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Where do manufacturing firms locate their Headquarters?

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Abstract

Firms' headquarters [HQ] support their production activity, by gathering information and outsourcing business services, as well as, managing, evaluating, and coordinating internal firm activities. In search of locations for these functions, firms often separate the HQ function physically from their production facilities and construct stand-alone HQs. By locating its HQ in a large, service oriented metro area away from its production facilities, a firm may be better able to out-source service functions in that local metro market and also to gather information about market conditions for their products. However if the firm locates the HQ away from its production activity, that increases the coordination costs in managing plant activities. In this paper we empirically analyze the trade-off of these two considerations.

Key words: headquarters, coordination, location decision, manufacturing

JEL codes: L60 R0 R12

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1. Introduction

A firm's production activities are supported by headquarters [HQ], which process information within the firm and between firms, provide service functions for the firm such as advertising, accounting and legal services, and co-ordinate and administer a variety of plant level activities within the firm. Sometimes, firms, especially bigger firms spatially separate administrative functions from production activity and create stand-alone HQs. This paper examines the trade-offs involved in manufacturing firms' decisions about where to locate these stand-alone HQs. Many stand-alone decisions may simply reflect a firm's desire to separate its administrative functions away from the noise and grime of production, within the same complex or local area. However as suggested in Lovely et al. (2003) and Davis and Henderson (2004), firms may choose a location away from production facilities, so as to gain better access to information and to better out-source certain service functions. Aarland, Davis, Henderson, and Ono (2005) find that when a firm's production is performed primarily in a small city, the firm is more likely to establish a stand-alone HQ; and often locates it in a larger metro area possibly to better out-source service activities. Ono (2003) finds that plants in firms with HQs do much less outsourcing than plants in firms without HQs.

While gathering information and outsourcing business services is one function of HQs, HQs play an important role in managing, evaluating, and coordinating internal firm activities. Being near production facilities reduces communication and monitoring costs and makes these other functions much easier to carry out. Of course if production facilities of firms are geographically dispersed, firms may find co-ordination costs are reduced by locating HQ's centrally to all production facilities, but away from any specific facility. For example, Aarland et al. (2005) find that firms with geographically dispersed production plants are more likely to locate HQ's in counties where they do not perform any production activities.

In this paper we consider a model where firms are trading-off these considerations in choosing the location of their HQs, in a context where many production facilities are in smaller cities or even rural areas. If they choose a large, service oriented metro area away from their production facilities they may be better able to out-source service functions in that local metro market and also to gather information about market conditions for their products. However if they locate away from the center of their production activity, that increases their coordination costs in managing plant activities. This paper thus extends Lovely et al. (2003) and Davis and Henderson (2004) which look at firms' choices of metro areas for their HQs without reference to plant locations. We ask how important proximity to production facilities is, compared to better access to information and intermediate service suppliers. And, how do such trade-offs change based on firm characteristics such as size?

Apart from learning about these trade-offs, studying firms' decisions about which cities to put HQs in will reveal how firms value different aspects of metro area environments such as the availability of local business services and the scale of other HQ activity reflecting localized scale externalities. For the former, we will employ a Dixit-Stiglitz-Either framework where firms value diversity of local intermediate inputs, as well as being concerned with their local costs.

We focus on manufacturing in this paper. Since manufacturing plants are found disproportionately in rural areas and small metro areas (see Section 2), this creates a stark contrast between locating a HQ close to plants and locating a HQ in bigger cities. As compared to manufacturing, retail, and service sectors have distinctly different geographical patterns. Retail outlets of major firms are found in most large metro areas. As such, in retail, HQs are almost always located in proximity to "production" facilities, simply because if a HQ is located in any major metro area there is also sure to be a retail outlet there. In addition, unlike manufacturing plants with their relatively high fixed plant capital and need for access to raw materials, retail chains have regional systems of administrative units coordinating and supplying local outlets, where the location of outlets is constantly shifting. Therefore, our empirical strategy may not be suitable for these sectors.

2. HQs Locations

To motivate our formulation of the location problem we first look at some data on location patterns of manufacturing, business services, and HQ activity. In order to capture the pattern of geographical distribution of each activity, we calculate the location quotients (LQs), which measure how disproportionately a given activity is concentrated in a location compared to overall economic activity. Based on the 1997 County Business

Patterns, for each county in the USA, we calculate a county's share of the national total count of establishments in a given activity (e.g., HQs) and divide, or normalize it by the county's share of national total private business establishments. We use establishment counts to measure LQs, rather than employment, since the latter are subject to censoring. In Figures 1-3, we plot LQs for each activity against the county's size, as measured by the ln(total private employment) for counties with 10,000 or more employment.[2]

What Figures 1 and 2 reveal is that manufacturing production activity is found disproportionately in rural counties and smaller urban counties, as indicated by the low (below 1) LQs for manufacturing in larger counties. In contrast business services are found disproportionately in large urban counties.

Turning to manufacturing HQs' location, note that based on the 1997 CBP, we can observe only the geographical distribution patterns of a slightly bigger category labeled as auxiliary establishments.[3] In the empirical part of this paper, we will use the Census micro data set, where we are able to identify HQs that support manufacturing activity. However, here, we use the CBP to circumvent disclosure problems for the Census micro data. In Figure 3, we explore the location patterns of manufacturing auxiliary establishments. The figure suggests a quite dispersed geographical pattern of manufacturing auxiliaries, which appears more like the figure for manufacturing production activity than that for business services. While we cannot present the corresponding graph based Census micro data, this same dispersed pattern is also found there.

The relative concentration of HQs in medium and smaller size cities contrasts with the geographical distribution of business service industries, which makes a fundamental point, noted in Aarland et al (2003). HQs are not as disproportionately concentrated in large metro areas as is commonly thought. For example, New York County (Manhattan) is not really a HQ's center per se, as can be seen in Figure 3. It is business service center. As such, it does draw in some number of HQs, which seek to

[2] For small counties, the measure of LQ is influenced by the lumpiness of the data.
[3] In the Census micro data for 1997, over 65% of auxiliary establishments fall in the category of HQs as defined as NAICS 551114. If one goes to the 2000 CBP data we can separate out HQs from other auxiliaries using the NAICS classification. However in 2000, we cannot distinguish manufacturing from other industries.

purchase business services or who seek visibility and exchange of information (Davis and Henderson, 2004); but the concentration is fairly modest compared to business services.

3. Model

To help structure the discussion, we outline a simple model of the relationship between a firm's HQ location and firm productivity. The model is stylized, but it motivates the empirical formulation and issues raised later. A firm's HQ activity is performed using HQ employment and purchases of local intermediate inputs. HQs purchase these services each in their local markets, and we assume that the variety of services available varies across locations. We also assume that a HQ's productivity is influenced by several other factors. First is the scale of HQ activity of other firms at the locality, which represents the externality from these activities such as information spillovers. Current evidence (eg., Rosenthal and Strange 2004) suggests such spillovers are very localized, consistent with the findings in Jaffe et al (1993). Second are firm characteristics such as firm size, and the third is the geographical relationship between the HQ's location and the locations of the firm's production activities. The geographical relationship between a HQ and the firm's production plants also influences how efficiently the HQ can support, manage, and monitor its plants.

Based on these notions, we write the production function of firm *k*'s HQ located at *i* as follows.

$$h_{ki} = A(N_i^{HQ}, \mathbf{X}_{ki}, S_k) l_{ki}^{\phi} (\sum_{j}^{m_i} z_{kij}^{\rho})^{\alpha/\rho} \qquad (1)$$

where h_{ki} is the service level of firm *k*'s HQ located at *i* and its direct inputs are l_{ki}, the HQ's own employment, and z_{kij}, the amount of service *j* that the HQ purchases in its location *i*. These purchased services enter in Dixit-Stiglitz-Ethier fashion, where m_i is the number of varieties of business services available at location *i*. ρ measures the technical need for variety of differentiated service inputs in HQ performance and α is a share parameter. The closer ρ is to one, the more substitutable are inputs and the less important is diversity of services. Note that the elasticity of substitution is $1/(1-\rho)$.

In equation (1), the HQ's service production is subject to a Hicks' neutral shift factor $A(\cdot)$, which contains three arguments. First is N_i^{HQ}, the number of other HQs at location i; assuming that there are localized scale economies of HQ activities, $\partial A / \partial N_i^{HQ} > 0$. Second, S_k represents characteristics of firm k, and $\mathbf{X}_{ki}$ is a vector of variables representing the geographical relationship between firm k's HQ located at i and the locations of the firm's production plants.

Assuming that HQs employ labor and purchase intermediate business services from local markets, we denote the wage of HQ labor and the price of service j in location i by w_i^{HQ} and p_{ij}, respectively. We assume that intermediate services are produced under monopolistic competition, where there are many local demanders, and the local equilibrium is symmetric. The labor required by a differentiated service to produce total local output Z_{ij} is $L_{ij} = c_0 + c_1 Z_{ij}$ and labor is employed at a wage rate of w_i. Then by standard results, $p_{ij} = c_1 w_i / \rho$, where $1/\rho$ represents the extent of mark-up over marginal cost $c_1 w_i$.

As the next step in defining the contribution of a HQ to a firm's profits, we now look at a firm's sub-problem of choosing the optimal level of its HQ's activity, by deciding the level of inputs used by the HQ, l_{ki} and $\{z_{kij}\}$, taking the locations of the HQ and the firm's plants as given. We write the contribution of a HQ located at i to the overall profit of firm k as $\pi_{ki}^{HQ} = h_{ki} - (w_i^{HQ} l_k + \sum_j^{m_i} p_{ij} z_{kij})$. Solving the maximization of π_{ki}^{HQ} w.r.t. l_{ki} and $\{z_{kij}\}$, assuming symmetry across intermediate service suppliers and using $p_{ij} = c_1 w_i / \rho$, we obtain

$$\pi_{ki}^{HQ} = c_4 A(N_i^{HQ}, \mathbf{X}_{ki}, S_k)^{1/c_3} (w_i^{HQ})^{-\phi/c_3} (w_i)^{-\alpha/c_3} (m_i)^{\frac{1-\rho}{\rho}\alpha/c_3} \quad , \tag{2}$$

where $c_3 \equiv 1/(1\text{-}\phi\text{-}\alpha)$, and c_4 is a collection of parameters.

Turning to the firm's problem of choosing its HQ location, given (2), a firm looks across feasible locations and chooses the location for the HQ that maximizes the HQ's contribution to firm profits. π_{ki}^{HQ} varies based on firm-county variables, $\mathbf{X}_{ki}$, which characterize each county's geographical relationship to production plants of firm k. π_{ki}^{HQ} is increasing in the variety of intermediate services available at the local market, decreasing in local labor costs, and increasing with the numbers of other HQs at the locality, due to positive scale externalities. Note that equation (2) shows that π_{ki}^{HQ} also depends on firm characteristics S_k; but since these do not vary across counties, if we impose separability within A(·), they will not influence the HQ location decision.

4. Empirical Implementation

Based on the above model, we assume that a firm chooses a location for its HQ by comparing π_{ki}^{HQ}, across possible locations. In particular, we use the county as the geographical unit and examine the firm's choice of counties for its HQ. Apart from the arguments in equation (2), we assume there is a random component, ε_{ki}, and unobserved county specific attributes, g_i that influence π_{ki}^{HQ}. Thus we write

$$\ln \pi_{ki}^{HQ} = \boldsymbol{\beta}'\mathbf{X}_{ki} + f_i + \varepsilon_{ki}, \quad (3a)$$

$$\text{where } f_i = \boldsymbol{\gamma}'\mathbf{X}_i + g_i \ . \quad (3b)$$

In (3), f_i represents both measured and unmeasured county attributes that influence HQ productivity. The measured county attributes are summarized in the vector $\mathbf{X}_i$. Below we discuss how we measure these county attributes, as well as firm county attributes, $\mathbf{X}_{ki}$, which describe the geographical relationship with the HQ and plants. $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are vectors of parameters.

To estimate the parameters in (3a), we assume the Type I extreme-value distribution for ε_{ki} and we perform multinomial logit with $\mathbf{X}_{ki}$ and county dummies as covariates. Then, to estimate the parameters of equation (3b), we use the estimated coefficients of the county dummies from (3a), $\hat{f}_i$, as the dependent variable; and estimate equation (3b) by OLS and IV methods. The issue with OLS estimation is that the measured county characteristics, $\mathbf{X}_i$, which affect profitability in the county may be correlated with the unobserved/unmeasured characteristics represented by g_i. The two stage estimation procedure follows Berry (1994) and Bayer, McMillan and Reuben (2004). We describe the instruments and IV estimation methods below.

Note that in (3a) and (3b), all firms are assumed to have the same coefficients for covariates, or the same technology. In estimation, we will experiment to allow firms to be heterogeneous in the sense of having different coefficients. Say larger firms which could be typed as higher quality firms may value aspects of urban environments differently. It may be that firms of different sizes value the availability of outsourcing possibilities or access to plants differently. Let us denote size of firm *k* as S_k. Then, based on equations (3a) and (3b) under heterogeneous coefficients, we rewrite the equation so that coefficients for X_i and X_{ki} vary with S_k:

$$\ln \pi_{ki}^{HQ} = (\boldsymbol{\beta}_1 + \boldsymbol{\beta}_2 S_k)'\mathbf{X}_{ki} + (\boldsymbol{\gamma}_2 S_k)'\mathbf{X}_t + f_i + \varepsilon_{ki}\,, \qquad (4a)$$

$$\text{where } f_i = \boldsymbol{\gamma}_1'\mathbf{X}_i + g_i \;. \qquad (4b)$$

In the above equation, f_i represents the effect of measured and unmeasured county variables that are common to all firms. $\boldsymbol{\gamma}_2$ represents how the effect of $\mathbf{X}_i$ changes depending on firm size and $\boldsymbol{\beta}_2$ represents how the effect of $\mathbf{X}_{ki}$ changes based on firm size. We perform multinomial logit to estimate $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$, $\boldsymbol{\gamma}_2$, with county fixed effects represented by f_i. Then, we perform OLS and IV estimation to recover $\boldsymbol{\gamma}_1$.

5. Data

We use micro-level data from the *Auxiliary Establishment Surveys* (*AES*) and the *Standard Statistical Establishments Lists* (*SSEL*) compiled and organized by the U.S. Census Bureau. The *AES* is a census containing information on firms' non-production (auxiliary) establishments including HQs, while the *SSEL* is the list of all private establishments in the USA containing basic information such as location, industry, and total employment. Among auxiliary establishments (that are physically separated from production plants of firms) in the *AES*, establishments we refer to as HQs are those which fall in the category of NAICS 551114 in the 1997 *AES*. NAICS 551114 includes corporate, subsidiary, and regional headquarters of firms.[4]

[4] NAICS 55114 definition: establishments (except government establishments) primarily engaged in administering, overseeing, and managing other establishments of the company or enterprise. These establishments normally undertake the strategic or organizational planning and decision making role of the company or enterprise. Establishments in this industry may hold the securities of the company or enterprise

5-1. Sample

As detailed in Aarland et al. (2005), stand-alone HQ activity applies to a small part of the firms in the USA economy. Only .34% of firms have HQs, although these firms do employ 37 million workers. And among the HQs, there is a big portion of HQ's belonging to some very large "multi-national" corporations with very diverse production patterns (Aarland et al., 2005). These firms typically have 20 to 30 HQs each, where each HQ is responsible for some sub-division of the firm or some set of operations. For these firms, it is not clear how to identify which plants are supported by a given HQ, and this makes it difficult to see how a specific HQ is located relative to the production facilities that the HQ supports.

In order to better see the effects of plant locations on a firm's decision on HQ location, we focus on the event where firms establish a single stand-alone HQ for the first time. In some sense, we are intercepting firms' growth path, where the firms initially have several plants and later decide to have a stand-alone HQ, possibly because of the increased needs for coordinating plant activities and outsourcing for plants, etc. By examining just these firms, we can see how the location for the first HQ is chosen, without introducing the complication that the location of the firms' pre-existing HQ's might also have some influence, apart from the whole issue of trying to assign specific HQ's to specific plants within the firm. Having said that, we note that our sample is not dissimilar to multi-establishment manufacturing firms more generally, where we define a firm as manufacturing, if over 50% of its plants' employment is in manufacturing. For example the 14,797 multi-establishment manufacturing firms in 1992 have a mean of 3.9 manufacturing plants per firms and a mean of ln(total firm manufacturing employment) of 5.06. For our sample, as discussed later in Table 1, the respective means are 3.6 and 5.36. Our firms are a little larger in terms of employment and a little smaller in terms of numbers of plants.

(US Census Bureau, 2001). These establishments are to be distinguished from "back offices" which the Census defines as establishments primarily engaged in providing a range of day-to-day office administrative services such as billing and record keeping. These come under NAICS 56111 (office administrative services).

Using 1992 and 1997 *AES*s and *SSEL*s, we identify 488 manufacturing firms that established a new single HQ between 1992 and 1997 and that pre-existed in 1992.[5] Of these 488 firms, 127 firms had all manufacturing production activity in one county and the rest had on average about 60% of their production activity (in terms of manufacturing plant employment) in one county. For firms with production activity spread over several counties, most have one county that is clearly the dominant location of plant activity. For each firm, we define a base county – the one which has the greatest share of the firm's production activity (in terms of plant employment). For the firms in our sample, 372 firms have an urban base county, and 116 firms a rural base one.

Of the 372 urban-based firms, almost all of them choose an urban county as their HQ location, and of those 55% locate the HQ in their base county. However, the firms that did not choose their base urban county establish a HQ that on average is 616 miles away from their base county.[6] For the 116 rural-based firms in our sample, 46 have their HQ in a rural area. Virtually all of these are either at their base rural county or are collocated with other plants. The rest (70 firms) chose urban counties as their HQ location away from rural production facilities. Interestingly, the majority of these firms do not choose the nearest PMSA, which is on average located about 51 miles from their base county. Instead, on average they establish their HQ 550 miles away from their rural base.

Our first focus is on the 429 urban and rural based firms that established their HQs in urban area. We restrict ourselves to urban counties, since it is only for these that we can construct some variables on county characteristics (see Section 5-2), and firms virtually never choose a rural county for an HQ unless production is sited there. For the 429 firms in our sample, we examine why a firm chooses a specific county for the HQ location, as compared to other urban counties. Is it because the county has the firm's production facility, or is close to the centroid of all the firm's production activities? Or is it because the county offers a greater variety of business services, for example?

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[5] The *AES*s vereport the main production activity that each auxiliary supports at the 2-digit SIC level. We focus on firms that did not have any stand-alone HQs in 1992 and established a single manufacturing HQ between 1992 and 1997.
[6] Note that we calculated the average distance excluding some outliers.

This choice problem describes the full problem for urban-based firms—which urban county to put their HQ in. However for rural-based firms, we have only analyzed which urban counties are chosen by the set of firms that do not put HQs in their rural dominant counties. In logit framework, for rural based firms there is an upper level of nesting, where the firm "first" makes a decision about whether to collocate the HQ with its rural facilities or not. At the end, we will look at the upper level nesting problem and the dichotomous decision for rural based firms of whether to collocate or not.

5-2. Covariates

Here we describe the variables used in estimation and their rationale. We construct all variables for covariates based on data in 1992, the base year in which births occur between 1992 and 1997. This avoids capturing the effect of a newly selected HQ location on the locations of a firm's production plants, which we treat as exogenous. For example, suppose a firm establishes a HQ in a county because of, say greater variety of services available there. It is possible that the firm learns that the locality of the HQ is also suitable for production activities and in order to reduce coordination costs, moves plants closer to the new HQ location. While this scenario is not inconsistent with the story that we have in our mind, looking at plant location ex post would result in overestimating the importance for HQ location decisions of proximity to production activity.

Firm-county attributes

What variables do we adopt to capture the geographical relationship between a potential county for a firm's HQ location and locations of the firm's production activities, as summarized by $\mathbf{X}_{ki}$? The $\mathbf{X}_{ki}$ variables are meant to capture how suitable a county is for a HQ to coordinate and serve production activities. As we discussed earlier, proximity to the production activity would reduce costs of coordination as well as costs of "transferring" business services both produced and outsourced by the HQ back to plants. As a measure for such proximity, we calculate the distance from a county to the centroid of a firm's production activity.

To do that, we first identify the centroid of all the places where the firm's manufacturing production takes place. Denoting firm *k*'s manufacturing employment in county *i* by n_{ki} and the longitude and latitude of geographic center of county *i* by (x_i, y_i), we calculate the centroid for firm *k*, (x_c^k, y_c^k), as:

$$x_c^k = \sum_i x_i \left(\frac{n_{ki}}{\sum_i n_{ki}} \right), \text{ and } y_c^k = \sum_i y_i \left(\frac{n_{ki}}{\sum_i n_{ki}} \right)$$

We then calculate the distance from each county to that centroid to measure how far each county is to the centroid of the firm's production activity.

Note that for a firm that has all of its production activities in a county, the centroid is the center of the base county. In our sample of 429 firms, 116 firms have all production activities in one county. In addition to the distance to the centroid, we also use dummy variables indicating, for each county, whether the county has any of the firm's activity; and we distinguish between firms that have all production activity in one county versus those which have production activity in multiple counties. And for multi-county firms, we also estimate the additional effect of a county being the base county.

County attributes

How do we measure county specific attributes summarized by $\mathbf{X}_i$? First, as discussed above in equation (2), we specify that firms' profitability is affected by the extent of other HQs in the county, representing the possibilities for localized information spillovers and gathering about market conditions, innovation, and the like. As a measure of the local scale of HQ activities, we use the number of other manufacturing HQs in a county.

Second, equation (2) also shows that firms consider cost conditions in choosing the location for HQs. There are labor costs for HQ employees. For each of all the stand-alone HQs in 1992, based on the AES data set, we calculate the average annual payroll per worker. Then, assuming that the labor market is at PMSA level, for each PMSA, we take the median of the average payroll among HQs in the PMSA. This is a standard procedure in the literature for calculating potential wage rates facing new establishments to a location. However for new HQs in particular, many employees may not be new and may be transferred from the base facilities. As such their labor costs may be determined by historical firm factors and prior wages, so the constructed county wage variable may poorly measure labor costs for these new HQs. In addition, we control for PMSA employment, which controls for rent costs, as well as urbanization economies and other aspects of general PMSA scale.

The most critical issue concerns how to treat the differentiated intermediate business service inputs in equations (1) and (2). Following Davis and Henderson (2004), rather than thinking of there being one type of differentiated business services, we consider eight categories to be included as intermediate service sectors. The eight categories we consider (with SIC code) are advertising (7310), employment agencies (7361), computer and data processing (7370), legal (8100), engineering and architectural (8710), accounting (8720), research and testing (8730), and management and public relations (8740). We assume intermediate service producers within each service sector are identical, so there is a symmetric outcome. We also assume that ρ is common across all eight sectors so as to allow eight rather than one sector to be included in equations (1) and (2), and we create two indices:

$$w_i^I \equiv \sum_{s=1}^{8} \frac{\alpha_s}{\alpha_T} \ln w_i^s, \quad m_i^I \equiv \sum_{s=1}^{8} \frac{\alpha_s}{\alpha_T} \ln m_i^s \text{ , where } \alpha_T \equiv \sum_s \alpha_s$$

Taking the logarithm of π_{ki}^{HQ} in (2), we can see that in estimation, the parameters of the two indices, w_i^I and m_i^I, are respectively $-\alpha_T / c_3$ and $(1-\rho)\alpha_T / \rho c_3$, from which we can recover ρ.

For any sector, such as advertising, α_s / α_T is calculated from national input-output tables for 1992 as total expenditures in all manufacturing on advertising divided by total expenditures on all eight business service inputs in all manufacturing. The index for each county w_i^I then is the weighted sum of wages (in log) in each of the eight sectors in that county and m_i^I is the weighted sum of the number of establishments (in log) in each service sector in that county. For sector wages, w_i^s, the median of the per-worker wage of establishments in each sector in a given county is used, and they are calculated based on the *SSEL*. Counts of establishments, m_i^s, are from the CBP (Davis and Henderson, 2004).

Note that, in order to calculate these indices for a given county, we need the data for wages as well as the number of establishments for all eight service inputs. However, these generally exist only for central urban counties; for rural and suburban counties there are almost always holes — sectors that don't appear. Business services are highly concentrated in the central business county of each metro area and data suggest that suburban firms make their purchases from these centrally located firms (Swartz, 1992).

Therefore, assuming that a HQ has access to the services at the central county, for each county in a PMSA, we assign the index calculated for the central county.

Firm-level variables

As we discussed earlier, we will also estimate a heterogeneous coefficients model, as specified in equations (4a) and (4b), where we want to represent firm "quality". Higher quality firms may have different profit functions, with different intensities of intermediate business service inputs usage or of local scale externalities. We will generally differentiate firms for this purpose by assuming "quality" is reflected in size, measured by the log of total number of employees of the firm in its manufacturing plants in 1992.

5-3. Summary Statistics

As we mentioned in Section 5-1, there are 429 firms, which chose urban counties as a HQ location. We will also look at a sub-sample of 133 firms, with free-standing HQs which are not collocated with production facilities, as discussed below. Some key firm characteristics are summarized in Table 1. Column 1 is for the full sample, and column 2 for the sub-sample. Firms in the full sample have on average 3.6 manufacturing plants each, which are geographically spread out. The average of log firm mfg. plant employment is 5.36 (sd = 1.34), which is equivalent to 212 employees.

Table 2 shows summary statistics of county variables. There are about 800 urban counties as of 1994 in the USA, but among them, only 204 counties (belonging to 140 PMSAs) were chosen as locations of HQs by the 429 firms included in our base sample, and 91 counties (belonging to 75 PMSAs) are chosen by 133 firms in our sub-sample.

6. Empirical Results

Here we present our empirical results. In Section 6-1, we discuss the results from the homogeneous case as specified in equations (3a) and (3b), and in Section 6-2, we discuss the results from the heterogeneous case.

6-1. Results from homogeneous case

Table 3a presents the results of the multinomial logit based on equation (3a), where we examine the effects of $\mathbf{X}_{ki}$ on firms' location choice for their HQs. We focus first on the results for the full sample containing 429 firms (column 1). However we also look at the sub-sample containing 133 firms with free-standing HQs (column 2). We then turn to equation (3b) to examine the effect of county specific characteristics, for which the results are shown in Table 3b. Why the sub-sample of 133 firms? As we will see momentarily, the location decisions of the 429 firms are typically "dominated" by concerns with collocating HQs with production facilities. Thus we want to check whether firms that don't collocate their HQs with production facilities evaluate county characteristics such as scale and business service cost and diversity differently than collocaters. For rural-based firms in this sample, who are non-collocaters, this is also a check that they have the same coefficients in equations (3) as other firms.

6-1-1. Results of multinomial logit: effect of firm county characteristics

Effect of distance

Table 3a presents the results from the multinomial logit in equation (3b) for the homogeneous case. In column 1, the results suggest that proximity to production plants is an overwhelmingly important attribute for a county to be selected as a HQ location. As we discussed above, a HQ has to communicate with, monitor, and evaluate production plants in supporting their activities. For a firm with production facilities in a single county, comparing the probabilities of being in a county without firm production to the county with production facilities, if the former has a base probability of say .005, ceteris paribus, the latter rises to .005 $e^{6.0}$, which is over 1. Of course the probability shouldn't exceed 1; but what the calculation ignores are the fixed effects (i.e., the ceteris paribus doesn't really hold). Counties with production facilities are generally inferior one to those without. For example the average fixed effect for the 113 counties where only collocating HQs locate is -1.76, while the average fixed effect for the 39 counties where only non-collating HQs locate is -1.06. Nevertheless the marginal effect of collocation is extremely large. Similarly, for firms with production facilities in multiple counties, the effect of a county having some production facilities is based on $e^{5.3}$; and, if that county is the dominant base county, the effect is enhanced by $e^{5.3+1.1}$. Note the overall effects of locating the HQ in the base county are similar for single and multiple county firms. Below when evaluating other effects we will do a comparison with the effects of collocation for a single county firm; but results would be similar if we did the comparison for a multi-county firms.

Apart from collocation effects, we also look at how distance from a county to the centroid of a firm's production activity, d^c_{ki}, influences a firm's probability of choosing that county as a HQ location. The coefficient is negative and significant. Locating the HQ further from the centroid reduces the HQ profitability. We can assess the magnitude of, say, a 1 s.d. decline in distance (538 miles) in two ways. First is the percent change in the probability which is approximately 77% (=538*.00143*100). Alternatively, one can compare the effect on profits relative to, say, choosing the base county for a single county firm. For a single-county firm, given that the firm did not choose its production county, the implied increase in HQ profit from decreasing the distance to the production county by 1 s.d. (536 miles) would be 13% (=(538*0.00143)/6.037*100) of what results from choosing to collocate in the production county.

This analysis should make it clear that collocation with plant activity is a dominant factor in location decisions for many firms. As such we also perform logit analysis for the sub-sample containing 133 firms, which do not collocate their HQs with any of their production activities, in order to see if the effect of distance to the centroid differs from the full sample. We exclude dummy variables (D1 and D2) here since we examine the location choice given that firms all establish non-collocated HQs. Column 2 in Table 3a presents the result, resulting in a similar coefficient to that in column 1, which shows again a negative and significant effect of the distance, d^{c}_{ki}, on HQ profitability.

6-1-2. Effect of county characteristics

Next, let us turn to the effects of county specific attributes as specified in equation (3b), based on the estimated fixed effects from equation (3a). As we discussed, estimation using OLS results in inconsistent estimates given the presence of unobserved and/or unmeasured county attributes, and we instrument all five county variables that we include in the model. In what follows, we first discuss our instruments.[7]

Instruments for IV Estimation

Instrumenting in a cross-section data set for aggregates such as county scale, HQ wages and the w_i^I m_i^I indices is difficult, in the sense that it is hard to find variables to use as

[7] For example, some unobserved county specific attributes such as the quality of labor and accumulation of creative persons, which might benefit HQs, would be correlated with average wage level. This would underestimate the negative effects of labor costs. Any unobserved county characteristics that attract these HQs may well attract other HQ activity as well as other activities to that county, causing the upward bias to the coefficient of the number of HQs as well as PMSA size.

instruments that are correlated with these covariates but do not plausibly affect HQ profitability. Nevertheless there are several strategies.

The first is to use variables that represent consumer amenities at each location but do not affect HQ profitability per se. For example, consumer amenities drawing in residents may partially be reflected in wage capitalization (Gyourko and Tracy, 1989) and also city size, but do not directly affect HQ productivity. We experiment with the full range of geographic variables from 1977 utilized by Rappaport and Sacks (2003).[8] In our context, however, these variables turn out to be weak instruments, and thus we do not adopt them. But we also have socio-economic measures of consumer amenities, such as the crime rate, which would not directly influence HQ productivity.

A second is to use historical measures of current covariates. The argument for these as valid instruments in identification is as follows. The shocks affecting productivity today are different from the shocks affecting productivity historically. The shocks that influence a firm's location choice for HQs might have to do with unobserved features such as density of the business district area, labor force quality, telecommunications, regulation and tax breaks for businesses, unobserved sources of information for HQs, etc. These change with time, especially given massive intra-state highway construction, suburbanization, changes in state and local political regimes, and massive population turnover in cities with the high degree of population mobility and immigration in the USA. However, despite these changes, for economic sectors where externalities are important, in theory (Arthur, 1989) and in practice (Black and Henderson, 2000), there is slower turnover of industries. This observation leads to a basic idea. Even if economic conditions change in a city so that for a cluster of firms in a particular sector it would be beneficial for all firms to move to some cheaper, sunnier, or less congested location, there is a co-ordination failure problem. Any one firm would not want to leave the original cluster since if all other firms do not follow, the firm loses the social capital and contacts at the original location. This idea can be expanded to looking at sales potential for a firm in a regional market and measures of the firm's market potential. Again it might pay the whole region to move en mass, but that also faces a co-ordination failure problem. And of course there are also pure relocation costs, from physically

[8] We thank to Jordan Rappaport for providing many of the variables.

moving, hiring new employees, re-establishing business links with suppliers and purchasers. All this suggests that there is potentially enormous persistence in magnitudes of covariates over time, even if certain unobservables affecting productivity change. But the usual view on historical variables is that to escape the correlation of unobservables affecting productivity over time, it is necessary to use "deeply" lagged covariates as instruments. We try to adopt variables calculated for 1977 going back 15 years. We will also use some county economic variables calculated for 1930.

Our instruments are a mixture of amenities and historical economic variables. As amenities, we include the 1977 violent crime rate and 1977 local employment by the federal government. We also include a dummy variable to indicate counties that belong to multi-county PMSAs and a dummy to indicate counties in suburban areas, which would represent PMSA size. For "deeply lagged" economic variables we used the 1930 Population Census counts of retail (central county of 1992 PMSA) and wholesale (own county) establishments and the average wage in the wholesale sector, as indicators of historical conditions in non-manufacturing that might persist and are correlated with later development of the business service sector. These instruments are satisfactory for some covariates but the degree of relevance indicated by the R-square from the first stage regression dramatically increases as we add 1977 measures for HQ wage and business service diversity and business service wage indices.

As a first stage regression, we regress each county specific variable on these ten variables. For all county variables, F-statistics and R-sq.'s are very high. For the base sample with 204 counties, adjusted R-sq.'s are .68 for the number of other manufacturing HQs (in log.), .96 for m_i^I, .62 for w_i^I, and .53 for HQ wage (in log), and .92 for PMSA employment (in log.). F-statistics are 44.9, 472.8, 33.4, 24.1, and 220.2, for the number of other manufacturing HQs, m_i^I, w_i^I, HQ wage, and PMSA employment, respectively, which are all high. They are strong instruments, with HQ wages having the weakest instruments. Below we report results on tests for their exogeneity and for the aptness of the overall specification.

We performed OLS, 2SLS, as well as IV-GMM to incorporate heteroskedasticity. The results from 2SLS and IV-GMM are qualitatively the same. Here, we report the results of IV-GMM.

Effect of the number of manufacturing HQs

Table 3b presents results on county characteristics. In terms of the estimation method, first we note F-tests in Table 3b and later Table 4b indicate the set of covariates are endogoneous.[9] Second we note that χ^2 values for specification tests, which test for exogeneity of instruments to residuals (as well as aptness of the overall specification) pass easily, with low test statistic values and high p-values.

In terms of estimated coefficients, we first look for evidence of positive scale externalities from having other HQs locally. As shown in Table 3b, for the homogeneous case, the effect of the number of manufacturing HQs is insignificant, which appears to be inconsistent with the findings in Lovely et al. (2003) and Davis and Henderson (2004). However as Lovely et al. (2003) also pointed out, it is possible that the externality has heterogeneous effects. We explore this possibility in Section 6-2, under the assumption of heterogeneous coefficients.

Effect of the degree of diversity of business services

Next, let us look at the effect of the price and the degree of diversity of intermediate services available at a county. In Table 3b, the effect of the index for local service diversity, m_i^I, is positive and significant. The variety of business services in a local market increases the profitability of HQs located there, and thus increases the probability that the county is chosen as the location for HQs. How about the effect of the price of business services represented by w_i^I? In column 1 of Table 3b, the coefficient for w_i^I is negative but insignificant. However, in column 2, where we focus on firms with non-collocated HQs, the results are sharper and the coefficient is negative and significant.

Based on the coefficients of m_i^I and w_i^I, we can recover ρ specified in equation (1). For the base sample (column 1 of Table 3b), ρ is calculated as .54 (=-.143/(-1.43-1.23)), and the elasticity of substitution σ is about 2 (=1/(1-.54)), indicating that there is some degree of substitution between intermediate services but it is not that high, so diversity is very important.[10] For the sharper results in column 2, the result is similar: ρ is .61 and σ

[9] The F-test for endogeneity involves regressing the county fixed effects on the five county specific attributes that we include as covariates and the residuals from the first stage OLS. The F-tests suggest the endogeneity of county specific variables, so that these variables have to be instrumented.

[10] From equation (2) the coefficients for m_i^I and w_i^I respectively are $(1-\rho)\alpha_T / \rho c_3$ and $-\alpha_T / c_3$.

is 2.5. To get a sense of magnitudes of diversity effects, as above, we compare the effects of collocating a single-county firm's HQ with its production facility versus that of the variety of services. For a single-county firm, given that the firm did not choose its production county, the implied increase in HQ profit from increasing diversity by 1 s.d. (1.12) would be 23% (=(1.23*1.12/6.037)*100) of what results from choosing the production county. Alternatively stated, the variety of business services has to increase by 4.4 s.d.'s – i.e., roughly from a minimum to maximum value of business services within the sample, in order for a firm to be indifferent between collocation and being non-collocated with a greater variety of business services, ceteris paribus.

For the sub-sample of non-collocating HQs, results are in column 2 of Table 3b. Effects of county variables are similar. But if we want to look at distance trade-offs for these firms alone, we would have to compare the effects of distance between their new HQs and their centroid and the effects of, say, diversity. Based on this, the percent increase in π_{ki}^{HQ} that results from increasing m_i^I by 1 s.d. (1.12) is around 1.8 times as large (=1.59*1.12/(.00156*642)) as the percent increase in π_{ki}^{HQ} that results from decreasing the distance by 1 s.d (642). Now for these firms that do not collocate HQs, diversity effects appear strong relative to access to plant effects.

Other effects

In both columns 1 and 2 of Table 3b, coefficients for PMSA size are negative and significant, showing that all other things being equal, congestion and rent effects make larger PMSAs relatively less attractive. Coefficients for HQ wage are insignificant. As mentioned before, firms may move their own employees to a new HQ location, and so that calculated HQ wage rates in that location may have little effect on the HQs' profitability. We also note this is the variable with the weakest instruments.

The upper level of nesting

In the estimation in Table 3, the full sample of 429 firms for that estimation excludes 46 rural firms whose production facilities are rural based and who chose to collocate HQs at the rural base. For the 116 total rural based firms, as explained above, we have only estimated the lower level nested logit problem: the choice of urban counties by 70 (=116-46) firms, conditional on those firms not having selected their rural production counties for their HQ locations. At the upper level of nesting, the 116 total rural based firms face a dichotomous choice of whether to collocate their HQs near their rural base production facilities versus away from their rural bases, in which case they then choose from the array of urban areas in which to put their HQs. To perform the upper level nesting, as in the standard procedure, we calculate the inclusive value for each of the 166 rural based firms, using the 204 urban counties included in lower level estimation (including county fixed effects for each urban county as part of the inclusive value calculation). We then add as covariates firm variables such as total firm manufacturing employment, share of that employment in the rural base county, distance from the rural base county to the nearest PMSA, and employment of the nearest PMSA. In the upper level logits, the inclusive value is always significant and positive, indicating correlation of error drawings across urban areas, compared to the drawing for the rural own county. However all other covariates are insignificant, whether entered collectively or on their own. If the inclusive value is excluded, then the share variable on its own is significant, where a greater share of the rural base county in firm production operations increases the probability of collocation. However given that the results on these other covariates are uninteresting once the inclusive value is added, we don't report them.

6-2. Results for the Heterogeneous Case

As we mentioned earlier, based on equations (4a) and (4b) we experiment with allowing for heterogeneous coefficients where effects vary by firm "quality", as measured by size. We first performed multinomial logit, allowing heterogeneous coefficients for all county and firm-county variables. Given our limited sample size, however, we found that there is little evidence of overall heterogeneity; and results with so many coefficients are weak. Therefore, we decided to focus on the variables, for which we found stronger evidence for heterogeneity. These are the dummy variables for multi-county firms and the effect of the scale externality from HQ activity. The last is statistically insignificant in the homogeneous case (Table 3b); but it has a different impact under heterogeneity.

Results are shown in Tables 4a and 4b. For county-firm variables, the variables having statistically significant heterogeneous effects are those for multi-county firms -- both the dummy variable (D1) indicating a county with firm production activity and that (D2) for the base county. Column 1 of Table 4a tells us that for larger firms, the effect of having collocated plant activity diminishes with firm size, but the effect of being in the base county itself increases with firm size. For larger firms, the absolute scale of production at the base county is greater. It is possible that the greater scale of production requires special support from the HQ, which might increase the likelihood of keeping HQs in the base county for larger firms.

We now turn to the effect of the scale externality variable, the key item we are interested in terms of heterogeneity. As shown in Table 4a where we estimate equation (4a), for the full sample, the coefficient of the heterogeneous term for the number of manufacturing HQs is positive and significant, indicating that bigger firms value the local scale of other firms' HQ activity more. In Table 4b based on equation (4b), the base effect of the number of manufacturing HQs is negative and is now significant; the overall scale effect is $-.561+.102\times S_k$. As shown in Table 1, mean firm size measured in terms of log plant employment is 5.4 and the standard deviation is 1.3. At just over the average firm size, the scale effect becomes positive and then rises with firm size. It is possible that larger firms have greater needs to learn from other firms, and therefore it might be beneficial for them to locate their HQs close to other firms' HQs. Note that in our current specification, however, for firms that are smaller than the average size, the effect of the number of manufacturing HQs appears to be negative. While this could just reflect the confines of the linear specification, it is possible that there are some competition effects that make counties with greater number of other manufacturing HQs less preferable for small firms.

Nevertheless, here we calculate the effect of scale externality for a larger firm. For a firm with the size of, say, 1.5 s.d. (1.95) above the mean firm size, the coefficient is .189 (=-.561+.102×(5.4+1.95)). From column (1) in Table 2, $\ln(N_i^{HQ})$ is on average 2.2 (which translates to about 9 HQs per county) and standard deviation is 1.3. Based on this, we found that, even for a big firm, the increase in its π_{ki}^{HQ} that results from 1 s.d. increase in $\ln(N_i^{HQ})$ is much smaller than that of m_i^I and is even smaller than the effect of 1 s.d. decrease in the distance to the centroid. The percent increase in π_{ki}^{HQ} due to 1 s.d. increase in $\ln(N_i^{HQ})$ is only 17.5% of that of m_i^I and is 28.9% of that for decreasing the distance to the centroid.

Lastly, in Table 4b, the coefficient of wage/cost index for services is now significant, while ρ is almost the same as we found from the homogeneous results. In Table 4b, ρ is .54 for base sample (column 1), and .62 for the sub-sample (column 2).

7. Conclusion

Using the sample of manufacturing firms that first established a single stand-alone HQ between 1992 and 1997, we found that in choosing the location for HQs, firms consider not only greater variety of services and/or greater local scale of other firms' HQ activities, but also geographical proximity to their production facilities. In fact, at least for the firms in our sample, our empirical results suggest that it is very costly for firms to send HQs away from the counties where they have production facilities, possibly due to increased communication and coordination costs. Thus, firms would not choose such counties unless the counties offer much greater variety of business service or, for bigger firms, greater scale of other HQ activities. However, once firms send HQs away from their base production counties, while a shorter distance to the centroid for HQ location is preferred, firms seem to be more focused on searching for county attributes that enhance their outsourcing possibilities.

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Table 1: Firm Characteristics

	(1)		(2)	
	All 429 firms (full sample)		133 firms with free-standing HQs	
	Mean	S.d.	Mean	S.d.
No. of mfg. plants	3.597	3.216	3.301	2.807
Firm's mfg. plant employment (in log)	5.356	1.337	5.608	1.300
Distance from the new HQ to the centroid	384.8	537.7	636.6	641.6
Distance from the new HQ to the base county	379.1	678.5	696.3	735.7

Table 2: Characteristics of counties in choice sets

	(1)		(2)	
	Counties chosen by firms in full sample		Counties chosen by firms with free-standing HQs	
	204 Counties		91 Counties	
	Mean	S.d.	Mean	S.d.
Log (No. of mfg. HQs)	2.168	1.297	2.623	1.280
w_i^I	2.481	0.247	2.500	0.240
m_i^I	3.917	1.121	4.208	1.121
Log (PMSA HQ wage)	3.626	0.148	3.647	0.139
Log (PMSA employment)	12.806	1.219	13.07	1.198

Table 3: The results from homogeneous case

3a: Multi-nomial logits

	(1)	(2)
	429 firms	133 firms
D1: =1 if a county has the firm's mfg. plants ×*DS*: =1 if *Single-county firm*	6.037*** (.338)	NA
D1 × *DM*: =1 if *Multi county firm*	5.344*** (.203)	NA
D2:= 1 if a county is the firm's base county × *DM*	1.101*** (.225)	NA
d_{ki}^{c} : Distance to the centroid	-.00143*** (.000143)	-.00156*** (.000220)
County fixed effects	Yes (204 counties)	Yes (91 counties)

Counties with D2=1 are a subset of counties with D1=1 for each firm**.**

3b: IV GMM: Dependent variables: County fixed-effects

	(1)	(2)
	204 counties	91 counties
No. of mfg. HQs (in log.)	-.0310 (.0590)	.0226 (.126)
m_i^I	1.229*** (.286)	1.585*** (.430)
w_i^I	-1.428 (.947)	-2.608** (.828)
HQ wage (in log.)	.977 (1.030)	.482 (1.244)
PMSA size	-.804*** (.223)	-.906*** (.209)
Hansen J statistic χ^2 [p-value]	χ^2 (5)=4.341 [.501]	χ^2 (4)=6.242† [.182]
F- test for endogeneity:	F(5, 193) 2.50 [.032]	F(5, 80) 4.64 [.0009]

Robust standard errors with clustering over counties in the same PMSA are used.

†: 1977 value for m_i^I is excluded from IV list in column 2 to increase the overall validity of the IVs.

Table 4: The results from heterogeneous case

4a: Multi-nomial logits

	(1)	(2)
	429 firms	133 firms
D1: =1 if a county has the firm's mfg. plants × *DS*: =1 if *Single-county firm*	6.123*** (.341)	NA
D1 × *DM*: =1 if *Multi county firm*	9.772*** (1.011)	NA
D2:= 1 if a county is the firm's base county × *DM*	-2.090*** (1.003)	NA
d_{ki}^{c} : Distance to the centroid	-.00140*** (.000200)	-.00157*** (.000220)
D1× *DM* × S_k	-.762*** (.167)	NA
D2 × *DM* × S_k	.547*** (.171)	NA
No. of mfg. HQs (in log.) × S_k	.102*** (.0390)	.0781 (.0517)
County fixed effects	Yes (204 counties)	Yes (91 counties)

4b: IV GMM: Dependent variables: County fixed-effects

	(1)	(2)
	204 counties	91 counties
No. of mfg. HQs (in log.)	-.561*** (.063)	-.412*** (.126)
m_i^I	1.248*** (.293)	1.582*** (.429)
w_i^I	-1.757* (.955)	-2.595** (.999)
HQ wage (in log.)	.952 (1.073)	.467 (1.247)
PMSA size	-.796*** (.231)	-.904*** (.209)
Hansen J statistic χ^2 [p-value]	χ^2(5)=5.036 [.411]	χ^2(4)=6.226† [.183]
F- test for endogeneity	F(5, 193) 2.59 [.0272]	F(5, 80) 4.77 [.0007]

Robust standard errors with clustering over counties in the same PMSA are calculated.

†: 1977 value for m_i^I is excluded from IV list to increase the overall validity of the IVs.

Figure 1. Location quotient for manufacturing production activity

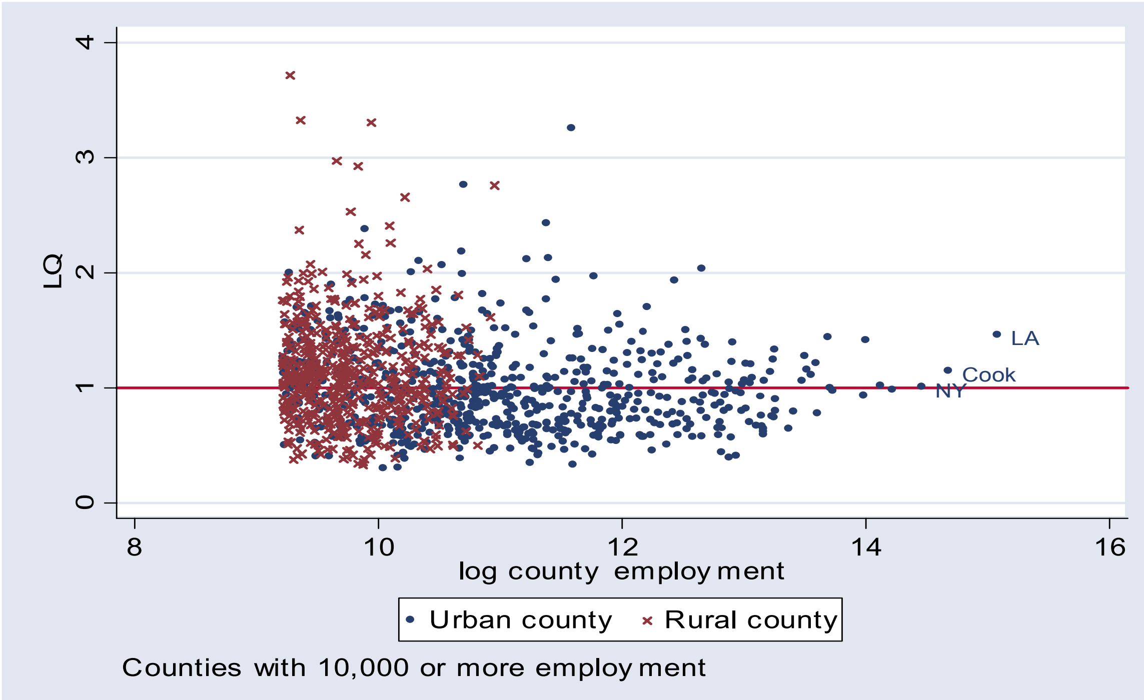


Figure 2. Location quotient for service industry

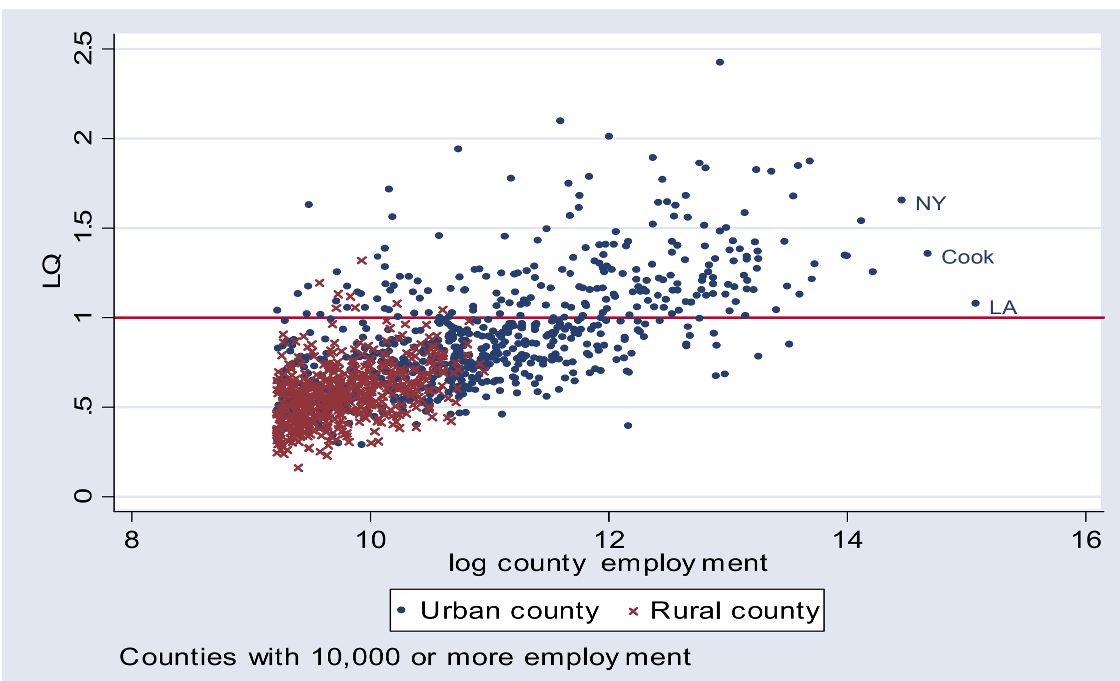
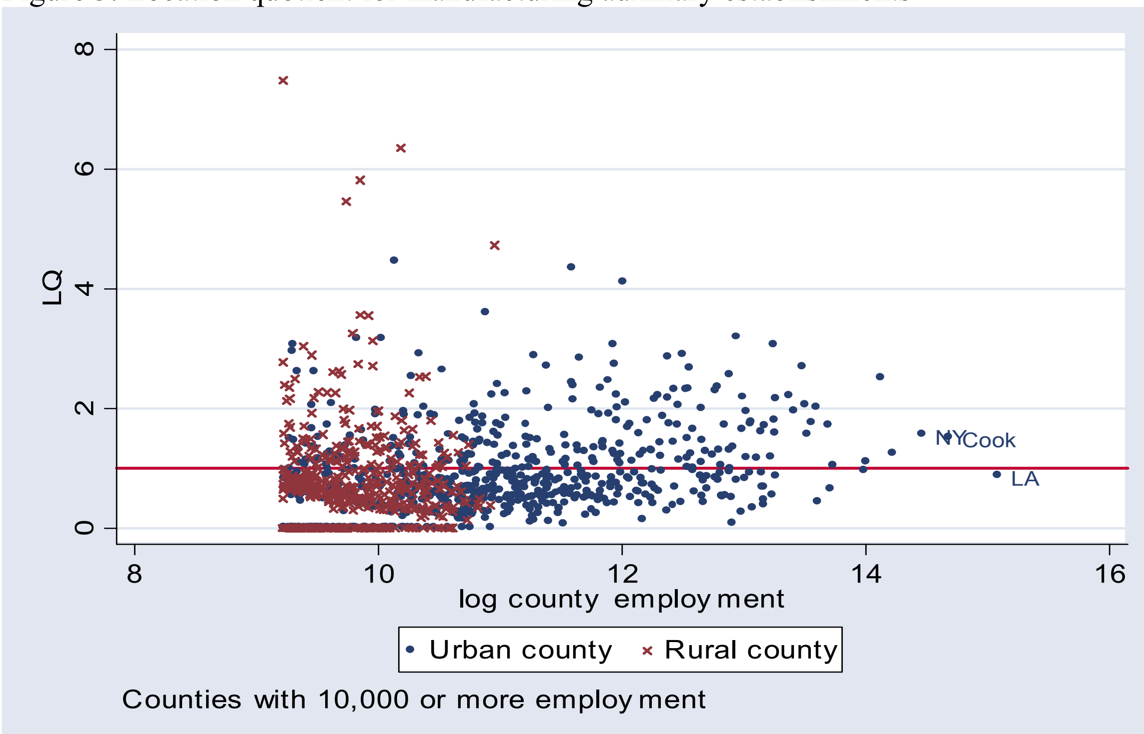


Figure 3. Location quotient for manufacturing auxiliary establishments



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