0.5
Services	Potential Subcenters	3752	1140	1343	2409	0.191	19665	5975	2.5	2.2	2	2.9	0.1
Services	Others	114289	38012	50850	63439	176.259	648	216	75.9	74.8	76	75.8	99.4

Table 9 provides a few characteristics of the identified potential subcenters of employment in Kampala. Total employment in a given subcenter has been most often used in studies such as McMillen and Smith (2003), McMillen (2003) and so on to eliminate centers of non-significant employment.[18] Depending on a city and a subcenter location, in most cases a cut-off of 10,000 or 20,000 employees is chosen for cities in the US. In the case of Mexico City, however, Aguilar and Alvarado (2004) applied a minimum cut-off of 5000 jobs and identified 35 subcenters in the city. For Kampala, we believe that the minimum cut-off should be lower than 5,000 given the general income and employment pattern vis-à-vis a city in Latin America. We adopt a conservative approach so as to retain most centers of employment and keep this cut-off at 750 jobs. Thus, the only center that we eliminate using this cut-off is the Katale village located in Kawempe sub-county and Bwaise II parish.

[18] Also see Giuliano and Small (1991), Small and Song (1994), Bogart and Ferry (1999), Anderson and Bogart (2001), Giuliano et al. (2007).

Table 9: Contribution by specific identified subcenters using GWR, 2011

	Aggregates			density		Share in			Average
Employment Centers	Total Employment	Firm Count	Area	Employment	Firm	Total Employment	Firm Count	Area	distance to CBD
CENTRAL KISENYI II MARKET VIEW	9563	7106	0.052	185,583	137,901	2.9	5.5	0.029	0
CENTRAL NAKASERO I KATONGA ROAD	2662	8	0.084	31,766	95	0.8	0	0.047	2
CENTRAL NAKASERO III NAKIVUBO ROAD	3858	1876	0.064	60,703	29,517	1.2	1.4	0.036	1.1
CENTRAL NAKASERO IV CITY HOUSE	1086	461	0.012	88,936	37,753	0.3	0.4	0.007	0.7
CENTRAL NAKASERO IV HUSSEIN	1305	559	0.018	72,929	31,239	0.4	0.4	0.01	0.8
CENTRAL NAKASERO IV KIYEMBE	1763	1028	0.022	79,790	46,525	0.5	0.8	0.012	0.5
CENTRAL NAKASERO IV LUWUM STREET	1295	449	0.025	51,471	17,846	0.4	0.3	0.014	0.9
CENTRAL NAKASERO IV NAKASERO MARKET	1127	475	0.013	83,530	35,206	0.3	0.4	0.008	0.8
CENTRAL NAKASERO IV OWINO VIEW	4223	2019	0.058	72,373	34,601	1.3	1.6	0.033	0.3
CENTRAL NAKASERO IV SULTAN	4002	2142	0.034	116,513	62,361	1.2	1.7	0.019	0.5
CENTRAL NAKASERO IV TEMPLE	2395	770	0.071	33,946	10,914	0.7	0.6	0.04	0.6
CENTRAL NAKASERO IV UNIVERSAL	1692	508	0.017	97,502	29,274	0.5	0.4	0.01	0.9
CENTRAL NAKASERO IV UTC	2349	1083	0.034	69,058	31,839	0.7	0.8	0.019	0.4
CENTRAL NAKASERO IV WILLIAM STREET	3479	1423	0.018	192,199	78,614	1.1	1.1	0.01	0.6
CENTRAL NAKIVUBO-SHAURIYAKO MUNNO A	1941	531	0.024	82,081	22,455	0.6	0.4	0.013	0.7
CENTRAL NAKIVUBO-SHAURIYAKO REMAND A	1996	809	0.029	67,901	27,521	0.6	0.6	0.017	0.7
CENTRAL NAKIVUBO-SHAURIYAKO REMAND B	1261	448	0.031	40,538	14,402	0.4	0.3	0.017	0.8
CENTRAL NAKIVUBO-SHAURIYAKO SALOMPASI A	2048	1072	0.014	149,675	78,346	0.6	0.8	0.008	0.6
CENTRAL NAKIVUBO-SHAURIYAKO SALOMPASI B	1433	486	0.024	60,279	20,443	0.4	0.4	0.013	0.7
CENTRAL NAKIVUBO-SHAURIYAKO SHAURIYAKO A	3564	1719	0.032	111,215	53,642	1.1	1.3	0.018	0.5
CENTRAL NAKIVUBO-SHAURIYAKO SHAURIYAKO B	4459	2161	0.022	205,678	99,679	1.4	1.7	0.012	0.5
KAWEMPE BWAISE II KATALE	221	145	0.006	34,559	22,674	0.1	0.1	0.004	4.9
KAWEMPE WANDEGEYA KATALE	1934	728	0.054	35,860	13,498	0.6	0.6	0.03	2.3
NAKAWA BUGOLOBI JAMBULA	830	418	0.013	63,761	32,111	0.3	0.3	0.007	5.7
NAKAWA KISWA ZONE VI	2381	79	0.084	28,337	940	0.7	0.1	0.047	5.3
NAKAWA LUZIRA MAMBI BBADO	791	43	0.026	30,739	1,671	0.2	0	0.014	8.5
RUBAGA NDEEBA KASUMBA ZONE	1802	1228	0.049	36,713	25,019	0.6	0.9	0.028	1.9
Others	261809	99907	177.193	1,478	564	80	77	99.478	4.4

Section 5: Conclusions and way forward

Our analysis on the city of Kampala in Uganda using the census of business establishment data for the years 2001 and 2011 suggests that Kampala has a very concentrated nucleus of economic activity. However, the comparative static predictions on declining employment density for a monocentric model is obeyed only up to 3 km. There does not appear to be any other significant peaks in employment density gradient beyond the city center. The preliminary analysis of a monocentric model suggests that employment in Kampala is spatially dispersed. Next, we carry a more robust non-parametric estimation of subcenters in the city. Our results indicate that although there are 5 potential subcenters in each of the census years, none of these subcenters are significant centers of economic activity. In sum, our results on employment density as well as firm density seem to suggest that Kampala has a very concentrated nucleus but the rest of the city is characterized by mixed land use.

Agglomeration theories contend that firms cluster spatially because agglomeration generates positive externalities. Firms gain from spatial clustering due to the ease of communication, increased knowledge sharing and spillovers, increased scale of markets, access to human capital and other inputs and outputs, and from sharing a common urban infrastructure.[19] The fact that employment in Kampala is dispersed

[19] Duranton and Puga (2004) summarize the gains from agglomeration in terms of sharing, matching, and learning effects. Sharing effects include the gains from a greater variety of inputs and industrial specialization, the common use of local indivisible goods and facilities, and the pooling of risk; matching effects correspond to improvement of either the quality or the quantity of matches between firms and workers; learning effects involve the generation,
diffusion, and accumulation of knowledge. Agglomeration economies explain the existence of cities. This is particularly important given the growing evidence about the importance of such agglomeration economies. For a more recent survey on the evidence on agglomeration economies, see Combes and Gobillon (2015). For a more detailed exposition of the implications

across the city rather than concentrated among significant subcenters speaks about the extent of production externalities operating in the city.

Knowledge of the spatial structure of employment in a city is critical for several reasons. One, the type of urban structure often defines the most efficient mode of transport. Specifically, the centers of residence and the spread of location of firms within a city and the residential and business density have a direct impact on trip length, on the feasibility of transit or private cars being the dominant mode of transport , and finally on pollution (Angel and Blei, 2015a). For instance, a dominantly polycentric structure has limited motivation for investment in transit operation because there is a multiplicity of routes and a few riders. In a city with mixed land use workers co-locate with firms and thus there is much less demand for a transit system in any case. Contrarily, a monocentric city where most trips have multiple origins but a unique destination in the form of a CBD offers an opportunity to build an efficient transit system. Similarly, urban form has significant implications for environment issues. For example, the extent of air pollution generated by urban transport depends on the length, speed and number of motorized trips and the type of vehicles. These variables are directly dependent on the urban spatial structure.

Recent works show that businesses, land and employment should be more concentrated in the optimal allocation relative to their equilibrium structure (Rossi-Hansberg, 2004). In equilibrium, the higher is the commuting costs, the greater is the presence of mixed areas in the city. This is because higher commuting costs force workers and producers to co-locate and economize on such costs. In the optimum allocation, however, land use turn out to be more specialized and mixed areas disappear. Even for a reasonably high commuting cost, optimal allocation results in a Mills city with a central business center surrounded by residential areas. Even though mixed areas emerge in equilibrium, they never form an optimal outcome. An important implication of this model is that a decline in the cost of commute brings the equilibrium allocation closer to the optimal one through, (i) a direct reduction in workers costs per mile commuted and (ii) an indirect effect via the concentration of business areas. Policies to bring workers closer to job, such as those on road construction and improving public transportation should also consider this latter indirect additional gain in their cost-benefit analysis.

In the presence of externalities, equilibrium urban form generated by profit maximizing firms and utility maximizing workers may not be the most efficient spatial structure. What can policy makers do to bring make the equilibrium allocation of land use more efficient? A government subsidy that lowers the labor costs for firms, motivates them to hire more workers would and has a positive impact on wages and rents (Rossi-Hansberg, 2004).[20] In response to increases in rents, workers move out of prime locations, thereby making equilibrium allocation an optimum one. Other policies that have similar effect include

of introducing agglomeration economies in a monocentric city model, see Duranton and Puga (2014) and Behrens and Robert-Nicoud (2015).

[20] We find similar suggestions in Kyriakopoulou and Xepapadeas (2013) as well.

such as those on parking lots construction, highway investments which reduce the costs of working at business centers, and thus actually subsidizes workers in these areas.[21]

How do we advance the policy front following this experiment? This study sets the stage for further research on the determinants of spatial location of employment in Kampala. In the follow-up study, we intend to formally test the predications of Lucas and Rossi-Hansberg theory on the internal structure of cities. . As in the Fujita and Ogawa (1982) model, Lucas and Rossi-Hansberg argue that the distribution of business and residential land, wages, and land rents, are the result of the trade-off between spatial production externalities and commuting costs. Their main results can be summarized as below:

1. With any decay parameter on production externalities, a CBD bordered with residential land use emerges if the cost of commute is extremely low (consistent with Lucas, 2001; Fujita and Ogawa 1982). The intuition for this result is that higher cost of commute, people want to live close to their places of work to economize on these costs, thus mixed use pattern appears. Secondly, as the rate of spatial decay of production externalities increases, the size of the business center shrinks.
2. When commuting cost is larger, mixed use is bordered by business use which in turn is surrounded by residential use. Again, as the rate of decay increases, the size of the purely business district shrinks.
3. When the cost of commute is extremely large, mixed use prevails in the entire city if the rate of decay is small. In the case the rate of decay is large, there are spikes of business areas and residential area at the city edge.

In the context of this model, we hope to examine if commute costs significantly distort the agglomeration of economic activity in Kampala. If commute cost is indeed a significant determinant of urban form, policy makers need to think about ways to help workers commute to areas that have higher potential for jobs. For example, the main form of public transport in Kampala is bicycle taxi or motorbike taxi. This sort of public transport is not efficient in carrying a large number of workers for a long distance travel to work.

Two, it is also possible that some land use regulations prevent firms from agglomerating in sub-centers. Spatial planning policy should help firms and workers in choosing optimal location, especially at the local level. There is evidence that zoning laws that exist for firms prove not to have functioned as such. What reforms can help Africa on this front?

Finally, our study also motivates us to think about the factors that prevents firm from agglomerating in business centers in Kampala. Given the extremely large share of non-tradable services in the city employment mix, we need to evaluate the spatial scales at which production externalities work in Kampala. We also need to think of innovative policies for transforming the city structurally from non-tradable services to more dynamic services and manufacturing sectors that can take advantage of inherent tendency for agglomeration in these sectors.

[21] Studies that evaluate the cost of congestion and the policies for reducing such costs include - Anas and Xu (1999); Wheaton (1998). Such policies may have similar effects.

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Annex

Table A.1: Monocentric Model, 2001

	employment density, in logs						Firm density, in logs					
	All villages (1)	Villages over 3 km from CBD (2)	Linear Splines with one knot (All villages) (3)	Linear Splines, with 3 knots (All villages) (4)	Linear Splines, with 2 knot (for villages >3 km of CBD) (5)	Cubic Splines, with 3 knots (All villages) (6)	All villages (1)	Villages over 3 km from CBD (2)	Linear Splines with one knot (All villages) (3)	Linear Splines, with 3 knots (All villages) (4)	Linear Splines, with 2 knot (for villages >3 km of CBD) (5)	Cubic Splines, with 3 knots (All villages) (6)
distance_CBD	-0.378+++	-0.269+++					-0.284+++	-0.223+++				
	(0.028)	(0.047)					(0.028)	(0.046)				
min(x, 3)			-0.892+++	-0.902+++		-2.800++			-0.693+++	-0.711+++		-4.788+++
			(0.089)	(0.096)		(1.418)			(0.095)	(0.103)		(1.524)
(x-3)*D(x>=3)			-0.223+++						-0.160+++			
			(0.042)						(0.042)			
min((x-3), 3)*D(x>=3)				-0.220+++	-0.358+++					-0.145+	-0.329+++	
				(0.082)	(0.096)					(0.081)	(0.096)	
min((x-3), 3)*D(x>=6)				-0.145	-0.083					-0.088	-0.006	
				(0.127)	(0.130)					(0.120)	(0.122)	
(x-9)*D(x>=9)				-2.192++	-2.280++					-2.385+++	-2.503+++	
				(1.051)	(1.067)					(0.756)	(0.768)	
$(min(x, 3))^2$						0.975						1.967++
						(0.934)						(0.995)
$(min(x, 3))^3$						-0.152						-0.279
						(0.178)						(0.188)
$min((x-3), 3)^3$*D(x>=3)						-0.030+++						-0.031+++
						(0.007)						(0.007)
$min((x-3), 3)^3$*D(x>=6)						0.001						0.018
						(0.019)						(0.018)
$(x-9)^3$*D(x>=9)						-0.079+++						-0.082+++
						(0.025)						(0.024)
Constant	8.378+++	7.736+++	9.429+++	9.441+++	8.103+++	10.416+++	6.994+++	6.659+++	7.829+++	7.852+++	7.098+++	10.018+++
	(0.129)	(0.264)	(0.200)	(0.205)	(0.442)	(0.592)	(0.137)	(0.265)	(0.223)	(0.227)	(0.449)	(0.634)
Observations	663	438	663	663	438	663	663	438	663	663	438	663
Adjusted R-squared	0.232	0.076	0.266	0.270	0.086	0.288	0.141	0.055	0.164	0.172	0.069	0.204

Notes: x refers to the distance from CBD, the knots are created at x1= 3, x2=6, x3=9

Table A.2: Subcenters identified using Geographical Weighted Regressions, 200

Sub-county	Parish	Village	distance_CBD
CENTRAL	CIVIC CENTER	NEETA	1.1
CENTRAL	INDUSTRIAL AREA	SIXTH STREET	3.1
CENTRAL	KISENYI II	MARKET VIEW	0.0
CENTRAL	NAKASERO III	NAKIVUBO ROAD	1.1
CENTRAL	NAKASERO IV	CITY HOUSE	0.7
CENTRAL	NAKASERO IV	DRAPER	0.7
CENTRAL	NAKASERO IV	HUSSEIN	0.8
CENTRAL	NAKASERO IV	KIYEMBE	0.5
CENTRAL	NAKASERO IV	NAKASERO MARKET	0.8
CENTRAL	NAKASERO IV	SULTAN	0.5
CENTRAL	NAKASERO IV	UNIVERSAL	0.9
CENTRAL	NAKASERO IV	UTC	0.4
CENTRAL	NAKASERO IV	WILLIAM STREET	0.6
CENTRAL	NAKIVUBO-SHAURIYAKO	MUNNO B	0.8
CENTRAL	NAKIVUBO-SHAURIYAKO	SALOMPASI A	0.6
CENTRAL	NAKIVUBO-SHAURIYAKO	SALOMPASI B	0.7
CENTRAL	NAKIVUBO-SHAURIYAKO	SHAURIYAKO A	0.5
CENTRAL	NAKIVUBO-SHAURIYAKO	SHAURIYAKO B	0.5
KAWEMPE	BWAISE II	KATALE	4.9
KAWEMPE	MULAGO II	BAKERY	3.6
MAKINDYE	KISUGU	KISUGU CENTRAL	3.9
NAKAWA	BUGOLOBI	JAMBULA	5.7
NAKAWA	BUKOTO II	BBUYE CENTRAL	6.8
NAKAWA	LUZIRA	MAMBO BADDO	8.4
RUBAGA	NAKULABYE	ZONE IX LCI	2.2

Sub-county	Parish	Village	ID	54	91	109	112	114	115	116	117	118	119	120	121	122	123	124	126	127	128	129	130	131	146	252	524	570	608	835
CENTRAL	KISENYI II	MARKET VIEW	54		2.0	1.1	0.7	0.8	0.5	0.9	0.8	0.3	0.5	0.6	0.9	0.4	0.6	0.7	0.7	0.8	0.6	0.7	0.5	0.5	4.9	2.3	5.7	5.3	8.5	1.9
CENTRAL	NAKASERO I	KATONGA ROAD	91	1.96		1.6	1.3	1.4	1.5	1.2	1.3	1.7	1.5	1.5	1.2	1.6	1.4	1.3	1.5	1.4	1.4	1.4	1.6	1.5	4.3	1.7	4.2	3.7	7.5	3.7
CENTRAL	NAKASERO II	NAKIVUBO ROAD	109	1.06	1.6		1.0	1.3	1.0	1.2	1.3	1.1	0.9	1.2	1.2	0.9	0.8	0.7	0.4	0.4	0.7	0.6	0.6	0.7	3.9	1.3	5.7	5.2	8.8	3.0
CENTRAL	NAKASERO I'	CITY HOUSE	112	0.70	1.3	1.0		0.3	0.2	0.2	0.2	0.4	0.2	0.3	0.2	0.4	0.2	0.3	0.7	0.6	0.3	0.4	0.5	0.4	4.8	2.1	5.0	4.6	7.9	2.4
CENTRAL	NAKASERO I'	HUSSEIN	114	0.78	1.4	1.3	0.3		0.3	0.2	0.1	0.4	0.4	0.2	0.1	0.5	0.4	0.6	1.0	0.9	0.6	0.6	0.8	0.7	5.0	2.3	4.9	4.5	7.7	2.3
CENTRAL	NAKASERO I'	KIYEMBE	115	0.46	1.5	1.0	0.2	0.3		0.4	0.4	0.2	0.1	0.2	0.4	0.2	0.2	0.4	0.7	0.7	0.3	0.4	0.5	0.4	4.9	2.2	5.2	4.8	8.1	2.2
CENTRAL	NAKASERO I'	LUWUM STREET	116	0.91	1.2	1.2	0.2	0.2	0.4		0.1	0.6	0.5	0.4	0.1	0.6	0.4	0.5	0.9	0.9	0.6	0.6	0.8	0.7	4.9	2.2	4.8	4.4	7.7	2.5
CENTRAL	NAKASERO I'	NAKASERO MARKET	117	0.83	1.3	1.3	0.2	0.1	0.4	0.1		0.5	0.4	0.3	0.1	0.6	0.4	0.5	0.9	0.9	0.6	0.6	0.8	0.7	5.0	2.3	4.8	4.4	7.7	2.4
CENTRAL	NAKASERO I'	OWINO VIEW	118	0.35	1.7	1.1	0.4	0.4	0.2	0.6	0.5		0.3	0.2	0.5	0.3	0.4	0.6	0.8	0.8	0.5	0.6	0.5	0.5	5.0	2.3	5.3	4.9	8.1	2.0
CENTRAL	NAKASERO I'	SULTAN	119	0.50	1.5	0.9	0.2	0.4	0.1	0.5	0.4	0.3		0.3	0.4	0.2	0.1	0.3	0.6	0.5	0.2	0.3	0.4	0.2	4.7	2.1	5.2	4.8	8.1	2.3
CENTRAL	NAKASERO I'	TEMPLE	120	0.57	1.5	1.2	0.3	0.2	0.2	0.4	0.3	0.2	0.3		0.3	0.4	0.4	0.5	0.8	0.8	0.5	0.6	0.6	0.5	5.0	2.3	5.1	4.7	7.9	2.2
CENTRAL	NAKASERO I'	UNIVERSAL	121	0.87	1.2	1.2	0.2	0.1	0.4	0.1	0.1	0.5	0.4	0.3		0.6	0.4	0.5	0.9	0.9	0.6	0.6	0.8	0.7	5.0	2.2	4.8	4.4	7.7	2.5
CENTRAL	NAKASERO I'	UTC	122	0.35	1.6	0.9	0.4	0.5	0.2	0.6	0.6	0.3	0.2	0.4	0.6		0.2	0.4	0.5	0.5	0.2	0.3	0.3	0.2	4.7	2.1	5.4	5.0	8.3	2.2
CENTRAL	NAKASERO I'	WILLIAM STREET	123	0.59	1.4	0.8	0.2	0.4	0.2	0.4	0.4	0.4	0.1	0.4	0.4	0.2		0.2	0.5	0.5	0.1	0.2	0.4	0.2	4.7	2.0	5.2	4.8	8.1	2.4
CENTRAL	NAKIVUBO-S	MUNNO A	124	0.72	1.3	0.7	0.3	0.6	0.4	0.5	0.5	0.6	0.3	0.5	0.5	0.4	0.2		0.4	0.4	0.2	0.1	0.3	0.2	4.5	1.8	5.2	4.7	8.2	2.6
CENTRAL	NAKIVUBO-S	REMAND A	126	0.71	1.5	0.4	0.7	1.0	0.7	0.9	0.9	0.8	0.6	0.8	0.9	0.5	0.5	0.4		0.1	0.4	0.3	0.2	0.3	4.2	1.6	5.6	5.1	8.6	2.6
CENTRAL	NAKIVUBO-S	REMAND B	127	0.77	1.4	0.4	0.6	0.9	0.7	0.9	0.9	0.8	0.5	0.8	0.9	0.5	0.5	0.4	0.1		0.3	0.3	0.3	0.3	4.2	1.6	5.5	5.0	8.5	2.7
CENTRAL	NAKIVUBO-S	SALOMPASI A	128	0.56	1.4	0.7	0.3	0.6	0.3	0.6	0.6	0.5	0.2	0.5	0.6	0.2	0.1	0.2	0.4	0.3		0.1	0.2	0.1	4.6	1.9	5.3	4.9	8.3	2.5
CENTRAL	NAKIVUBO-S	SALOMPASI B	129	0.65	1.4	0.6	0.4	0.6	0.4	0.6	0.6	0.6	0.3	0.6	0.6	0.3	0.2	0.1	0.3	0.3	0.1		0.2	0.1	4.5	1.8	5.3	4.8	8.3	2.6
CENTRAL	NAKIVUBO-S	SHAURIYAKO A	130	0.51	1.6	0.6	0.5	0.8	0.5	0.8	0.8	0.5	0.4	0.6	0.8	0.3	0.4	0.3	0.2	0.3	0.2	0.2		0.1	4.5	1.8	5.5	5.1	8.5	2.5
CENTRAL	NAKIVUBO-S	SHAURIYAKO B	131	0.52	1.5	0.7	0.4	0.7	0.4	0.7	0.7	0.5	0.2	0.5	0.7	0.2	0.2	0.2	0.3	0.3	0.1	0.1	0.1		4.5	1.9	5.4	5.0	8.3	2.4
KAWEMPE	BWAISE II	KATALE	146	4.93	4.3	3.9	4.8	5.0	4.9	4.9	5.0	5.0	4.7	5.0	5.0	4.7	4.7	4.5	4.2	4.2	4.6	4.5	4.5	4.5		2.7	7.8	7.1	11.3	6.8
KAWEMPE	WANDEGEYA	KATALE	252	2.34	1.7	1.3	2.1	2.3	2.2	2.2	2.3	2.3	2.1	2.3	2.2	2.1	2.0	1.8	1.6	1.6	1.9	1.8	1.8	1.9	2.7		5.8	5.2	9.1	4.3
NAKAWA	BUGOLOBI	JAMBULA	524	5.66	4.2	5.7	5.0	4.9	5.2	4.8	4.8	5.3	5.2	5.1	4.8	5.4	5.2	5.2	5.6	5.5	5.3	5.3	5.5	5.4	7.8	5.8		0.7	3.6	6.5
NAKAWA	KISWA	ZONE VI	570	5.27	3.7	5.2	4.6	4.5	4.8	4.4	4.4	4.9	4.8	4.7	4.4	5.0	4.8	4.7	5.1	5.0	4.9	4.8	5.1	5.0	7.1	5.2	0.7		4.3	6.3
NAKAWA	LUZIRA	MAMBI BBADO	608	8.47	7.5	8.8	7.9	7.7	8.1	7.7	7.7	8.1	8.1	7.9	7.7	8.3	8.1	8.2	8.6	8.5	8.3	8.3	8.5	8.3	11.3	9.1	3.6	4.3		8.7
RUBAGA	NDEEBA	KASUMBA ZONE	835	1.94	3.7	3.0	2.4	2.3	2.2	2.5	2.4	2.0	2.3	2.2	2.5	2.2	2.4	2.6	2.6	2.7	2.5	2.6	2.5	2.4	6.8	4.3	6.5	6.3	8.7	

Table A.4: Contribution by specific identified subcenters using GWR, 2001

	Aggregates					density		Share in					Average
Employment Centers	Total Employment	Firm Count	Female Employment	Male Employment	Area	Employment	Firm	Total Employment	Firm Count	Female Employment	Male Employment	Area	distance to CBD
CENTRAL CIVIC CENTER NEETA	5822	193	1970	3852	0.141	41365	1371	3.2	0.3	2.7	3.6	0.079	1.1
CENTRAL INDUSTRIAL AREA SIXTH STREET	8430	62	1901	6529	0.332	25429	187	4.7	0.1	2.6	6.1	0.186	3.1
CENTRAL KISENYI II MARKET VIEW	8587	6250	5197	3390	0.052	166642	121290	4.8	11.3	7	3.2	0.029	0
CENTRAL NAKASERO III NAKIVUBO ROAD	2097	1382	818	1279	0.064	32995	21745	1.2	2.5	1.1	1.2	0.036	1.1
CENTRAL NAKASERO IV CITY HOUSE	840	197	463	377	0.012	68791	16133	0.5	0.4	0.6	0.4	0.007	0.7
CENTRAL NAKASERO IV DRAPER	635	127	289	346	0.021	30294	6059	0.4	0.2	0.4	0.3	0.012	0.7
CENTRAL NAKASERO IV HUSSEIN	858	339	350	508	0.018	47949	18945	0.5	0.6	0.5	0.5	0.01	0.8
CENTRAL NAKASERO IV KIYEMBE	841	185	397	444	0.022	38062	8373	0.5	0.3	0.5	0.4	0.012	0.5
CENTRAL NAKASERO IV NAKASERO MARKET	631	320	291	340	0.013	46768	23718	0.3	0.6	0.4	0.3	0.008	0.8
CENTRAL NAKASERO IV SULTAN	1011	338	530	481	0.034	29434	9840	0.6	0.6	0.7	0.5	0.019	0.5
CENTRAL NAKASERO IV UNIVERSAL	805	145	325	480	0.017	46388	8356	0.4	0.3	0.4	0.5	0.01	0.9
CENTRAL NAKASERO IV UTC	1287	383	633	654	0.034	37836	11260	0.7	0.7	0.9	0.6	0.019	0.4
CENTRAL NAKASERO IV WILLIAM STREET	1477	368	695	782	0.018	81597	20330	0.8	0.7	0.9	0.7	0.01	0.6
CENTRAL NAKIVUBO-SHAURIYAKO MUNNO B	1198	228	437	761	0.031	38960	7415	0.7	0.4	0.6	0.7	0.017	0.8
CENTRAL NAKIVUBO-SHAURIYAKO SALOMPASI A	830	318	383	447	0.014	60659	23241	0.5	0.6	0.5	0.4	0.008	0.6
CENTRAL NAKIVUBO-SHAURIYAKO SALOMPASI B	986	189	392	594	0.024	41476	7950	0.5	0.3	0.5	0.6	0.013	0.7
CENTRAL NAKIVUBO-SHAURIYAKO SHAURIYAKO A	2337	1234	1266	1071	0.032	72927	38507	1.3	2.2	1.7	1	0.018	0.5
CENTRAL NAKIVUBO-SHAURIYAKO SHAURIYAKO B	1571	462	739	832	0.022	72465	21310	0.9	0.8	1	0.8	0.012	0.5
KAWEMPE BWAISE II KATALE	338	197	179	159	0.006	52855	30806	0.2	0.4	0.2	0.1	0.004	4.9
KAWEMPE MULAGO II BAKERY	441	49	144	297	0.028	15924	1769	0.2	0.1	0.2	0.3	0.016	3.6
MAKINDYE KISUGU KISUGU CENTRAL	1057	167	169	888	0.029	37014	5848	0.6	0.3	0.2	0.8	0.016	3.9
NAKAWA BUGOLOBI JAMBULA	479	298	313	166	0.013	36797	22892	0.3	0.5	0.4	0.2	0.007	5.7
NAKAWA BUKOTO II BBUYE CENTRAL	413	280	249	164	0.017	24485	16600	0.2	0.5	0.3	0.2	0.009	6.8
NAKAWA LUZIRA MAMBO BADDO	1504	161	364	1140	0.086	17441	1867	0.8	0.3	0.5	1.1	0.048	8.4
RUBAGA NAKULABYE ZONE IX LCI	233	84	109	124	0.012	19357	6978	0.1	0.2	0.1	0.1	0.007	2.2
Others	135617	41493	55370	80247	177.033	766	234	75.2	74.8	74.9	75.5	99.388	4.4

Figure A.1a: Linear fit versus linear splines

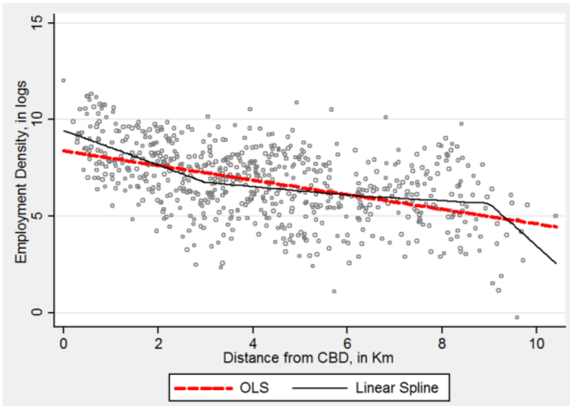

Figure A.1b: Linear fit versus cubic splines

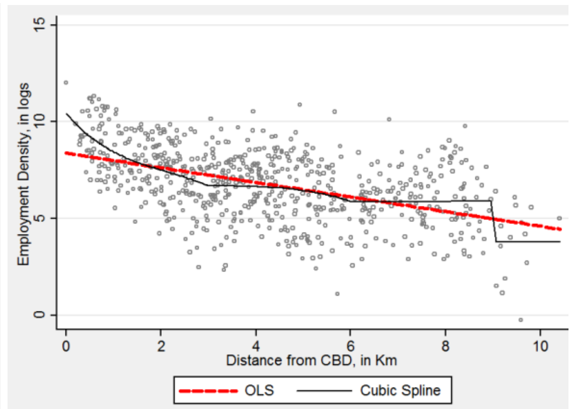

Figure A.2: Subcenters identified using GWR, 2001