The Role of Small Firms in Urban Economic Development in a Polycentric City

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Abstract

The research in this paper empirically explores the importance of small firms in fostering economic growth, by using both cross sectional and time series variation in the relative location of large and small firms in urban centers of employment. The paper estimates two polycentric density functions, one for employment in large firms, the other for employment in small. Our method is to compare how the relative location of large and small firms varies between the older and established centers of employment to the newly emerging employment subcenters by using the newer areas as proxies for the older areas prior to their development. We reinforce this approach by separately examining data from 1990, and from 2010. We find that large firms are more likely than small to be found only in the CBD, but that conversely small firms are equally as likely as large firms to be found in the neighboring areas of the other subcenters. The results are mixed for the distribution of firm size within the subcenters themselves. Our other methodology, however, is informative in this regard. A polycentric density function, capturing the simultaneous influence of each of the employment subcenters on employment throughout the county, shows that small and large firms have equal effects on employment.

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I. Introduction[1]

One of the outstanding research questions concerning economic development is the relative role played by large and small firms. On the one hand, many local and even state governments have engaged in highly visible and expensive competitions for select large industrial projects, which certainly conveys the idea that large firms are the engine of economic growth. On the other hand, a high proportion of net new job creation is known to be coming from small firms. The research we conduct here attempts to illustrate the relative role of large and small firms in an urban growth context. Specifically, we examine whether small businesses are important in developing and maintaining the concentrations of employment that characterize large cities. Traditionally, large cities have been characterized by downtown centers of employment consistent with monocentricity. Recent decades, however, have seen a proliferation of employment subcenters outside of the downtown area. The rise of urban employment subcenters also coincides with a revitalization of major cities in the U.S. Thus the role of small businesses in the formation, maintenance, and growth of employment subcenters provides an excellent window for observing the relative role of small and large firms in overall economic development.

The objective of this research is to illustrate the role of small as opposed to large firms. The advantage of the multi-centric urban context that we use for our empirical examination is that we will address both time series and cross sectional differences. Specifically, we have Census tract

[1] We have benefitted from presentations at the Regional Science Meetings and the Western Regional Science Meetings. We are grateful to the Houston Galveston Subsidence District for funding used to create the 2010 data, and to the U.S. Small Business Administration's Office of Advocacy for funding used to create the 1990 data. We have benefited from data assistance by Evert Crawford, Xiahong Ju and Moe Kyaw Pyi Soe, and from the comments of Chad Moutray. Finally, we wish to acknowledge the excellent research assistance of Jia-Huey Lin.

level employment data for 1990 and 2010 by firm size for Houston, Texas. This data allows us to compare how firm size is associated with employment subcenter growth, and as well it allows us to address history based on the pace of development . While there is not yet existing theoretical work which characterizes the growth of subcenters, it seems natural to assume that employment concentrations closer to the CBD are more likely to be older and more established than employment concentrations much farther from the CBD.[2] This presents the opportunity to compare the close-in and CBD centers with employment subcenters farther from the CBD.

We use two different methodologies to distinguish how firm size interacts with the employment subcenters. In the first, we estimate a probabilistic model to determine whether large or small firms are more likely to locate within, or near, an employment subcenter. This is informative because it would be expected that the export firms most important to the economic success of a city are more likely to be in a subcenter than randomly dispersed across the urban area. That is, in order to compete in worldwide markets export firms would need to exploit all of the available agglomeration economies. Conversely, service and retail firms that primarily rely on local markets would be expected to be more likely to be dispersed across the urban area.

The other methodology we use to investigate the role of firm size is to estimate separate polycentric density functions for employment within large firms, and within small firms. The density function tests the extent to which each subcenter influences the location of other firms. Specifically, if it is valuable to be near a particular subcenter, firms will be willing to pay, and the resulting increases in land prices will cause land to be used more densely. If a location near large firms is more valuable than is a location near small firms, we should observe that the resulting

[2] Berliant and Wang (2008) for example have a static model of subcenter formation, which nonetheless suggests that the growth of subcenters depends on the size of the city, in which case it would be natural to expect more subcenters with larger cities.

density gradients are steeper when we look at large firm employment.

The employment centers we examine in Houston are quite varied in their stage of development. We perform our economic analysis for each center separately, and we develop alternative strategies to attempt to circumvent the statistical problem of subcenter success creating large firms out of what were originally small ones. For example, as in virtually all cities, the central business district (CBD) is the oldest center of employment in Houston. Other subcenters have formed more recently and, as we show below, exert less influence on the surrounding urban areas. Thus, we use a logit specification to analyze the relative frequency of small firms in the newer subcenters compared to the well established areas. This allows us to examine the impact of alternative business sector concentrations, although in the end we find that industrial sector is not important in determining the relative importance of small firms in urban economic development. In part, as we show below, this is because the subcenters are amazingly diverse to the extent that most industries are well represented in every subcenter.

Our analysis of the role of small businesses has four essential parts. In the first, we examine the role of small compared to large firms within the actual employment centers. One potential problem with the identified employment centers is that the actual relevant economic area may not correspond to census tract boundaries as assumed. We deal with this potential problem by conducting the analysis of which firms are likely to locate within an employment center by using not only the actual tract, but also including concentric rings of between one and three miles from the tract centroid.

An important additional reason to examine the area around each center is found in the nature of urban economic theory. An important element in identification of an employment center is that it attracts firms not just to the center itself, but also to neighboring areas. Most

urban models based on transportation costs, for example, predict that land prices will rise as proximity to employment centers improves. The increase in land prices is the cause of higher density (in employment or population), as economic agents capitalize on the scarce resource of center proximity. The key to higher prices for center accessibility resides in that firms within the center create a positive externality for other firms. The key for our second analysis here is whether small firms are able to compete with large firms for scarce land near the employment subcenter. Small firms will only be able to do so if they are contributing to the economic output of the subcenter in a material way.

The third leg of our empirical strategy is to examine the propensity to locate within an employment center by separate industries. This aspect gives a sense of the importance of economies of scale and allows us to look at the industries separately to determine whether they are likely to be export industries or instead those that serve exclusively local interests. Export oriented businesses are those that are essential for economic growth as they attract resources into a region from the outside world.

The fourth element of the proposed research strategy is to estimate a polycentric employment density function, again segmented by large and small firms. The advantage of this approach is that it allows the myriad influences of the diverse subcenters to affect a firm's location. Further, it provides a quantitative estimate of the differential willingness to pay of large versus small firms for increments of proximity to an employment center.

II. Specification

Whether firm size affects economic growth is arguable, as there are ambiguous effects on both export trade, and the generation of agglomeration economies. One reason large firms may be

more important at leading export growth is potential economies of scale in actually exporting. While export to other markets within the country may be relatively simple, it is easy to believe that exports to foreign markets may involve significant fixed costs. It is also conceivable there are other elements that would determine economies of scale, even in the nature of transportation itself. Further, the development of the agglomeration economies themselves may require large firms, as a focal point for the location of other firms, for example. On the other hand, one of the key factors to fostering trade is specialization. If small firms are more specialized, it is possible they have a comparative advantage in the international marketplace. Further, it is possible the production of agglomeration economies themselves is more responsive to a group of people with similar but slightly different purposes rather than with a group of people all working for a single firm. The purpose of our empirical investigation is to determine whether one of these forces is observably more important than the other.

We identify the employment subcenters in Houston using McMillen's locally weighted regression (LWR) procedure, using the natural log of the employment density of each tract (McMillen, 2001) . The observations for each regression are those that fall within a given distance or bandwidth from the current tract of interest. Once the tracts that fall within the bandwidth are identified, they are weighted using a tricube kernel, which is a negative function of distance from the tract of interest. Each LWR produces a predicted value of the natural log of employment density $\hat{y}$ for each observation. Candidate employment centers are then defined as tracts or sets of contiguous tracts whose true value of y falls above the 95% confidence interval of $\hat{y}$.

This methodology identifies 14 employment centers in the central county, Harris. We further winnow down the subcenter candidates, however, by estimating the impact of each candidate subcenter on population. Those areas with significant population impacts are six plus the CBD, and

we focus on these six subcenters to estimate whether there are differential impacts of large and small firm employment.

We implement two empirical models for building our understanding of how small firms have shaped the urban growth process. In the first model, we use the individual firm level data to build a probabilistic model of firm location. The second model is a polycentric density function, which allows us to estimate more directly the willingness of firms, both large and small, to pay for proximity to a subcenter.

1. Dichotomous Location Model

The specification we propose to use for determining the type of firm that develops urban employment centers is a probabilistic function showing the tendency of particular sized firms to locate in, or near, the urban employment centers. We use the definition of the employment centers as described above, consistent with the definition of subcenters as first advocated by Craig and Ng (2001). The methodology we use is first proposed in Kohlhase and Ju (2007) where they study specific two-digit Standard Industrial Classification (SIC) industries. Specifically, we model the probability that a small firm will be in an employment center, as opposed to being located elsewhere in the urban economy, as:

$$(1) \qquad Pr(SC) = f(Size, Ind)$$

where Pr(SC) is an indicator variable equal to one when a firm is located within a particular subcenter, and zero if it is not. Ind is a series of indicator variables for the 1 digit industrial code. The Size variable is the key to the estimating equation, as it indicates whether additional employees of a firm make it more likely to locate in a particular subcenter. Equation (1) is estimated for each of the subcenters, and for the central business district. We then also estimate (1) for each of the

major industrial sectors, to understand whether there are any scale effects within particular industries that affect how firms agglomerate in the urban core economy.

It is not clear what to expect from estimating equation (1). On the one hand, public officials put a lot of emphasis on the largest firms, and often a large firm is identified with a particular industry in a metropolitan area. On the other hand, small firms are known to be innovative and often more aggressive. In this case, it may be that a collection of small firms is the initial catalyst that causes an employment subcenter to form. Another reason to suspect an important role for small firms is the industrial diversity we observe in existing subcenters.

Specifically, irrespective of whether a large firm is the anchor, small firms may form a central part of the supply chain, and firms in a variety of industries may provide the creative energy to find ways to link to the large successful firm. The key result from (1) will be to determine whether the effect of firm size is different in the new and emerging subcenters, such as Carrilon or Greenspoint, compared to the older and established subcenters including the Galleria and the CBD.

A second method we use to estimate (1) is to define the left hand side indicator variable as pertaining not just to the employment center itself, but to a relatively close radius (three miles) around each center. The importance of such a specification is that we test the extent to which 11 small firms are participating in the important economic phenomenon shaping U.S. cities, that of polycentricity. Estimation of the probability of 'nearness' provides an alternative specification to the density function specification presented below. Demand to be near, but not within, a center is consistent with a firm that provides a support role for employment within a center. These support roles are crucial, since they represent cost savings that are part of the agglomeration cost advantage firms need to compete nation- or world- wide. On the other hand, the probabilistic approach lacks the quantitative preciseness of the density function methodology. Nonetheless, the probabilistic

method allows a detailed picture of how small businesses support employment centers.

2. The Density Function Approach

The empirical model to test whether small firms have an essential supporting role to subcenter formation is a reduced form model based on the extensive literature on firm location and employment density functions (for a review, see Anas et al., 1998; Small and Song, 1994). Through an examination of employment per unit of land area, a density function captures how important an area is to economic functions. Valuable land will be used intensely to reduce land costs. Land is valuable because of demand by firms to be near transportation nodes, customers, suppliers or other firms. Recent models have used density functions not just to show the importance of land near the CBD, but to examine the multi-centricity of an urban area. Thus, recent research uses distance to several areas to model the importance of all of the subcenters to an urban economy.

The innovation in the work proposed here is to split the study of employment density into 12 employment density for small firms and employment density for large firms. Such a split in the data would not be possible without the firm specific data on individual firm employment we bring to this project. The poly-centric employment density function is thus:

$$(2) \qquad Emp/Area_{(small/large)} = f(Dist_{CBD}, Dist_{subs}, Charact)$$

where Emp/Area represents employment per acre (or equivalently, per square mile) in a census tract. The small/large subscript indicates we will estimate equation (2) separately for employment in small firms and employment in large firms. The CBD is presumed to affect all locations in the metropolitan area; thus, $Dist_{CBD}$ is the distance to the CBD in all census tracts.

For a location closer to the CBD, land prices are expected to be higher reflecting the more valuable locations, and therefore employment densities are expected to be higher. The other

subcenters in the city are expected to have a more limited market area. While the distance to each of the other subcenters in Houston will be entered in the regression ($Dist_{subs}$), it will be done for a limited range. Within that range, however, each subcenter is expected to influence areas as is the CBD so that being closer to a subcenter will drive up land prices since firms value proximity. The higher prices will be reflected in more intense land use, so that employment densities are higher. The optimal range for each subcenter is where the influence of each subcenter goes to zero and is captured by a slope dummy on distance.[8] Marginal increases.

In equilibrium, both large and small firms would be expected to pay the same land price and would be expected to exhibit equal employment densities. In fact, however, if one size firm benefits more from agglomeration economies than the other, the firm size which receives the highest value will dominate, and the low demander firms would have low resulting employment densities. Thus, segmenting the regression by large and small firms promises to yield important new insights into whether firm size is an important attribute in determining benefits to urban agglomeration. That is, it may be that only large employers value proximity to an employment subcenter, in which case only the large firm version of equation (2) will show effects on other areas. Conversely, if small firms value proximity as highly as do large firms, the coefficients in the two versions of equation (2) will be found to be statistically equal.

A confounding factor in analysis of the spatial impact of employment centers is the extent of their influence. Following the innovation in Perdue (2011), we utilize data from the CTPP on location of residence and work to estimate the spatial extent of subcenter influence based on commuting patterns. Specifically, we find the point where commuters are no longer concentrated as working in a specific subcenter, and use that distance as the radii of influence.

III. Data

We use privately available data to identify firm size and employment, and Census data for the remainder of the variables. Specifically, 1990 data on employment by firm is from Dun and Bradstreet, while 2010 employment data is from RefUSA. Table 2 reports on the means of these data for both years. We deleted firms which did not address match (about 20%), and for which employment was unknown. Nonetheless, the data are quite comprehensive, as they represent almost 75% of total employment. Because of the change in source, however, our conclusions regarding changes over time will be cautionary, and generally conducted as changes relative to the CBD. The data include firm specific characteristics such as the name and address of each firm, the number of employees, annual sales, 4-digit SIC codes and year established.[3] In order to create spatially detailed variables, the addresses of the individual firms are geocoded using GIS software, and a newly available more detailed address file.

Table 1 reports descriptive statistics for the subcenters by presenting the total number of firms by employment center, and it presents the number of employees in those firms by whether the firms are larger or smaller than 45 employees.[4] Table 2, in addition, reports the sectoral breakdown in each of the employment centers and includes the number of firms and employees in small firms using our distinction. As an example, Figure 2 shows the location of firms relative to the employment centers for one of the industrial sectors, petrochemicals, modeled to influence the entire

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[3] The observations are for establishments, which may be stand alone firms, subsidiaries, or branches. Henceforth for brevity, we will use the term "firms" interchangeably with "establishments."

[4] We experimented with a large number of definitions of "small" firms. The qualitative results discussed below are preserved for all definitions, with the caveat that the definition of small firm must be small enough to leave a substantial number of observations. For example, defining small firms as up to 500 employees (the largest definition we found in any context) is too small to statistically distinguish differences by firm size.

region.

A unique feature of the data is that they are organized by firm size. Table 1 reports descriptive statistics for the subcenters by presenting the total number of firms by employment center, and it presents the number of employees in those firms by whether the firms are larger or smaller than 45 employees. Table 2, in addition, reports the sectoral breakdown in each of the employment centers and includes the number of firms and employees in small firms using our distinction. As an example, Figure 2 shows the location of firms relative to the employment centers for one of the industrial sectors, petrochemicals, modeled to influence the entire region.

A. Description of the Distribution of Small Firms

Table 1 contains some preliminary descriptive statistics that are useful for understanding the role of small firms. The data are organized around the six employment subcenters, plus the CBD. Our premise is that the close-in subcenters are older and more established, while those farther from the CBD are newer and less developed.[5] Thus we will in part compare the closest three subcenters to the three subcenters further out. We also must note that there are two different data sources, so we will compare changes to the CBD as a point of reference.

It is clear that large firms are more important in the CBD, and in the three closest subcenters, compared to the three further out subcenters. For example, employment in small firms in the CBD is only 23% of total CBD employment, while in the three subcenters furthest from the CBD the average is that 45% of the employees work in small firms. That these averages do not tell us about the contribution of small firms is obvious when one considers the possibility small successful firms

[5] This is likely because the Houston metropolitan area has grown relatively quickly for a major urban area. The five county area employment in 1990 was about 1.7 million, it had grown to over 2.5 million by 2010.

are likely to grow.

The Table also shows the means for the three close-in subcenters, compared to the mean for the farther-out subcenters. The three close-in subcenters show a higher share of their total employment than does the CBD by itself, but nonetheless these close-in subcenters have a significantly lower share of workers than do the farther-out subcenters.

IV. Results

Using a variety of tests, we find that there is little to distinguish whether a given level of employment is organized into small firms, or large firms. We reach this conclusion based on our logit regressions, which tests whether firm size is correlated with the likelihood that a firm is located within a subcenter. We also confirm these results using a polycenter density function. A key to our conclusion from the logit regressions is our assumption that subcenters are older and more established the closer they are to the traditional CBD. That we find that larger firms are more likely to be in the closer in subcenters we attribute to the success they may have experienced by their central location. A different test is contained in the polycentric density function, where we estimate two functions, one with employees within large firms, and separately with employees within small firms. We find no significant difference in the coefficient estimates based on firm size.

Table 3 presents the results of a series of logit regressions, one for each center, on the probability that a firm will locate in a designated employment center as a function of firm size.[6] The regressions reported are for the year 2010, although the results using the 1990 data are very similar. The important aspect of these results is how they differ between employment centers, using either

[6] We also control for 1 digit industry, but this addition makes little difference to the results.

the probability a firm is within a subcenter, or is within three miles of the census tract centroid of the employment subcenter.[7]

Reflecting the dominance of large firms in the traditional downtown area of Houston, the coefficient on firm size in Table 3 is positive and statistically significant, and is larger than the coefficients for any of the other subcenters. The elasticity of 0.014 suggests that if a firm doubled in size, it would be 1.4 percent more likely to locate in the CBD.

The Galleria is the densest employment center after the CBD, and is quite developed. Despite that the Galleria is long established, we find a different pattern of firm size in Table 3. For location within the subcenter itself (the first columns), we find a positive and statistically significant effect of firm size. A firm that doubled in size would be about 1.0 percent more likely to locate in the Galleria. In the three mile radius, however, we see an important distinction compared to the CBD. The effect of firm size is not statistically significantly different from zero, and the quantitative impact of the point estimate is quite small. Thus, large firms are no more likely than small firms to be within three miles of the Galleria subcenter. In contrast, the coefficient estimate for the CBD suggests a positive effect of firm size of about 2/3 the direct magnitude of being located within the center itself, and different statistically from zero.

The outstanding question, however, is whether the importance of size for location in the CBD and the Galleria represents that large firms are what caused these areas to be the primary employment centers or instead whether the success of all of the firms in the employment core. Thus, we turn to the results for the other employment subcenters.

The results for the other subcenters actually show a rather mixed set of results, suggesting

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[7] We actually estimate the logit model including areas within one, two, or three miles. To the extent the results differ for the actual subcenter compared to the larger areas, we find the largest area is the most informative concerning the difference.

that the analysis here does not answer all questions. We find that firm size has no significant effect on firm location, within or near, for any of the other five subcenters with the exception of within Baytown. These last effect, however, significantly suggests that this subcenter is more likely to contain larger firms. That all of these results are replicated for the 1990 data indicates that firm size does not appear to be driving subcenter existence, or growth.

While not decisive, the results are consistent with the view that small firms are as important for subcenter development as large firms. The results also suggest, however, that understanding the dynamics of subcenter development may require a stronger theoretical base, with perhaps more information, that the basic framework we have presented here. In any case, however, we do not find evidence that large firms dominate the landscape of the cornerstone of the urban economy.

To examine the possibilities further, we turn to an analysis by industry because of the possibility that economies of scale in some industries pre-dispose some sectors to being oriented towards large firms. The logit regressions in Table 4 are based on whether firms in a specific Division-level (or 1- digit SIC) industry are more likely to be in an employment subcenter than in a more dispersed location. The results show that agriculture, mining, and wholesale trade are the only industries where large firms do not tend to concentrate in a subcenter. This suggests that large firms would be expected when looking at the concentration by firm size within subcenters, and any findings that show an important role for small firms are, at least in this sense, surprising. An interesting aspect of these results, however, and one that suggests the crucial role played by small businesses is that Houston's most important industrial sector is mining, which consists of most of the petrochemical industry (manufacturing is the other). Yet, this is one of the few sectors that does not show a tendency to concentrate large firms in subcenters in 1990 or 2010. It is also interesting to note that the results for 2010 provide even less emphasis on large firms than do the results from

1990. Thus the potential role of large firms seems far from dominant.

As a final test on the role of small business in urban economic growth, we present a polycentric density function incorporating the identified subcenters in the central county, Harris. The main purpose of this analysis is to examine the employment density in each neighborhood of the city with the purpose of determining the extent to which the employment subcenters affect that density. The expectation in such an analysis is that the CBD should exert the most influence, since proximity to the CBD should be quite valuable to a firm that wants to do business with firms in the downtown area. Nearness to each additional subcenter should also be valuable since the costs of transacting business with firms in the subcenters will be reduced by proximity.

In the empirical implementation of the density function analysis, the market area of each subcenter is restricted since the marginal effect is presumed to go to zero after a certain distance (see Craig and Kohlhase, 2009). As discussed above, the market areas are based on the extent of commuting patterns. In contrast, the influence of the CBD is allowed to permeate the entire region.

One innovative aspect of our work is to segment the polycentric density function by firm size. Table 5 presents the results of the analysis for both 1990 and 2010. Like many polycentric density function estimates, the estimated coefficients are not always of the expected negative signs (McMillen, 2004)

The important attribute of the polycentric density function results, however, is shown in the estimates of the density function separately for total employment located in large firms and small firms. We find that the influence on large firms is statistically equivalent to the influence of a subcenter on small firms. That is, even when the density function coefficients are statistically different from zero, they are not found to be statistically different from each other as shown in columns 3 and 6. This finding is important in our context because it shows that small firms compete

equally with large firms for space within the urban economy and for access to the centers for economic growth and vitality. This result is stronger, in some sense, than the logit location functions discussed above. This result shows that small firms are a vitally important element of the urban economic landscape because their location is just as important to land values as is the location of large firms. Further, as the intercept terms are also of virtually the same value, the impact of small firms on the core of the subcenter is found to be equivalent to that of large firms. Thus, the polycentric density function strengthens the first hypothesis offered on the individual subcenter logit location functions.

IV. Summary and Conclusion

The research described in this project contributes important new understanding of the role of small businesses in economic growth. The key to performing this research are the two large data sets that allow the researchers a unique opportunity to perform urban economic analysis that focuses on the role of firm size. This data set matches well with the available census data as the sample represents almost 3/4 of all the employment in Harris County. The perspective we bring is to look at the economic development around the employment subcenters closest to the traditional center, and compare this activity to the subcenters farthest from the CBD, assuming this latter group is newer and less developed. The analysis is undertaken in two components. The first examines the propensity of firms to locate in specific employment subcenters, and the second is estimation of an overall density function that examines the role of the employment centers on employment location throughout the central county.

As is well-known, the data show that there are a large number of small firms, but that large firms employ a high proportion of the workforce. The question we seek to answer is whether the

large firms exert a disproportionate impact on urban economic growth, or alternatively whether small firms perform an equally key role. This is a difficult question because if small firms are successful, they become large. Thus, an important advantage of our approach is to compare the older established areas with newly emerging employment centers. This view is consistent with new research that describes how the economies of cities operate (Glaeser and Kohlhase, 2004).

An important contribution of our research here, however, is we show the key role that small firms play in the process of economic development. Our analysis of individual subcenters examines two parts of the role of small business in economic development. In the first, we compare the likelihood that a firm will locate within the employment subcenter itself. This examination is central since the subcenters form the economic magnet around which urban employment is organized. We examine, in addition, the area within three miles of the subcenter. This nearby area is an important support to the subcenter and represents a necessary component to subcenter formation. We find that large firms are more likely than others to locate within the established subcenters including the CBD and the three subcenters closest to it. In contrast, in the newly emerging subcenters, we find that larger firms are more likely to be found in several of them, although not all. There is mixed support for the idea that large firms simply represent small firms that have grown rather than being needed to foster economic development on their own.

The areas surrounding the centers, however, provide much clearer evidence that small firms are necessary for economic development. The CBD is found to contain larger firms than otherwise would be expected within three miles. The Galleria is shown to have a statistically insignificant effect of firm size, albeit positive. The other subcenters, however, are quite consistent in showing that small firms are more likely to be close to the subcenter than others. The areas near the center, therefore, decisively show a pattern that suggests that small firms constitute the bulk of support for

urban growth but that as economic development proceeds, these small firms grow substantially. To the extent the near-center areas develop later, these areas would appear to be the model that suggests that small firm growth is the key component to economic development rather than starting with large firms de novo.

The final piece of evidence that we find that supports the small firm growth effect on economic development is the density function estimation. This second stage of the analysis examines how employment in each area of Harris County is related to the employment centers. As with the first stage, we bifurcate the estimation into looking at only large firms and only small firms. Our evidence shows that the subcenters exert statistically equal impact on firms of either size. That is, small firms are equally able to compete with large firms for proximity to employment centers.

The fundamental policy question raised in this analysis is whether cities that are pursuing an economic development strategy should spend their scarce resources on attracting large firms from other locations or, instead, whether cities should invest in encouraging new start-ups that may eventually develop. Our analysis provides substantial support to the hypothesis that small firms are the cornerstone to economic growth. We find that small firms are key components of the support areas around each subcenter excepting only the CBD where they appear to have grown to be classified as large firms. We also find that small firms effectively compete with large firms for proximity to all of the employment centers in Harris County. We believe these pieces of evidence suggest that our mixed findings with respect to firm size in the subcenters themselves reflect that we do not have ample understanding of the earliest development stages; but that once a subcenter can be statistically identified, it will be primarily populated by larger firms reflecting their success at fostering economic development.

REFERENCES

Anas, A., R. Arnott, K. A. Small, "Urban Spatial Structure," *Journal of Economic Literature*, 36, 1998, 1426-1464.

Agarwal, Ajay, Genevieve Giuliano, and Christian L. Redfearn, "Strangers in our midst: the usefulness of exploring polycentricity," Annals of Regional Science, 2012, forthcoming.

Craig, S. G., "A Report on the Economic Growth Potential for the Region of the Greenspoint Management District," Report to the Greenspoint Management District, 2002.

Craig, S. G. and J. E. Kohlhase, "Employment Subcenters and the Distribution of Economic Activity," University of Houston working paper, 2009.

Craig, S. G. and P. Ng, "Using Quantile Smoothing Splines to Identify Employment Subcenters in a Multicentric Urban Area, " *Journal of Urban Economics*, 49, 2001, 100-120.

Duranton G, and D. Puga, "Micro-foundations of urban agglomeration economies," in Henderson, J. and J,Thisse (eds), *Handbook of regional and urban economics*, Chap 48. North Holland, New York, 2004, 2063–2117.

Fujita, M. and H. Ogawa, "Multiple Equilibiria and Structural Transition of Nonmonocentric Urban Configurations," *Regional Science and Urban Economics*, 12, 1982, 161-196.

Garreau, J., *Edge City: Life on the New Frontier*, New York: Doubleday, (1991).

Glaeser, E. L., H. D. Kallal, J.A. Scheinkman, A. Shleifer, "Growth in Cities," *Journal of Political Economy*, 100 (1992) 1126-1152.

Glaeser, E. L and J. Kohlhase, "Cities, Regions, and the Decline in Transport Costs," *Papers of the Regional Science Association*, 83, Jan. 2004, 197-228.

Guiliano, G., C. Redfearn, A.Agarwal, C. Li and D. Zhuang, "Employment Concentrations in Los Angeles, 1980-2000," *Environment and Planning A*, 39(12), 2007, 2935-2957.

Kohlhase, J. E. and X. Ju, "Firm Location in Houston: The Effects of Public Policy and Firm Characteristics on Location Decisions," *Environment and Planning C*, 25(5), 2007, 671-691.

Lucas, R. E. Jr. and E. Rossi-Hansberg, "On the Internal Structure of Cities," Econometrica, 70, 2002, 1445-1476.

McMillen, D. P., "Nonparametric Employment Subcenter Identification," *Journal of Urban Economics*, 50, 2001, 448-473.

McMillen, D. P., "Employment Densities and Subcenters in Large Metropolitan Areas," *Journal of*

Regional Science, 44, 2004, 225-243.

McMillen, D. P. and S. C. Smith, "The Number of Subcenters in Large Urban Areas," *Journal of Urban Economics*, 53, 2003, 321-338.

Rosenthal, S. and W. Strange, "Evidence on the Nature and Sources of Agglomeration Economics," in *The Handbook of Urban and Regional Economics: Vol. 4*, J. V.Henderson and J. Thisse (eds.), Elsevier North Holland, 2004, 2119–2171.

Small, K. A. and S. Song, "Population and Employment Densities: Structure and Change," *Journal of Urban Economics*, 36, 1994, 292-313.

Figure 1 Harris County, Texas Employment Centers 1990-2010

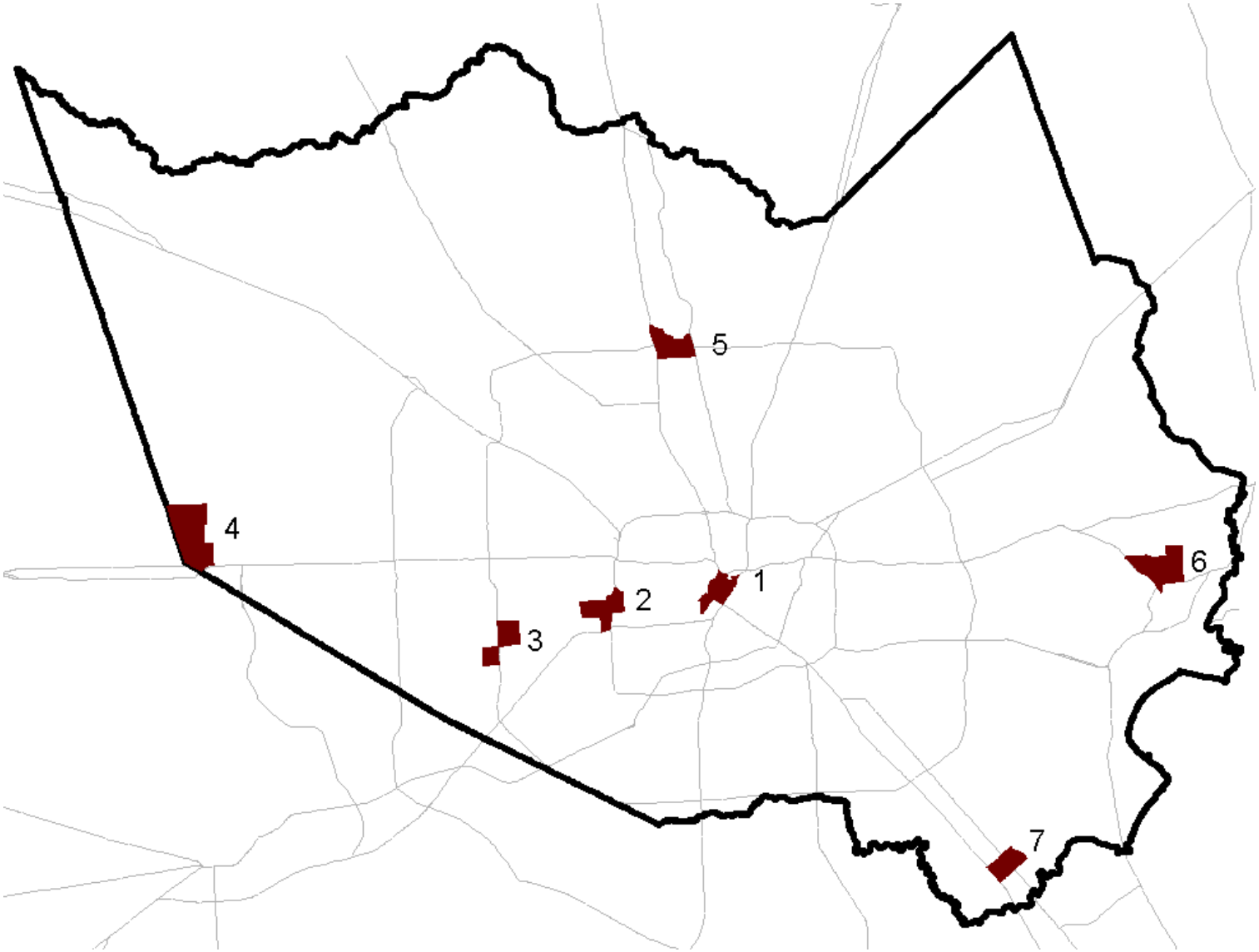

Table 1: Firms and Employees by Employment Center in Houston 1990 and 2010

	Total Firms	*Large Firms*	*Small Firms* [a]	*Total Employees*	*Large Firm Employment*	*Small Firm Employment*	*Emp Share in Small Firms*
Total Houston							
1990 [b]	63,325	3,683	58,642	1,089,653	687,720	401,953	37%
2010 [b]	166,193	7,574	158,619	2,138,111	945,163	1,192,948	56%
Growth	162.44%	105.65%	170.49%	96.22%	37.43%	196.79%	
Total Subcenters							
1990	5,199	494	4,705	183,313	145,010	38,303	21%
2010	14,200	774	13,426	259,582	180,374	79,220	31%
Growth	173.13%	56.68%	185.36%	41.61%	24.39%	106.82%	
Subcenter Totals excluding the CBD							
1990	2,870	239	2,631	78,655	57,462	21,193	27%
2010	7,397	401	6,996	111,744	67,072	44,684	40%
Growth	157.74%	67.78%	165.91%	42.07%	16.72%	110.84%	
Growth in three Closest-in Subcenters [c] (Galleria, Westchase, Greenspoint)							
1990	4,265	437	3,828	161,748	130,249	31,499	19%
2010	11,210	647	10,563	221,366	160,234	61,132	28%
Growth	149.31%	52.13%	159.34%	37.62%	14.87%	101.10%	
Growth in three Farthest out Subcenters (Webster, Baytown, Katy)							
1990	615	28	587	14,301	10,099	4,202	29%
2010	1,775	80	1,695	23,179	12,664	10,515	45%
Growth	188.62%	185.71%	188.76%	62.08%	25.40%	150.24%	
Individual Subcenters							
CBD							
1990	2,329	255	2,074	104,658	87,548	17,110	16%
2010	6,803	373	6,430	147,838	113,302	34,536	23%
Growth	192.10%	46.27%	210.03%	41.26%	29.42%	101.85%	
Galleria (7.0mi)							
1990	1,494	128	1,366	39,934	28,869	11,065	28%
2010	3,902	218	3,684	61,266	38,210	23,056	38%
Westchase (13.4mi)							
1990	442	54	388	17,156	13,832	3,324	19%
2010	505	56	449	12,262	8,722	3,540	29%
Greenspoint (13.4mi)							
1990	319	29	290	7,264	4,662	2,602	36%
2010	1,215	47	1,168	15,037	7,476	7,573	50%

	Total Firms	*Large Firms*	*Small Firms* [a]	*Total Employees*	*Large Firm Employment*	*Small Firm Employment*	*Emp Share in Small Firms*
Webster (22.2mi)							
1990	273	15	258	8,083	5,996	2,087	26%
2010	787	46	741	11,677	6,546	5,131	44%
Baytown (26.1mi)							
1990	198	11	187	5,252	3,999	1,253	24%
2010	529	22	507	8,286	5,182	3,104	37%
Katy (31.1mi)							
1990	144	2	142	966	104	862	89%
2010	459	12	447	3,216	936	2,280	71%

Notes

[a] Small firms are defined as having 45 or less employees.

[b] Data source for 1990 is Dun and Bradstreet, and for 2010 is RefUSA. We deleted firms that did not address match, and which were recorded as having zero or unknown numbers of employees.

[c] We divide the subcenters, assuming those close-in are older and more mature than those farther from the CBD.

Table 2: Employment Characteristics by Industry, Houston 1990 and 2010

	Number of Firms	Total Employees	Number of Small Firms [a]	Employees in Small Firms	Share of Firms that are Small	Share of Total Emp in Small Firms
Total Houston						
1990	63,325	1,089,653	58,642	401,953	93%	37%
2010	166,193	2,138,111	158,619	1,192,948	95%	56%
By Industrial Sector						
Mining						
1990	1,494	56,380	1,302	9,575	87%	17%
2010	1,783	65,565	1,597	11,993	90%	18%
Construction						
1990	5,962	69,720	5,721	38,332	96%	55%
2010	11,358	137,624	10,840	64,150	95%	47%
Manufacturing						
1990	4,990	147,171	4,441	42,218	89%	29%
2010	6,540	189,675	5,777	52,666	88%	28%
Transport & Comm						
1990	2,720	89,796	2,434	20,819	89%	23%
2010	7,836	131,628	7,380	46,708	94%	35%
Wholesale Trade						
1990	7,393	93,468	7,079	51,967	96%	56%
2010	10,202	158,402	9,604	67,341	94%	43%
Retail Trade						
1990	12,599	146,563	12,045	78,550	96%	54%
2010	35,423	418,235	33,891	234,067	96%	56%
FIRE						
1990	5,989	89,246	5,740	37,715	96%	42%
2010	18,629	156,746	18,166	94,190	98%	60%
Services						
1990	21,057	374,417	19,799	121,720	94%	33%
2010	72,636	817,752	69,800	358,809	96%	44%
Public Administration						
1990	121	22,892	81	1,037	67%	5%
2010	1,786	62,484	1,564	15,239	88%	24%

Notes

a Small firms are defined as having 45 or less employees.

Table 3: Probability of Location by Subcenter by Firm Size: 2010
Logit Regression of Firm Location

		Subcenter [a]			*Three Mile Radius* [b]		
		Employees	t[d]	Elasticity[c]	Employees	t[d]	Elasticity[c]
CBD	Parameter	0.000562*		0.0142	0.000434*		0.0101
	Std Error	0.000150	3.75		0.000130	5.55	
	n[e]	63,134					
Galleria	Parameter	0.000238*		0.0100	0.000038		0.0018
7.03 mi	Std Error	0.00009	4.76		0.000066	1.42	
to CBD	n[e]	52,091					
Westchase							
13.4 mi	Parameter	-0.000302*		-0.0003	-0.00005		-0.0043
to CBD	Std Error	0.00008	-0.15		0.0002	-1.86	
	n[e]	11,043	3.775				
Greenspoint	Parameter	-0.000623		-0.0125	-0.000055		-0.0011
13.43 mi	Std Error	0.00103	-0.60		0.000272	-0.20	
to CBD	n[e]	18,596					
Webster	Parameter	0.000219		0.0046	0.000018		0.0004
22.24 mi	Std Error	0.000249	0.88		0.000221	0.08	
to CBD	n[e]	24,876					
Baytown	Parameter	0.000511*		0.0087	-0.000133		-0.0022
26.14 mi	Std Error	0.000198	2.58		0.000401	-0.33	
to CBD	n[e]	15,968					
Katy	Parameter	0.000313		0.0057	-0.000899		-0.0157
31.31 mi	Std Error	0.000229	1.37		0.000584	-1.54	
to CBD	n[e]	49,349					

Notes:
* indicates coefficient is statistically different from zero at the 10% level.
The regressions have as control variables the industrial sector of the firm at the 1 digit level, and a constant term. Each row represents a separate regression for each distance.
a Logit regression on the probability a firm locates in the designated subcenter, as a function of the number of employees of a firm.
b Logit regression that a firm locates within a subcenter, or within a three mile radius of the subcenter, as a function of the number of employees of a firm.
c For employees, calculated at the means.
d t statistic on the employee coefficient relative to zero.
e Number of firms in the market area of the regression (see notes to Table 2 for market areas). Note that the total number of firms is less than the the sum, as many of the market areas overlap.

Table 4: Logit Results by Industrial Sector[a] for 1990 and 2010

		1990			2010		
		Coeff	**Std Err**	**t**	**Coeff**	**Std Err**	**t**
Mining							
	Employees	0.00017	(0.00017)	1.00	0.000261	(0.000279)	0.94
	n			1,494			1,783
Construction							
	Employees	0.002*	(0.00071)	2.84	0.000254	(0.000314)	0.81
	n			5,962			11,358
Manufacturing							
	Employees	0.00202*	(0.00070)	4.49	0.000764	(0.000573)	1.33
	n			4,990			6,540
Transport and Communications							
	Employees	0.00139*	(0.00043)	3.30	0.0019***	(0.000748)	2.54
	n			2,720			7,836
Wholesale Trade							
	Employees	0.00029	(0.00049)	1.13	-0.00075	(0.001170)	-0.64
	n			7,393			10,202
Retail Trade							
	Employees	0.0019*	(0.00059)	3.27	0.00105***	(0.000370)	2.84
	n			12,599			35,423
FIRE (finance, insurance, and real estate)							
	Employees	0.0027*	(0.00112)	2.66	0.0042***	(0.001490)	2.82
	n			5,989			18,629
Services							
	Employees	0.000283*	(0.00011)	3.00	0.000168	(0.000109)	1.54
	n			21,057			72,636
Public Administration							
	Employees	0.00053*	(0.00017)	1.66	0.000348	(0.000261)	1.33
	n			121			1,786

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Logits for 1990 using Dun and Bradstreet data, for 2010 using RefUSA data.
The regressions also have a constant term. They use the market area equal to that of the Table 3.

a Logit regressions for one digit SIC codes, testing whether size influences whether the firm is within one of the seven subcenters (including the CBD).

b The number of observations varies for each industry

TABLE 5: Multi-Centric Employment Density Functions by Small and Large Firms: 1990 and 2010

Parameter Estimates		(1) 1990 *Small Firms*	(2) 1990 *Large Firms*	(3) Difference *Large - Small*	(4) 2010 *Small Firms*	(5) 2010 *Large Firms*	(6) Difference *Large - Small*
Intercept	Parameter	7.582***	7.66***		7.955***	7.81***	
	Std Error	0.213	0.266		0.214	0.226	
Slope[a] on Distance to:							
CBD	Parameter	-0.160***	-0.145***	0.015	-0.119***	-0.115***	0.004
	Std Error	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Galleria	Parameter	-0.0147	-0.033***	-0.018	-0.0082	-0.0124	0.004
7.03 mi to CBD	Std Error	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
WestChase	Parameter	-0.0299	-0.0029	0.015	0.028	0.0292	0.004
13.4 mi to CBD	Std Error	(0.04)	(0.02)	(0.04)	(0.02)	(0.02)	(0.03)
Greenspoint	Parameter	-0.00541	0.00093	0.015	0.011	0.007	0.004
13.4 mi to CBD	Std Error	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Webster	Parameter	-0.00839	-0.009	0.015	-0.021***	-0.012	0.004
22.2 mi to CBD	Std Error	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Baytown	Parameter	-0.0211***	-0.015*	0.015	-0.026***	-0.0125	0.004
26.1 mi to CBD	Std Error	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Katy	Parameter	0.0342***	0.0154*	0.015	0.017**	0.0146*	0.004
31.3 mi to CBD	Std Error	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
n (Census tracts)		572	520		647	629	
R^2 adjusted		0.518	0.426		0.439	0.339	

Notes:

* indicates coefficient is statistically different from zero at the 10% level.
The reported coefficients in each column are from a single polycentric regression.
Each subcenter has a limited market area, equal to the logit areas.
There are 649 Census tract observations in 2010, 20 of them have zero large firms.
There are 574 Census tract observations in 1990, 52 of them have zero large firms.

[a] Parameter estimate on distance to each employment subcenter, where the left hand side variable is employment density based on total employemnt in either small firms (<= 45 employees), or large firms (> 45 employees).
We include distance of the subcenter to the CBD because of the hypothesis that the farther out subcenters are more likely to be the newer ones.

Table 6: Probability of Location by Subcenter by Firm Size Over Time Using Individual Firm Observations

		Subcenter Location 1990[a]			*SubCenter Location 2010*[a]		
		Constant	Employees	t[d]	Constant	Employees	t[d]
CBD	Parameter	-3.268***	0.000806***		-3.16*	0.000562*	
	Std Error	-0.0214	-0.000158	5.10	0.013	0.000150	3.75
	n[e]	62,325				63,134	
Galleria	Parameter	-3.518***	0.000479***		-3.62*	0.000238*	
7.03 mi to CBD	Std Error	-0.0263	-0.000113	4.24	0.016	0.00009	4.76
	n[e]	51,386				52,091	
Westchase	Parameter	-4.700***	0.000471***		-5.51***	-0.000302*	
13.4 mi to CBD	Std Error	-0.0479	-0.000108	4.36	0.045	0.00008	3.78
	n[e]	48,494				11,043	
Greenspoint	Parameter	-5.035***	0.000208*		-4.641***	-0.000153	
13.43 mi to CBD	Std Error	-0.0562	-0.000107	1.94	-0.0291	-0.000307	-0.50
	n[e]	49,129				49,349	
Webster	Parameter	-4.496***	0.000218		-4.215***	0.000013	
22.24 mi to CBD	Std Error	-0.0613	-0.000249	0.88	-0.036	-0.000174	0.08
	n[e]	24,627				24,876	
Baytown	Parameter	-4.331***	0.000340*		-4.174***	0.000452	
26.14 mi to CBD	Std Error	-0.0717	-0.0002	1.70	-0.0446	-0.000549	0.82
	n[e]	15,140				15,968	
Katy	Parameter	-4.721***	-0.0164**		-4.855***	-0.00875**	
31.31 mi to CBD	Std Error	-0.0941	-0.0064	2.56	-0.0528	-0.00348	2.51
	n[e]	18,759				18,596	

Notes:

* indicates coefficient is statistically different from zero at the 10% level.

a Logit regression on the probability a firm locates in the designated subcenter, as a function of the number of employees of a firm.

d t statistic on the employee coefficient relative to zero.

e Number of firms in the market area of the regression (see notes to Table 2 for market areas). Note that the total number of firms is less than the sum, as many of the market areas overlap.

We include distance of the subcenter to the CBD because of the hypothesis that the farther out subcenters are more likely to be the newer ones.