The Location of Sales Offices and the Attraction of Cities
Author(s): Thomas J. Holmes
Source: *The Journal of Political Economy*, Vol. 113, No. 3 (June 2005), pp. 551-581
Published by: The University of Chicago Press
Stable URL: http://www.jstor.org/stable/10.1086/429135
Accessed: 19/05/2011 02:10

# The Location of Sales Offices and the Attraction of Cities

Thomas J. Holmes

*University of Minnesota, Federal Reserve Bank of Minneapolis, and National Bureau of Economic Research*

This paper examines how manufacturers locate sales offices across cities. Sales office costs are assumed to have four components: a fixed cost, a frictional cost for out-of-town sales, a cost-reducing knowledge spillover related to city size, and an idiosyncratic match quality for each firm-city pair. A simple theoretical model is developed and is estimated using data from the Census of Wholesale Trade. The factors emphasized in the home market effect literature, namely, fixed costs and frictional costs, are found to play an important role in location decisions. Match quality also matters. The results for knowledge spillovers are mixed.

## I. Introduction

Sales offices are the home bases of company representatives who call on customers to mediate sales. Sales offices are highly concentrated in large cities. This paper asks why this is so. Two important explanations in the literature for the attractiveness of large cities are the home market effect and knowledge spillovers. For the sales office sector, it is reason-

I acknowledge support from National Science Foundation grant SES-9906087 for funding this project. I thank the Center for Economic Studies at the U.S. Census Bureau for making it possible for me to access the census data. I thank the editor and the referees for comments that led to a major revision. I thank Zvi Eckstein, Gautam Gowrisankaran, Joe Harrington, Shawn Klimek, Sam Kortum, Ariel Pakes, Arnie Resnik, and Jim Schmitz for detailed comments or help. I thank Adam Copeland and Junichi Suzuki for research assistance. I am grateful for helpful comments from numerous seminar participants. The views expressed herein are those of the author and not necessarily those of the Federal Reserve Bank of Minneapolis, the Federal Reserve System, or the National Science Foundation.

[*Journal of Political Economy*, 2005, vol. 113, no. 3]

able to suppose that both effects matter. In many contexts, it is hard to distinguish these factors from each other. The model developed and estimated here with micro data allows these two factors to be separately identified. The keys to identification are how large firms with multiple sales offices behave and how this behavior varies with firm size.

The model has five main ingredients. First, a frictional cost is incurred when a manufacturer mediates sales to a city without having a local sales office in the city. This is intended to capture the travel cost (including the time cost) for a representative to make a sales call on an out-of-town customer. The home market effect literature has emphasized the transportation cost of moving goods. Surely this must be dwarfed by the cost of moving people. A salesperson based in Chicago calling on a client in New York City for a one-hour meeting incurs a time cost of at least a full working day.

Second, there is a fixed cost to setting up an office at any location. As such, the firm has an incentive to limit the number of locations in which it opens an office. The frictional cost makes it advantageous to allocate the limited number of offices to the largest cities, that is, those with the largest home market. This interaction between scale economies and transportation cost in the model captures the essence of the home market effect. See Fujita, Krugman, and Venables (1999) and Fujita and Thisse (2002) for recent textbook treatments of this literature.

Third, there is a systematic relationship between productivity and city size. A large literature emphasizes the role of cities in facilitating the diffusion of "knowledge spillovers."[1] There is reason to believe that this factor matters for sales offices. A sales representative's job is to match the needs of customers with the products of the firm; information is the essence of the job. A salesperson needs to know the market, not just the product line carried by his or her firm, but also the products offered by competing as well as complementary firms. In a large city, this kind of information likely spills over from contacts with others. Beyond knowledge spillovers, there may be other advantages to larger cities (higher-quality workers) or even disadvantages (higher rents). All these other factors—apart from the home market factor—are netted out in the model in a single parameter called the knowledge spillover term.

Fourth, there are random, firm-specific factors that make some cities a good match for a firm and other cities a bad match. Without this heterogeneity, all firms of a given size act the same way. In particular, all firms with one office would place it in the largest city. This is inconsistent with the data. With the match component in the model, firms

[1] Recent work includes Eaton and Eckstein (1997), Black and Henderson (1999), Glaeser (1999), and Lucas (2001).

sometimes choose smaller locations over larger locations, trading off the benefits of a larger home market for the benefit of a better match. The matching factor is a force of dispersion in the model.

Fifth, firms vary exogenously in size. Manufacturers such as Kraft Foods are large, and others such as Tom's Widgets are small, for reasons outside the model.

In this environment, large and small firms face fundamentally different problems. Large firms have the scale economies to open a vast network of many offices; small firms perhaps have only one. Differences in the number of offices lead to differences in the geographic distribution of sales office activity. To understand the nature of these differences, consider first what happens when the model has no matching considerations. Then if a firm has only one office, it goes in the largest city; if it has a second office, it goes in the second-largest city; and so on. Here, increases in firm size shift the distribution of sales office activity away from the largest cities. Consider next what happens when match considerations are important. A small firm cannot do much about reducing frictional costs. Since it will have just a few offices to work with and since even the largest cities are only a small portion of the national market, a small firm incurs frictional costs on the vast majority of its customers, regardless of what it does. In contrast, a large firm, with potentially dozens of offices, is in the position to substantially reduce frictional costs. As a result, larger firms end up putting more weight on frictional costs and less weight on matching costs than smaller firms. This makes larger firms less dispersed and, in particular, less heavily concentrated in the smallest cities than smaller firms.

The empirical portion of the paper examines establishment-level data on manufacturers sales offices from the Census of Wholesale Trade. The analysis determines how the geographic distribution of sales office activity varies with firm size. The main finding is that as firm size increases, the distribution of activity shifts away from the smallest cities. Moreover, with the smallest firms excluded, an increase in firm size also shifts the distribution away from the largest cities. Thus the distribution shifts away from the extremes of city size toward the cities in between. This is an implication of the model with the home market effect and matching ingredients. A version of the model with only the knowledge spillover ingredient has no particular implication for how location behavior varies with firm size. If knowledge spillovers make salespeople more productive, then presumably this benefits large firms and small firms alike.

The structural model is estimated by fitting moments for how sales vary by city size and firm size and how the number of offices varies by firm size. The parsimonious model fits the moments reasonably well. In the estimated model, the ingredients of the home market effect—frictional costs and fixed costs—as well as the matching ingredient all play substantial roles as location factors. The evidence for knowledge spillovers is mixed. In one estimated model, the knowledge parameter is essentially zero; in another, the parameter plays some role, albeit a small one.

While the theoretical literature on the home market effect is substantial, relatively little empirical work quantifies its importance as a location factor. Previous work, including Rosenthal and Strange (2001), consists of cross-industry studies that attempt to find proxies for variables such as scale economies, transportation costs, and knowledge spillovers and then relate differences in geographic concentration of industries to differences in these proxies. A challenge with this approach is that it is difficult to come up with reliable proxies. This paper pursues an alternative approach that makes no attempt to directly measure these variables. Rather, the approach is to infer the parameters from the revealed choice behavior of firms of different sizes.[2]

The rest of the paper proceeds as follows. Section II provides background information about sales offices and shows that sales office activity is concentrated in large cities. Section III develops the theory. Section IV presents the data analysis. Section V presents conclusions.

## II. Sales Offices and Cities

This section explains what sales offices are and shows that they are concentrated in large cities to a remarkable degree. Subsection *A* presents the census definition of sales offices and provides summary statistics about sales offices from census data. Subsection *B* provides context by discussing the sales office operations of several large and familiar companies. Subsection *C* uses census data to document the relationship between sales office location and city size.

### A. *What Are Sales Offices?*

The Census Bureau defines *manufacturers sales offices and branches* as wholesaling establishments that sell "products manufactured or mined in the United States by their parent company" (U.S. Bureau of the Census 2000, 5). These are distinct from *merchant wholesalers*, which sell goods manufactured by some other firm, handling the goods and taking title in the process. A third distinct category is *agents and brokers*, who sell products made by others but do not handle or take title to the merchandise. These three categories make up sector 42, "wholesale

[2] Another empirical line of work on the home market effect by Davis and Weinstein (1996, 1999) examines how production structure varies with market size. Their approach is quite different from mine. The key to identification here—the role of large firms—plays no part in their analysis.

trade," in the North American Industry Classification System (NAICS). Within the category manufacturers sales offices and branches, an *office* is an establishment that carries zero inventory and does not handle the goods. These establishments tend to be located in suites in office buildings. A *branch* carries some inventory and includes distribution centers.

In the 1997 Economic Census (U.S. Bureau of the Census 2001), there were 29,305 establishments in the category of manufacturers sales offices and branches. These accounted for $1.3 trillion in sales, $46 billion in payroll, and just under 1 million employees. Of these totals, offices accounted for 61 percent of the sales, and branches accounted for the rest. In what follows, I use the abbreviated term *sales offices* for the entire category of manufacturers sales offices and branches.

### *B. The Sales Office Operations of Some Familiar Companies*

A clearer understanding of what sales offices are and how they fit into the operations of a firm can be gained by discussing the operations of some example companies. This subsection provides such a discussion based on data obtained from publicly available sources, such as business directories, phone books, and the Internet.[3] I shall show that sales offices of these example firms are highly concentrated in large cities, the same pattern that I shall later show to hold in the broader census data.

To begin, consider the case of Kraft Foods. The company is the largest branded food and beverage company headquartered in the United States. It manufactures and distributes brands such as Nabisco, Oscar Mayer, Maxwell House, and Kraft. The company's facilities can be classified into three groups: *manufacturing plants*, of which there are 72; *administrative facilities* (such as corporate headquarters, divisional headquarters, and research facilities), of which there are nine; and sales offices, of which there are 249.

A good idea of what these hundreds of sales offices do can be obtained from the job description of "sales representative" posted on the company's Web site: "As a Sales Representative, you will be responsible for distributing, selling, promoting, and merchandising Kraft Foods products. . . . You'll be responsible for executing company promotions, for meeting inventory needs, and for monitoring the competitive activity within your region. . . . Most of our sales people represent our entire product line."

The locations of Kraft's facilities are mapped in figure 1. Sales offices are marked with circles, manufacturing plants with triangles, and ad-

[3] The business directories used include ReferenceUSA (a product of InfoUSA) and the Harris InfoSource's Selectory Online. This information along with other Web-based information was processed by hand. The data are available on request. See Holmes (2004) for further discussion about data compilation.

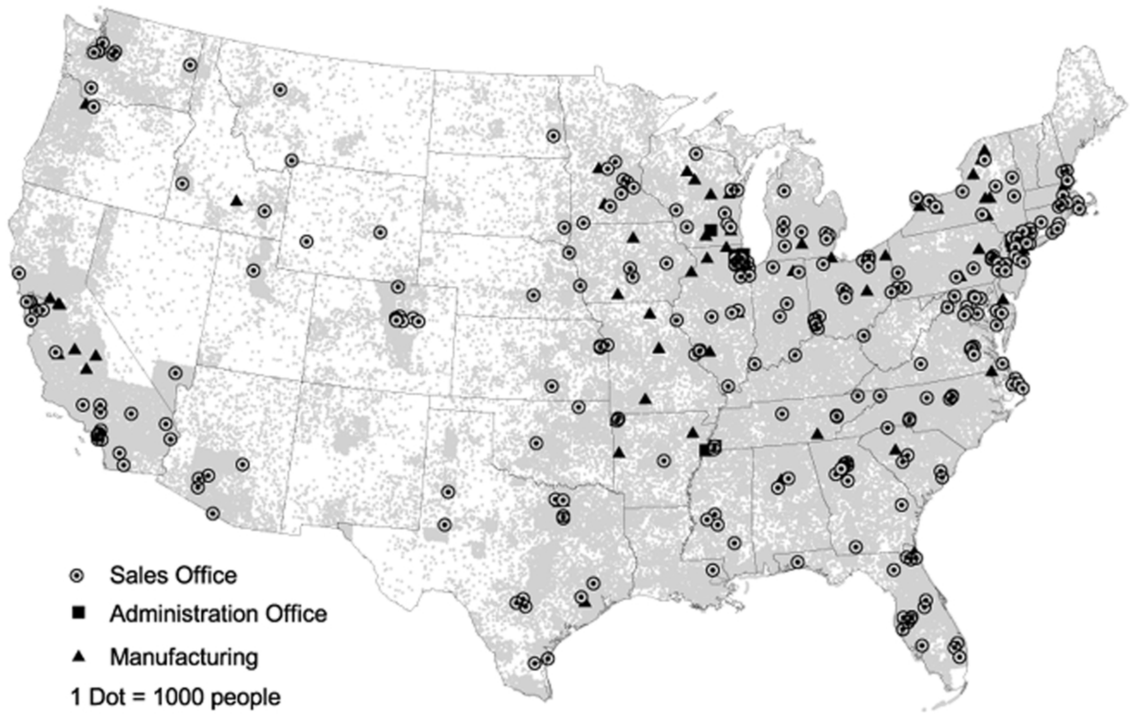


FIG. 1.—Map of facilities of Kraft Foods

ministrative facilities with squares. The map also illustrates the distribution of population, with one small gray dot for each 1,000 people. The map shows that the 256 sales offices form a national network with concentrations in the various centers of population. In contrast, the manufacturing facilities (which mostly process food) are regional, with concentrations in the Midwest, California, and New York agricultural areas.

Table 1 shows the relationship between sales office location and city size for Kraft and nine other familiar companies. The city size category with the largest cities—over 8 million in population—includes three cities: New York, Los Angeles, and Chicago. (Cities are defined to be metropolitan statistical areas [MSAs] or consolidated metropolitan areas; see App. A for details.) The next category, 2–8 million, has 19 cities and includes cities such as Portland and Tampa at the bottom of the population scale and Washington and Philadelphia at the top. There are 57 cities in the 0.5–2 million size class and 194 in the under 0.5 million class. (The smallest city, Enid, OK, has a population of 57,000.) For each company and each city size class, the table reports the fraction of cities that have a sales office for the company. For all the companies, the probability of having a sales office in the smallest cities is quite low. For virtually all the companies, the probability of having an office in the largest cities is one; that is, virtually all have New York, Los Angeles, and Chicago sales offices. There is a strict monotone relationship between probability of an office and city size for all the firms.

Table 1 makes clear that larger cities are more likely to have sales offices in an *absolute* sense. What about a *relative* sense? New York is 350 times larger in population than Enid, so even if sales offices were allocated across cities randomly in proportion to population, New York could be expected to end up with more. To control for such relative population differences, consider the following simple statistical model that is in the spirit of the Ellison and Glaeser (1997) dartboard analysis. Suppose that for a particular company $i$, the probability that city $j$ *does not* have a sales office is given by

$$\text{prob}_{ij}(\text{no office}) = \lambda_i^{n_j^\alpha}, \tag{1}$$

for $\lambda_i \in (0, 1)$, $\alpha \geq 1$, and $n_j$ the population of city $j$. Assume that this random event is an independently and identically distributed draw across cities. Observe that $\lambda_i$ is the probability of no office for firm $i$ in a city of unit size, $n = 1$. Think about a unit size city as getting one potential draw for an office and an $n$-size city getting $n$ independently and identically distributed draws. Then if $\alpha = 1$, the probability that a city of size $n$ would *not* get an office is $\lambda_i^n$, the probability of missing on all $n$ draws. If $\alpha > 1$, cities scale up in their attractiveness more than in proportion to population. Column 7 of table 1 reports the maximum

TABLE 1
SALES OFFICE LOCATION PATTERNS FOR SELECTED COMPANIES

| Company | Industry (1) | Number of Sales Offices (2) | Fraction of MSAs with Sales Office by MSA Population Groupings (Millions): Under 0.5 ($N=194$) (3) | 0.5–2 ($N=57$) (4) | 2–8 ($N=19$) (5) | 8+ ($N=3$) (6) | Estimate of $\alpha$ (7) |
|---|---|---|---|---|---|---|---|
| Philip Morris | Cigarettes | 17 | .01 | .11 | .37 | .67 | 1.16 (.19) |
| Merck | Pharmaceuticals | 29 | .02 | .14 | .53 | 1.00 | 1.41 (.21) |
| Clorox | Household products | 29 | .01 | .14 | .58 | 1.00 | 1.61 (.22) |
| Kimberly Clark | Paper | 33 | .02 | .11 | .58 | .67 | 1.08 (.14) |
| Eli Lilly | Pharmaceuticals | 60 | .02 | .42 | .79 | 1.00 | 1.36 (.15) |
| Rockwell | Industrial automation | 78 | .08 | .60 | .89 | 1.00 | 1.15 (.11) |
| Sun Microsystems | Computers | 84 | .03 | .56 | 1.00 | 1.00 | 2.38 (.30) |
| Cisco Systems | Networking equipment | 105 | .11 | .70 | 1.00 | 1.00 | 1.79 (.20) |
| Xerox | Photocopiers | 138 | .10 | .81 | 1.00 | 1.00 | 2.21 (.25) |
| Kraft | Food products | 265 | .16 | .72 | 1.00 | 1.00 | 1.26 (.15) |

NOTE.—Standard errors are in parentheses.

likelihood estimates of $\alpha$ estimated separately for each company. (The separate estimate of $\lambda_i$ for each company is not reported.) The estimate of $\alpha$ is greater than one for each company, and in most cases it is substantially greater than one. If $\alpha$ is constrained to be the same for all companies and the model is estimated jointly, the estimate is $\hat{\alpha} = 1.42$ with a standard error of 0.05. The interpretation is that when city size increases 100 percent, its “attractiveness” to sales offices increases at a rate of 142 percent.

One issue that could be raised at this point is the joint location of sales offices and other facilities. One might speculate that if sales offices tend to colocate with other facilities of the firm and if the other facilities of the firm tend to be located in larger cities, then the connection between sales office location and city size may be spurious. In Appendix A, I address this issue by extending the statistical model to allow sales office locations to depend on the locations of a firm’s other facilities. I draw the following conclusions. First, controlling for the locations of these other facilities makes no difference for the estimate of $\alpha$. Second, the connection between sales office locations and manufacturing plants is negligible. This is not surprising since manufacturing activity is so different from sales office activity. Third, there is a positive connection between the colocation of sales offices and administrative facilities that is statistically significant. This is not surprising given the plausibility of some overlap between white-collar jobs. However, the importance of colocation in explaining the location of sales offices is not large. The number of sales offices across the 10 companies, at 799, is an order of magnitude greater than the 69 administrative facilities. This limits the extent of possible geographic connection. The overwhelming majority of sales offices for this set of companies (85 percent) are located in MSAs in which the parent company has no administrative facilities. This point can be seen graphically in figure 1, where it is clear that the colocation of sales offices with other facilities is negligible.

### C. *The Census Data*

I now turn to the data on the 29,305 sales offices in the 1997 Census of Wholesale Trade. The data contain information about sales, employment, payroll, operating expenses, and inventories, among other things. Table 2 shows how these measures of sales office activity vary with city size.[4] The table uses the same city size groupings as in table 1, and it adds a column for activity in nonmetropolitan areas. Panel A of

[4] This table was constructed with published census data. Other tables in this paper were constructed with data that can be accessed only at one of the seven regional Research Data Centers operated by the Census Bureau. Appendix A discusses this further.

TABLE 2
SALES OFFICE INTENSITY MEASURES BY CITY SIZE

| | Non-MSA (1) | MSA Population (Millions): Under 0.5 ($N=194$) (2) | 0.5–2 ($N=57$) (3) | 2–8 ($N=19$) (4) | 8+ ($N=3$) (5) |
|---|---|---|---|---|---|
| | A. Per Capita Measures | | | | |
| Sales ($1,000s per person) | .62 | 2.70 | 4.92 | 7.98 | 6.86 |
| Employment (per 1,000 in population) | .99 | 2.71 | 3.86 | 4.86 | 5.23 |
| Payroll ($1,000s per person) | .03 | .11 | .18 | .27 | .28 |
| Operating expenses ($1,000s per person) | .07 | .22 | .36 | .54 | .61 |
| Inventories ($1,000s per person) | .05 | .14 | .16 | .22 | .24 |
| | B. Location Quotients | | | | |
| Sales | .11 | .29 | .96 | 1.57 | 1.34 |
| Employment | .23 | .41 | 1.03 | 1.30 | 1.39 |
| Payroll | .15 | .32 | .95 | 1.47 | 1.48 |
| Operating expenses | .17 | .33 | .93 | 1.40 | 1.57 |
| Inventories | .27 | .49 | .97 | 1.31 | 1.42 |

SOURCE.—Author's calculations with publicly available data from the 1997 Census of Wholesale Trade.

the table reports per capita measures. For these measures, total activity (e.g., total sales) across all sales offices in the geographic grouping is divided by the total population of the geographic grouping. Panel B of table 2 reports the same group of measures as in panel A but renormalized. I take the ratio of the per capita measure in city size class to the per capita measure in the United States as a whole. This ratio is commonly called a *location quotient*. When activity is proportional to population, the location quotient is one everywhere. When activity increases more than proportionally with population, it is less than one for small cities and greater than one for large cities.

Table 2 reports that the total sales of offices located in nonmetropolitan areas are $620 per person living in nonmetropolitan areas. Per capita sales increase to $2,700 for small cities (under 0.5 million in population) and to $4,920 for cities in the 0.5–2 million category. Sales rise all the way up to $7,980 and $6,860 for the two largest city size categories, more than a tenfold increase compared to nonmetropolitan areas. The sales location quotient for nonmetropolitan areas is only 0.11. The location quotient increases with city size all the way up to 1.57 and 1.34 for the two largest size classes. The other measures of sales office activity reveal a similar pattern. Payroll per capita and operating expenses per capita both increase by a factor of 10, going from the

TABLE 3
MSA-Level Regressions: Log Sales on Log Population

| | Slope (1) | $R^2$ (2) |
|---|---|---|
| Cross-section regressions (year): | | |
| 1982 | 1.64 | .78 |
| | (.05) | |
| 1987 | 1.63 | .76 |
| | (.06) | |
| 1992 | 1.68 | .75 |
| | (.06) | |
| 1997 | 1.71 | .75 |
| | (.06) | |
| 1997, with controls* | 1.56 | .82 |
| | (.06) | |
| Fixed-effect regression: 1982–97 | 1.80 | .09 |
| | (.34) | |

Source.—Author's calculations with confidential micro data from the Census of Wholesale Trade, 1982–97.
Note.—Standard errors are in parentheses.
* Controls are added for education, airport access, and manufacturing activity.

smallest to the largest city size categories. Employment and inventories also increase, by a factor of five rather than 10.

The significant concentration of office activity in large cities is a recurrent feature in earlier census years. Table 3 takes the cross section of MSAs and reports the results of a simple regression of the log of sales on the log of MSA population.[5] The population elasticity (the slope of the regression line) for sales ranges from 1.63 in 1987 to 1.71 in 1997. This is roughly comparable with the elasticity of 1.42 obtained with the count data on the 10 example firms. Table 3 also reports a regression of differences in log sales on differences in log population between 1997 and 1982. The estimate from this "fixed city effect, fixed time effect" regression is 1.80. Thus the pattern that relative sales office activity increases with city size holds within cities over time as well as across cities.

Table 3 also reports the population elasticity when additional city characteristics are included in the regression. These characteristics include a measure of education level of the workforce, a measure of airport access, and a measure of manufacturing activity (see App. A for details), all of which I would expect to be associated with higher sales office activity in a city. The additional variables do play some role in the regression, raising the $R^2$ for 1997 from 0.75 to 0.82, and they lower the

[5] MSA definitions change from census year to census year. With one exception, the regressions in table 3 fix MSA definitions equal to their 1987 county-equivalent definitions as set forth by the Census Bureau. The exception is that the regression with 1997 data with controls for city characteristics uses the 1997 MSA definitions to maintain comparability with the later analysis.

population elasticity from 1.71 to 1.56. While lower, the population elasticity remains quite high. I conclude that no matter how I cut the data, sales offices are heavily concentrated in large cities.

## III. The Theory

Subsection *A* describes the environment. Subsection *B* characterizes the solution to the firm's problem and determines how firm behavior varies with firm size.

### *A. The Environment*

There are $J$ cities ordered by population size, $n_1 < n_2 < \cdots < n_J$, and total population is normalized to unity: $\sum_{j=1}^{J} n_j = 1$. There are $I$ firms, ordered by total sales, $q_1 < q_2 < \cdots < q_I$, and each firm's sales are distributed across cities in proportion to population. Hence, sales of firm $i$ in city $j$ are $q_{ij} = q_i n_j$.

The cost structure of the sales operation has three components: fixed costs, frictional costs, and selling costs. The fixed cost $\phi$ is paid per sales office. The frictional cost $\tau \geq 0$ is paid per unit sold outside the city in which the servicing sales office is located. Each of these costs is the same for all firms and all cities. The selling cost $c_{ij}$ is paid per unit and varies with the firm $i$ and the city $j$ in which the sales office is located. Assume that

$$c_{ij} = \bar{c} - \gamma n_j + \epsilon_{i,j}. \tag{2}$$

Aside from the constant $\bar{c}$, this cost has two components. The component $-\gamma n_j$ allows selling costs to vary in a systematic way with city size. If $\gamma > 0$, then larger cities have a cost advantage. External knowledge spillovers of the type emphasized by Lucas (2001) are one example. If $\gamma < 0$ holds, larger cities have a cost disadvantage, perhaps because rents are higher. In the analysis, I assume that $\gamma \geq 0$, and I refer to $\gamma$ as the *knowledge spillover* parameter. The final term $\epsilon_{i,j}$ is an idiosyncratic component of cost that varies across firms and cities, as I now explain.

The $\epsilon_{i,j}$ term captures the idea that for various reasons outside of the model, a particular firm might find a particular city to be a good match for locating a sales office. For example, perhaps a firm is looking for salespeople with a unique set of skills. If a particular city happens to be the home of such a unique individual, ceteris paribus, this city is a good place to set up an office. Or perhaps a firm has its headquarters in a particular city and there is some complementarity in locating a sales office near headquarters. It is intuitive that in a larger city, there is a better chance that a particular firm would be able to find a unique talent and a better chance that the firm would have other administrative facilities in the area, since the firm would be drawing from a larger pool. To capture this notion, the value of the match term $\epsilon_{i,j}$ is assumed to be the minimum of $Nn_j$ draws from a distribution $F(x)$ for some scaling parameter $N$. With this cost structure, a city that is twice as large gets twice as many idiosyncratic draws $x$ and has twice the chance of finding a rare firm-specific talent.

It is convenient to assume that the random $\tilde{x}$ is drawn from the double exponential distribution used in the logit model,

$$\Pr(\tilde{x} \geq x) = 1 - F(x) = \exp(-e^x). \tag{3}$$

In this case, the distribution of the first-order statistic remains double exponential, that is,

$$\Pr(\epsilon_{i,j} \geq x) = \exp(-n_j N e^x). \tag{4}$$

I normalize $N = 1$.

### B. *The Firm's Problem and Solution*

Firm $i$ takes as given its total sales $q_i$, the distribution of its sales $(n_1, n_2, \ldots, n_J)$ across cities, and its vector of match draws $(\epsilon_{i,1}, \epsilon_{i,2}, \ldots, \epsilon_{i,J})$. It chooses a set of office locations and an allocation of servicing activity across offices. The firm's objective is to minimize the sum of selling costs plus frictional costs plus fixed costs.

In a solution to the firm's problem, let $B_i \subseteq \{1, 2, \ldots, J\}$ denote the set of locations in which firm $i$ places an office. The variable intermediation cost to firm $i$ for servicing sales at location $k$ from an office $j \neq k$ is $c_{ij} + \tau$. This cost does not depend on $k$, the location being serviced. Hence, the firm has one *export location* $j_i^*$, the office with the lowest selling cost, that is,

$$j_i^* = \arg\min_{j \in B_i} \{c_{ij}\} = \arg\min_{j \in B_i} \{\bar{c} - \gamma n_j + \epsilon_{ij}\}.$$

Suppose that a location $j \neq j_i^*$ also has an office. Then the following condition must hold:

$$\phi + c_{ij} q_i n_j \leq (c_{ij^*} + \tau) q_i n_j. \tag{5}$$

The left-hand side of (5) is the cost of a local office at city $j$; it equals the fixed cost plus the selling cost at $j$ times sales $q_i n_j$ at $j$. The right-hand side is the cost of servicing $j$ from the export location; the fixed cost of $\phi$ is avoided, and the variable cost is the export location's selling cost plus the frictional cost.

Let *sales office activity* of firm $i$ in city $j$ be denoted $s_{ij}$ and define it as total servicing activity undertaken at city $j$. (This is zero if there is no office at $j$.) The location quotient for firm $i$ at location $j$ is that location's share of national sales office activity divided by that location's share of population:

$$\mathrm{LQ}_{ij} = \frac{s_{ij} / \sum_{k=1}^{J} s_{ik}}{n_j}. \tag{6}$$

Let $\overline{\mathrm{LQ}}_{ij}$ be defined as the expected location quotient for firm $i$ at location $j$, where the expectation is taken over the match vector $(\epsilon_{i,1}, \epsilon_{i,2}, \ldots, \epsilon_{i,J})$.

I begin my analysis of the firm's problem by looking at extreme values of firm size for which complete solutions can be obtained.

### 1. Limiting Case 1: The Very Small Firm

Suppose for a firm of size $q$ that

$$qn_J\tau < \phi. \tag{7}$$

Under this assumption, the firm is small enough that the maximum possible savings in frictional cost from opening an office (the frictional cost of servicing the largest city) is less than the fixed cost. If condition (7) holds, there is a single office in the optimal configuration. Denote this the case of the *very small firm.*

The firm's objective is to minimize average total cost. When the firm has a single office and puts the office in city $j$, the average total cost is

$$\begin{aligned} \mathrm{ATC}_j &= c_j + (1 - n_j)\tau + \frac{\phi}{q} \\ &= (\bar{c} - \gamma n_j + \epsilon_j) + (1 - n_j)\tau + \frac{\phi}{q} \\ &= \left(\bar{c} + \tau + \frac{\phi}{q}\right) - (\gamma + \tau)n_j + \epsilon_j. \end{aligned} \tag{8}$$

The first term in the first line is the selling cost per unit. The second term is frictional costs. They are incurred on all sales, except for the local sales $n_j$ of the office in $j$. The third term is average fixed cost. The second line substitutes in equation (2) for $c_j$. When I rearrange terms, the third line expresses average total cost as a constant, a term that depends on $n_j$ and a random term. The firm picks the location that minimizes $\mathrm{ATC}_j$.

Equation (8) for average total cost highlights a fundamental identification problem faced in this paper. The sum of $\gamma$ and $\tau$ enters multiplicatively with city size $n_j$. Higher values of $\tau$ and $\gamma$ increase the relative advantage of large cities in the same way ($\tau$ also affects the constant, but that has no effect on behavior). If firms always chose only one location, there would be no way to separately identify $\gamma$ from $\tau$. But large firms tend to open more than one office, and, as I shall show, this opens up a window for identification.

### 2. Limiting Case 2: The Very Large Firm

Suppose for a firm of size $q$ that

$$qn_1\tau > \phi. \tag{9}$$

Under this assumption, the firm is large enough that the minimum possible savings in frictional cost from opening an office (the frictional cost of servicing the smallest city) exceeds the fixed cost. Call this the case of the *very large firm*. In this case, it is always optimal to open an office at the location with the lowest selling cost and use this as the export location $j^*$:

$$j^* = \arg \min_{j \in \{1,2,\ldots,J\}} \{c_j\}. \tag{10}$$

When I divide condition (5) through by sales $qn_j$ at $j$, there is an office at a location $j \neq j^*$ if and only if the average total cost is lower:

$$\frac{\phi}{qn_j} + c_j \leq c_{j^*} + \tau.$$

Substituting in $c_k = \bar{c} - \gamma n_k + \epsilon_k$ and rearranging, I have that the condition for an office at $j$ is

$$\frac{\phi}{qn_j} + \gamma(n_{j^*} - n_j) \leq \epsilon_{j^*} - \epsilon_j + \tau. \tag{11}$$

Notice that $\gamma$ is multiplied by the difference in city size, but $\tau$ is not. This is unlike the small firm's problem in (8) in which only the sum $\gamma + \tau$ matters. The crucial difference between the two problems is that, to open at $j$, the large firm's problem involves moving *only* sales at $j$, whereas the small firm's problem involves moving the servicing location for total sales across all locations. Consequently, $\gamma$ and $\tau$ can be separately identified by the behavior of large firms.

Using (10) and (11) and the assumption (3) of a double exponential distribution, I can derive analytic expressions for the probability that an office at location $j$ services location $k$. (A related probability is derived in Eaton and Kortum [2002].) A formula for the location quotient $\overline{\mathrm{LQ}}_j$ at $j$ can then be derived. The formula is reported in Appendix B and is used to prove the following comparative statics result.

PROPOSITION 1. For large enough firm size $q$, the expected location quotient $\overline{\mathrm{LQ}}_J(q)$ in the largest city strictly decreases in $q$.

*Proof.* See Appendix B.

To understand the intuition, take a fixed draw $(\epsilon_1, \epsilon_2, \ldots, \epsilon_J)$ of the match components, and consider how firm behavior varies as a function of size $q$. For large $q$, the firm always opens an export office at the lowest-cost location $j^*$. Whether or not it opens a local office in another city $j$ depends on condition (11). The condition is more likely to be satisfied the larger $q$ is and the larger the city size $n_j$ is. As firm size increases, it becomes cost efficient to open offices in smaller cities, shifting the distribution of sales office activity away from the largest city.

### 3. General Firm Size

If the firm is neither very small nor very large, an analytic expression for the expected location quotient appears unattainable. It is straightforward, however, to solve numerical examples on a computer. In this subsection, I present a particular numerical example and discuss the generality of the findings.

In the example, the city population distribution equals the empirical size distribution of MSAs for 1997 used in the empirical analysis. The knowledge spillover parameter $\gamma$ is set to zero. The frictional cost $\tau$ is set to

$$\tau = E\left[\sum_{j=1}^{J} n_j \epsilon_j\right] - E\left[\min_j \{\epsilon_1, \epsilon_2, \ldots, \epsilon_J\}\right]. \tag{12}$$

This is the difference in expected selling cost per unit between servicing all sales with a local office and servicing all sales with the best match location. This is a measure of the importance of the matching. With $\tau$ equal to this measure, there is a sense that the example contains frictional cost and matching in equal measure, at least for a large firm for which it might be feasible to open an office in every city. Figure 2 plots $\overline{\mathrm{LQ}}_J(q)$ and $\overline{\mathrm{LQ}}_1(q)$, the expected location quotients in the largest and smallest cities, as a function of firm size $q$.

Note first that $\overline{\mathrm{LQ}}_J(q)$ decreases in $q$ for large enough $q$. This has to be true from proposition 1. But observe that $\overline{\mathrm{LQ}}_J(q)$ first increases before decreasing in $q$. For the very small firm with only one office, the primary job of the office is necessarily export activity. This is true even if the office is located in the largest city since the population share $n_J$ of the largest city (New York in this case) is only 9.4 percent. The savings in frictional cost from locating in the largest city applies to 9.4 percent of sales; any saving on matching cost applies to all sales. Hence, given the value (12) of frictional cost chosen, minimization of selling cost is the primary location factor for the very small firm, and the location of the single office is usually not the largest city. If firm size increases to give

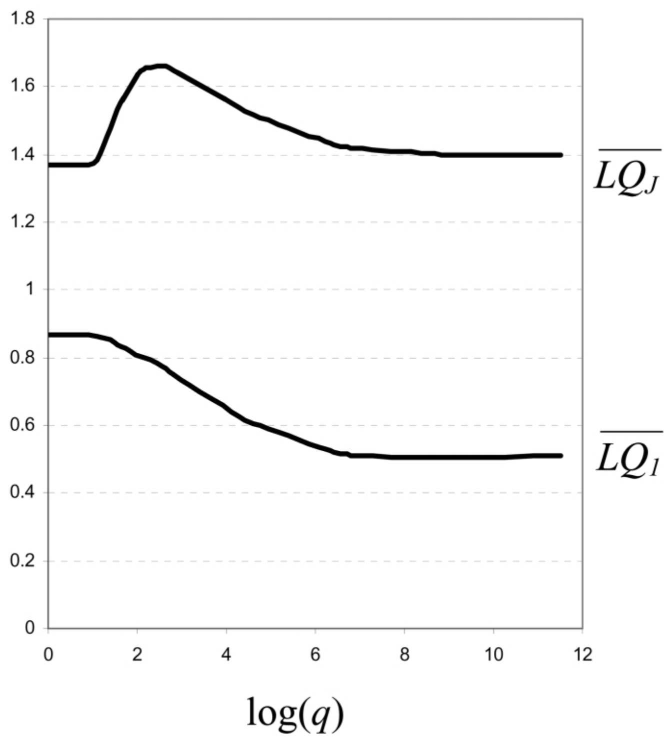


FIG. 2.—Location quotients and firm size for city 1 and city $J$

the firm sufficient scale economies to open a second office, it is relatively likely to be placed in the largest city if the first office is not already there. This follows because the second office services only local sales, not exports; so frictional cost reduction is a relatively more important location factor. These second offices in city $J$ account for why $\overline{LQ}_J(q)$ is initially increasing.

If $\tau$ is extremely large or if $\gamma$ is extremely large, then the argument just made does not apply. In either case, the very small firm will put its single office in the largest city, so concentration there can only go down. But if neither parameter is large, I find in other example simulations that $\overline{LQ}_J(q)$ is first flat in $q$ (the region in which there is a single office) and then increases in $q$ (where second offices are placed in the largest city) before it eventually decreases.

Note next that $\overline{LQ}_1(q)$ sharply decreases in firm size $q$. This is surprising since this happens in a range of $q$ in which $\overline{LQ}_J(q)$ also decreases. In this range, expected sales office activity is being shifted from the largest and smallest cities toward the cities in between. To get a rough understanding of the forces underlying the result, consider a very small firm with one office. If it were to open an office in the smallest city, virtually all sales activity would be export activity, since the population of the city itself is negligible ($n_1 = 0.0003$). If the firm's size were to increase, enabling it to add local offices in other cities, the (relative) export activity of the office in the smallest city would decline, pulling down its location quotient. A potential offsetting positive effect is that, in the event that some other city is the export location, an increase in firm size might lead the firm to open a local office, just to service customers in that city. However, this latter positive effect is not relevant for the smallest city because its negligible size means that the savings in frictional cost from a local office are swamped by the fixed cost and the bad matches usually found in tiny cities. This effect of replacing imports with a local office *does* matter for medium-sized cities, accounting for why the location quotients of medium-sized cities increase in firm size, whereas the location quotients in the smallest and largest cities decline.

If $\tau$ is extremely large or if $\gamma$ is extremely large, then the argument just made does not apply. In either case, the very small firm will not put its single office in the smallest city, so concentration there can only go up. But if neither parameter is large, the pattern for $\overline{\mathrm{LQ}}_1(q)$ is like that illustrated in figure 2. My formal result is as follows.

PROPOSITION 2. Assume $\gamma = 0$, $n_J \leq 0.5$, and $n_1 = 0$. For small enough $\tau$, there is a range of $q$ in which $\overline{\mathrm{LQ}}_1(q)$ strictly decreases.

*Proof.* See Appendix B.

## IV. The Empirical Analysis

This section takes the theory to the data. Subsection *A* shows that the qualitative patterns found in the model economy are also found in the data. Subsection *B* shows that the theory is a quantitative success: the model is estimated, and it fits the data reasonably well.

### *A. Location and Firm Size*

The data are taken from the 1997 Census of Wholesale Trade discussed in Section II. I make adjustments to the data to make them consistent with the theoretical model. In the model, a firm has at most a single office at a given location. In the data, there are firms with multiple offices in the same MSA. I handle this by aggregating the establishments of the same firm within the same MSA into a single office. The fixed cost in the model is best interpreted as the cost to open the first sales office in the city (with additional offices having zero marginal cost). I also exclude sales offices outside of MSAs; they account for a negligible

TABLE 4
SUMMARY STATISTICS BY SALES SIZE OF FIRM: MEAN SALES SIZE AND CELL COUNTS BY SALES SIZE CATEGORY

| Sales of Firm ($ Millions) | Mean Sales ($ Millions) (1) | Number of Firms (2) | Number of Offices (3) | Offices per Firm (4) |
|---|---|---|---|---|
| Under 25 | 7.5 | 2,097 | 3,551 | 1.7 |
| 25–50 | 35.8 | 426 | 1,403 | 3.3 |
| 50–100 | 70.7 | 364 | 1,772 | 4.9 |
| 100–250 | 159.1 | 368 | 2,791 | 7.6 |
| 250–1,000 | 479.0 | 335 | 4,628 | 13.8 |
| 1,000+ | 4,856.9 | 196 | 5,566 | 28.4 |
| All firms | 324.3 | 3,786 | 19,711 | 5.2 |

SOURCE.—Author's calculations from confidential micro data from the 1997 Census of Wholesale Trade. Non-MSA establishments are excluded.

amount of sales office activity (2.5 percent of total sales). Excluding offices outside of MSAs reduces the total number of establishments from 29,305 to 26,629, and then aggregating establishments of the same firm in the same MSA results in 19,711 offices for 3,786 firms.

Table 4 presents summary statistics and cell counts by firm size class. Firm size is defined by aggregating sales across MSAs. The size classes range from "under $25 million" in sales to "over $1 billion." Column 4 of the table shows that the average number of offices increases sharply with firm size, starting at 1.7 offices in the bottom category and rising to 28.4 offices in the top category. This is an immediate implication of the theory, and this relationship will be incorporated into the estimation below.

Table 5 presents location quotients by firm size class and city size class. The MSAs are grouped into the same size classes as in Section II. To construct panel A, I used the raw data from the 1997 census to calculate the location quotient for each firm in each city size class according to (6) and then took unweighted means across firms by city size class and firm size class. Panels B and C use an alternative procedure to summarize the relationship that includes controls for industry. The procedure treats each $1 million of sales as an observation and classifies it by firm size and city size categories. It estimates a multinomial logit model for the allocation of the sales units across the city size classes conditioned on firm size class and industry.[6] The industry definitions are at the four-digit NAICS level for 1997 and the three-digit standard industrial clas-

[6] The logit procedure also incorporates non-MSA sales activity, which, as mentioned above, is negligible. Non-MSA locations are included as a fifth city size class. In panels B and C, the location quotients for non-MSA areas are not reported, and those that are reported do not include non-MSA population when population shares are calculated. I do this to be consistent with panel A and with the later results. Holmes (2004) reports panels B and C with the non-MSA locations included, and the results are similar.

TABLE 5
Location Quotients by Sales Size of the Firm and MSA Size

| Sales of Firm | MSA Population (Millions) Under 0.5 (1) | 0.5–2 (1) | 2–8 (3) | 8+ (4) |
|---|---|---|---|---|
| | A. Raw Data, 1997 Census | | | |
| Under 25 | .76 | .91 | 1.04 | 1.27 |
| 25–50 | .62 | .78 | 1.09 | 1.47 |
| 50–100 | .52 | .80 | 1.13 | 1.48 |
| 100–250 | .55 | .89 | 1.16 | 1.28 |
| 250–1,000 | .44 | .89 | 1.22 | 1.29 |
| 1,000+ | .32 | .85 | 1.33 | 1.28 |
| | B. Estimates of a Logit Model of Sales Distribution, 1997 Census | | | |
| Under 25 | .52 | .82 | 1.12 | 1.48 |
| 25–50 | .47 | .78 | 1.15 | 1.51 |
| 50–100 | .32 | .76 | 1.29 | 1.44 |
| 100–250 | .42 | .90 | 1.23 | 1.29 |
| 250–1,000 | .33 | .91 | 1.28 | 1.27 |
| 1,000+ | .30 | .84 | 1.45 | 1.10 |
| | C. Estimates of a Logit Model of Sales Distribution, 1992 Census | | | |
| Under 25 | .45 | .82 | 1.20 | 1.42 |
| 25–50 | .41 | .81 | 1.13 | 1.58 |
| 50–100 | .34 | .81 | 1.22 | 1.51 |
| 100–250 | .33 | .92 | 1.23 | 1.36 |
| 250–1,000 | .29 | .86 | 1.39 | 1.23 |
| 1,000+ | .28 | .84 | 1.47 | 1.15 |

Source.—Author's calculations with confidential micro data from the 1997 and 1992 Census of Wholesale Trade.

sification level for 1992.[7] The estimated sales shares by city size and firm size are evaluated at the means of the industry dummy variables and are converted into location quotients by dividing through by population shares. Panel B shows the results for 1997. Panel C reports the results from applying the same procedure with the earlier 1992 census data and 1992 MSA definitions.

There are four notable features of the location quotients in table 5. First, when firm size classes are fixed, location quotients increase in city size, that is, when one moves from left to right along a row. Second, in the column for the largest cities (col. 4), for large enough firm size, the location quotient decreases in firm size; that is, far enough down the column it is decreasing. This is the implication of proposition 1. Third, there is some evidence that for the largest city class, the location quotient first increases before decreasing. This is the same pattern as in figure 2, and it holds in the model if $\gamma$ and $\tau$ are not too large. In

[7] There are 18 such industries for each classification. A major switch from the standard industrial classification to the NAICS classification occurred between the 1992 and 1996 censuses.

panels A and C, there are sizable increases between the first and second firm size categories: 1.27–1.47 and 1.42–1.58. However, the increase in panel B is negligible.[8] Fourth, in the column with the smallest cities (col. 1), the location quotient decreases in firm size. This is an implication of the model if $\gamma$ and $\tau$ are not too large. For example, in panel A, the location quotient falls monotonically from 0.76 for the smallest firm size class down to 0.32 for the largest firm size class.

It should be emphasized that the features just described are characteristics of the complete census of the universe of firms, not of a sample. As can be seen in table 4, in each firm size class there are thousands of offices and hundreds of firms or more underlying the statistics that are reported. Note also that the quantitative results for the years 1992 and 1997 in panels B and C of table 5 are very similar, despite the substantial entry and exit and reallocation of sales across firms that occur in a five-year census period.

It is worth noting that the pattern for the largest city size classes and larger firms can also be seen in table 1 from the discussion of the 10 large example companies. The companies are sorted by total number of sales offices. The table suggests a hierarchy in which offices are placed in the largest cities first.

### *B. Structural Estimation*

The model is estimated with population size and the other observable city characteristics that made a difference in the regression analysis of table 3. In particular, the selling cost of firm $i$ in city $j$ depends on three additional characteristics,

$$c_{ij} = \bar{c} - \gamma n_j - \eta_1 z_{1,j} - \eta_2 z_{2,j} - \eta_3 z_{3,j} + \epsilon_{ij}, \tag{13}$$

where characteristic $z_{1,j}$ is the education level in city $j$, $z_{2,j}$ is airport access, and $z_{3,j}$ is the level of manufacturing activity. The constant term $\bar{c}$ is normalized to be zero since changing it does not affect any choices. The parameters to be estimated are the frictional cost $\tau$, the systematic city size effect $\gamma$, the fixed cost $\phi$, and the coefficients $\eta_1$, $\eta_2$, and $\eta_3$ on the city-specific characteristics. Let $\boldsymbol{\theta} = (\phi, \tau, \gamma, \eta_1, \eta_2, \eta_3)$ denote the parameter vector.

It simplifies computation to discretize firm size. I use the six sales size categories from table 4 and assume that the sales $q_h$ of each firm in a

[8] In Holmes (2004), I also report the results of a logit model with 1997 data in which firm size is defined by the number of offices. For firms with one office, the location quotient in the largest city size class is 1.46, and this increases to 2.27 for firms with two to five offices.

given size category $h \in \{1, 2, \ldots, 6\}$ are equal to the mean sales of firms in the size category.

The estimation procedure is simulated method of moments. There are three sets of moments. The first set consists of the $6 \times 4 = 24$ location quotients by firm size class and city size class in panel A of table 5. Let $\overline{\text{LQ}}_k^h(\boldsymbol{\theta})$ be the expected location quotient in city size class $k$ and firm size class $h$, given the parameter vector $\boldsymbol{\theta}$. The second set, six moments, is the number of offices per firm by firm size class, from column 4 of table 4. Let $\bar{O}^h(\boldsymbol{\theta})$ be the expected number of offices. For scaling, the actual number of offices is divided by $\bar{O}^h(\boldsymbol{\theta})$, so the expectation of the normalized variable is one. The third set, three moments, is correlations between the three city characteristics (e.g., airport access) in city $j$ and the residuals (the realized location quotient in the city aggregated across all firm size levels less the predicted level).[9] The expected values of these three correlations are zero. There are 33 moments. The estimate $\hat{\boldsymbol{\theta}}$ minimizes the sum of the squared deviation of the moments from their expectations.

Because analytic expressions for the expectations $\overline{\text{LQ}}_k^h(\boldsymbol{\theta})$ and $\bar{O}^h(\boldsymbol{\theta})$ are not available, I use simulation to approximate them. Specifically, I draw the match vector $(\epsilon_1, \epsilon_2, \ldots, \epsilon_J)$ 100,000 times, solve the firm's problem for each $\epsilon$ and each size class $h$, and then average over the 100,000 draws.

Before I discuss the parameter estimates, it is useful to first discuss the magnitude of the cost variation due to the match term $\epsilon_{ij}$. Just as in a standard logit model, a normalization is required, since when the $\epsilon_{ij}$ are scaled up by a constant factor and $\tau$, $\gamma$, and $\phi$ all change in the same proportion, all decisions remain the same. Hence, the normalization $N = 1$ in (4). Table 6 presents statistics about the distribution of $\epsilon_{ij}$, under the normalization. The variance *within* a city is constant at 1.6, independent of city size. This is a little less than half of the overall variance of 3.8, meaning that the variation *across* cities is substantial. The expected value of $\epsilon_{ij}$ falls from 5.1 for the city at the first (population-weighted) quartile of the city size distribution and falls to 2.9 for the city at the third quartile, a differential of 2.2. The expected value of the lowest match component for a firm, $\min_j\{\epsilon_{ij}\}$, is $-0.6$. The expected difference between the mean of $\epsilon_{ij}$ and this minimum is 4.6. (This difference is the expression on the right-hand side of [12] and is the value of $\tau$ used to construct fig. 2.)

[9] Sales data aggregated across firm size classes are published for the majority of cities. (These public data are used to construct table 2.) For this third set of moments, I use the cities with public data so that, along with panel A of table 5, all the data moments are public. Thus the estimation procedure can be replicated outside the census data.

TABLE 6
DISTRIBUTION OF THE MATCH COMPONENT (Scaling Set at $N=1$)

| City Index $j$ | Population Share $n_j$ (1) | Cumulative Population Share (2) | Mean of $\epsilon_j$ (3) | Variance of $\epsilon_j$ (4) |
|---|---|---|---|---|
| All cities | | | 4.0 | 3.8 |
| Individual cities: | | | | |
| 1 | .0003 | .0003 | 7.7 | 1.6 |
| 215 | .0035 | .2509 | 5.1 | 1.6 |
| 269 | .0314 | .7592 | 2.9 | 1.6 |
| 273 | .0935 | 1.0000 | 1.8 | 1.6 |

NOTE.—The cumulative population share is the population share of city $j$ plus that of all cities smaller than $j$. The mean and variance calculations use the population weights.

Table 7 reports the parameter estimates for two specifications.[10] Model 1 zeros out city characteristics other than population (i.e., $\eta_1 = \eta_2 = \eta_3 = 0$) and excludes the corresponding moments. Model 2 is the full specification.

The estimate of $\tau$ is approximately 3.8 in both models and is precisely estimated. To interpret this magnitude, it is useful to compare it to the magnitude of matching cost. There are two interesting points to be made about this comparison.

First, the relative importance of frictional costs versus matching depends on city size. For the smallest city, the expected difference between its match draw and the best match draw is $7.7 - (-0.6) = 8.3$, much higher than $\tau = 3.8$. So the savings in frictional cost from opening in the smallest city would be more than offset by the higher cost of a (typically poor) bad match in the smallest city. In contrast, for the largest city, the same difference is $1.8 - (-0.6) = 2.4$, which is much less than $\tau$. Matches are typically good in the largest city, so there is less of a trade-off between enjoying a good match and saving on frictional costs.

Second, the relative importance of frictional costs and matching also depends on firm size. Suppose that a firm is so large that fixed costs are irrelevant, and consider two strategies. Strategy 1 is to service sales in each location out of a local office. Strategy 2 is to open a single office, putting it in the best match location (the lowest $\epsilon_{ij}$) and using this to service sales in all locations. Strategy 1 raises expected match cost by 4.6 but reduces frictional cost by anywhere from $(1 - n_J)\tau = 3.5$ to $(1 - n_1)\tau \approx 3.8$, depending on where the single office with strategy 2 is located. On net, strategy 2 is preferred to strategy 1. But for this large

[10] Nondifferentiability of the objective function precluded the use of a gradient-type method for optimization. Instead, I used a simplex-type method called the *amoeba method*. A bootstrap procedure was used to approximate standard errors.

TABLE 7
Structural Parameter Estimates

| Parameter | Model 1: No Additional City Characteristics | Model 2: Additional City Characteristics |
|---|---|---|
| $\tau$ | 3.81 | 3.75 |
| | (.07) | (.07) |
| $\phi$ | 1.52 | 1.53 |
| | (.10) | (.09) |
| $\gamma$ | .15 | 5.93 |
| | (.69) | (1.35) |
| $\lambda_{\text{college}}$ | . . . | −.02 |
| | | (.01) |
| $\gamma_{\text{airports}}$ | . . . | .22 |
| | | (.02) |
| $\lambda_{\text{manufacturing}}$ | . . . | .05 |
| | | (.01) |
| Number of MSAs | 273 | 273 |
| Number of firms | 3,786 | 3,786 |

Source.—Author's estimates with moments from the 1997 Census of Wholesale Trade that have been cleared for release by the Census Bureau and are available from the author.

firm, the trade-off between better matching and savings on frictional cost is a close call.

Next, suppose that a firm is so small that it chooses a single office. The analogue of strategy 1 above is to locate the office in city $J$ to minimize frictional costs. Strategy 2, as before, is to place a single office in the city with the lowest matching cost. Strategy 1 raises expected matching costs by $1.8 - (-0.6) = 2.4$ and reduces frictional costs by at most $(n_J - n_1)\tau = 0.36$. Hence, the savings on frictional cost is small compared with the increase in matching costs, since even the largest city is only a small portion of the total population. Thus reducing frictional costs is relatively unimportant for a very small firm. This is the fundamental reason, in the model, that smaller firms are more concentrated in the smallest cities.

The estimate of the fixed cost $\phi$ is 1.5 in both models and is precisely estimated. To interpret the magnitude, it is useful to relate it to the population shares of the smallest and largest cities, $n_1 = 0.0003$ and $n_J = 0.094$. The smallest firm type has sales of $q_1 = 7.5$, as reported in table 4. If the smallest firm were to locate an office in the largest city, the savings in out-of-town costs would be $\tau q_1 n_J = 3.8 \times 7.5 \times 0.094 = 2.7$. This exceeds the fixed cost of $\phi = 1.5$. This does not mean that a small firm will always open an office in the largest city, because it has to consider selling costs as well. The population of the smallest city is so tiny that, for the small firm, the fixed cost obviously swamps savings in the frictional cost. For the largest firm type, the savings in frictional cost from locating in the smallest city is $\tau q_6 n_1 = 5.6$, more than three times as large as the fixed cost of opening the office. If these were the only considerations, the largest firms would always open an office in the smallest city. But again, firms also take selling costs into consideration.

The estimates of the knowledge spillover parameter $\gamma$ have standard errors in the range of 0.7–1.4, which are high compared to the standard errors on the $\tau$ and $\phi$ estimates. The point estimates vary from 0.15 in model 1 to 5.9 in model 2. Consider the magnitude of the high estimate. The cost difference due to knowledge spillovers between the largest and smallest cities is $(n_J - n_1)\gamma \approx 0.1 \times 5.9 = 0.6$. This is swamped by the expected difference in match quality, which from table 7 is $7.7 - 1.8 = 5.9$.

In model 2, the coefficient estimates for the airport and manufacturing city characteristics variables are positive as expected. The coefficient on the education variable is negative, but the magnitude is close to zero. Appendix table A1 shows how the city characteristics vary across city size classes. A notable feature of that table is that the manufacturing activity measure tends to decrease with city size. Using the coefficient estimate on this characteristic, I find that the change in average selling cost between the top city size class (8 million plus) and the bottom (under 0.5 million) is 0.28.[11] The change attributable to the knowledge spillover component is $-0.44$. Thus the manufacturing activity component to some extent offsets the knowledge spillover component, and this may account for why the estimate of $\gamma$ increases when the additional city characteristics are included. In any case, the average cost differences from spillovers and other characteristics across city size classes are quite small relative to the differences in average matching quality.

The estimated model economy fits the data well, considering that it is highly stylized and has only a few parameters. Panels B and C of table 8 report the moments of the model economy data for model 1 and model 2. For comparison purposes, panel A repeats the moments reported earlier from the actual data. The estimated models in panels B and C are qualitatively like the data, and the numerical values are in many instances fairly close. Each row is increasing from left to right. Column 2 is decreasing from top to bottom, column 3 is U-shaped, column 4 is increasing from top to bottom, and column 5 has an inverted U shape.

## V. Conclusion

This paper develops a model in which firms can choose multiple locations for sales offices. There are two main theoretical results. First,

[11] The change attributable to changes in the education level is 0.08 and to changes in the airport variable is $-0.37$.

TABLE 8
Comparison of Model 1 with 1997 Census Data

| Sales of Firm | Offices per Firm (1) | Sales Location Quotient by MSA Population Groupings (Millions): Under 0.5 (2) | 0.5–2 (3) | 2–8 (4) | 8+ (5) |
|---|---|---|---|---|---|
| | | A. 1997 Census Data | | | |
| Under 25 | 1.7 | .76 | .91 | 1.04 | 1.27 |
| 25–50 | 3.3 | .62 | .78 | 1.09 | 1.47 |
| 50–100 | 4.9 | .52 | .80 | 1.13 | 1.48 |
| 100–250 | 7.6 | .55 | .89 | 1.16 | 1.28 |
| 250–1,000 | 13.8 | .44 | .89 | 1.22 | 1.29 |
| 1,000+ | 28.4 | .32 | .85 | 1.33 | 1.28 |
| | | B. Model 1 | | | |
| Under 25 | 1.3 | .88 | .90 | .97 | 1.28 |
| 25–50 | 3.9 | .80 | .81 | .96 | 1.48 |
| 50–100 | 6.2 | .75 | .77 | 1.01 | 1.49 |
| 100–250 | 9.8 | .71 | .75 | 1.07 | 1.46 |
| 250–1,000 | 15.6 | .67 | .77 | 1.10 | 1.43 |
| 1,000+ | 25.4 | .67 | .80 | 1.10 | 1.40 |
| | | C. Model 2 | | | |
| Under 25 | 1.3 | .65 | .89 | 1.16 | 1.19 |
| 25–50 | 3.9 | .59 | .80 | 1.12 | 1.41 |
| 50–100 | 6.4 | .56 | .76 | 1.17 | 1.42 |
| 100–250 | 10.0 | .53 | .74 | 1.22 | 1.40 |
| 250–1,000 | 15.1 | .50 | .76 | 1.24 | 1.38 |
| 1,000+ | 22.4 | .50 | .78 | 1.23 | 1.36 |

the concentration of sales office activity in the *largest* cities decreases in firm size for large enough firms. Second, if the frictional cost and knowledge spillover parameters are not too large, then the concentration of sales office activity in the *smallest* cities also decreases in firm size.

Using micro data on sales offices from the Census of Wholesale Trade, I find that the implications of the theory are salient features of the data. After first normalizing the match quality parameters, I estimate the remaining parameters of the model. While there are multiple estimates for the knowledge spillover parameter, even with the high-end estimate, the parameter is unimportant relative to matching considerations. The estimates of the fixed cost and frictional cost parameters are precise. The fixed cost matters for the smallest firms in the data but has negligible importance for the largest firms. The savings in frictional cost from having a local office is approximately equal to the savings in matching costs from using the best match location rather than the average.

The analysis has a number of limitations. First, the model assumes that all firms, large and small, sell to a national market and that the distribution of sales across cities is the same for all. In reality, some firms are regional. Second, the model assumes that all firms are constrained to mediate sales through an internal sales operation. In reality, firms are sometimes able to outsource this activity through independent agents. Third, the modeling of frictional costs is crude. In a richer model, the frictional cost would increase with distance rather than be flat. I expect that the tensions at work in the simpler model considered here would continue to hold in a more general model incorporating these features.

The paper has implications beyond the sales office sector. Sales office activity is but one example of the white-collar, information-oriented work that is highly concentrated in large cities. (See Holmes and Stevens [2004] for a recent accounting.) The frictional costs found to exist for the sales office sector are likely to matter for this information-oriented work more generally. The case for extending the results is easiest to make for the remaining components of the wholesaling sector besides manufacturers sales offices, namely, merchant wholesalers and agents and brokers, because the activities are very similar, for example, the making of sales calls. It is more of a stretch to apply the results to other sectors such as finance and business services that are different from sales offices in many ways. But like sales offices, these other sectors rely heavily on face-to-face contact. The potential frictional costs of providing these face-to-face contacts may be just as important for these sectors as for sales offices.

The problem of a manufacturer allocating sales offices across cities is analogous to the problem of a multinational firm allocating local affiliates across countries (Helpman, Melitz, and Yeaple 2004). Also related is how a firm's export decision depends on the size of the destination country (Eaton, Kortum, and Kramarz 2004). This trade literature so far has not incorporated matching considerations. Since matching seems to matter for sales offices, perhaps it matters in these trade contexts as well.

## Appendix A

### Notes for Section II

*Definition of Cities*

I use MSAs as defined by the 1997 Economic Census, and the population figures are taken from the geographical file that accompanies these data. In cases in which MSAs are combined into a *consolidated* MSA, I use the consolidated entity. For example, New York is an aggregation of 15 *primary* MSAs (PMSAs), including, for example, the Newark, New Jersey, PMSA, the Danbury, Connecticut, PMSA, as well as, of course, the New York, New York, PMSA. With these aggregations, the data contain 273 metropolitan areas.

*Sales Offices and Other Facilities*

The issue of the joint location of sales offices and other facilities is raised in the text. To address this issue, I extend the earlier statistical model to allow for the sales office location probability to depend on the presence of other facilities. Suppose that the λ parameter in (1) takes the functional form

$$\lambda_{ij} = \frac{\exp(\theta_i - \beta^M y_{ij}^M - \beta^A y_{ij}^A)}{\exp(\theta - \beta^M y_{ij}^M - \beta^A y_{ij}^A) + 1},$$

where $y_{ij}^M$ and $y_{ij}^A$ are the number of manufacturing and administrative establishments that firm $i$ has in city $j$. If $\beta^M = 0$ and $\beta^A = 0$, things reduce to what I had before. If $\beta^A > 0$, then, with everything else including city size held fixed, an increase in the number of local administrative facilities increases the likelihood a city will have a sales office (since the probability $\lambda_{ij}^{\alpha^{n_j}}$ of *not* getting one decreases).

Allowing for this more general structure has virtually no effect on the point estimate of $\alpha$. (The estimate is 1.43 rather than 1.42.) The estimate of $\beta^M$ is $-0.34$, with a standard error of 0.20, making it barely statistically significant. The estimate of $\beta^A$ is 0.94, with a standard error of 0.26. To make sense of the magnitudes, I evaluate the estimated probability of an office at the mean value of city size $n$ and the mean value of $\theta_i$, starting with $y^M = y^A = 0$. Adding one manufacturing plant reduces the probability of an office from 0.248 to 0.193. Adding one administrative facility increases the probability from 0.248 to 0.440. Thus the probability of having a sales office in a city goes up if the firm also has an administrative office in a city. But again, as emphasized in the text, the number of administrative facilities is small compared to the number of offices, and 85 percent of all sales offices are in cities without an administrative office.

*Controls for Additional City Characteristics*

The variables used in the regression with additional controls are defined as follows. The education measure is the fraction of workers 25 years and older with a bachelor's, graduate, or professional degree in the MSA in 1990. The source is the U.S. Bureau of the Census (1996). The airport variable is domestic enplanements in 1999 per person. The source is the U.S. Bureau of Transportation Statistics (2000). The manufacturing intensity measure is sales of manufacturing plants per person. The source is the 1997 Economic Census (U.S. Bureau of the Census 2001). Table A1 shows a cross tabulation of these three variables.

TABLE A1
DISTRIBUTION OF CITY CHARACTERISTICS BY CITY SIZE

| | Non-MSA | MSA Population (Millions) | | | |
|---|---|---|---|---|---|
| | | Under 0.5 | 0.5–2 | 2–8 | 8+ |
| | (1) | (2) | (3) | (4) | (5) |
| Education level | 13.26 | 18.56 | 20.44 | 24.64 | 23.80 |
| Airport activity | . . . | .92 | 2.76 | 4.06 | 2.64 |
| Manufacturing activity | 14.54 | 16.65 | 15.36 | 14.27 | 10.86 |

NOTE.—Education level is the percentage of population 25 years and older with four years of college; airport activity is domestic enplanements per person in 1999; and manufacturing activity is sales of manufacturing plants, $1,000s per person in 1997.

*Accessing the Census Data*

Three kinds of census data are used in the project. First, raw micro data were examined in the Census Bureau's Center for Economic Studies site in Suitland, Maryland. Second, moments from the micro data were constructed that were released by census officials after a disclosure review. These moments were subsequently analyzed outside the census. Third, the project used data from published tabulations. Table 2 uses only published tabulations. Tables 3–6 use the raw micro data. Table 7, the structural estimates, takes as input the disclosed moments (table 5) as well as published tabulations of sales by MSA (used for estimating the coefficients on city characteristics). These data and the programs to estimate the model are available from the author.

## Appendix B

### Proofs of Propositions

*Proof of Proposition 1 (Sketch)*

The first step in the proof is to derive an analytic formula for $\overline{\mathrm{LQ}}_j$ in the large-firm case (9). Let $p_{j,k}$ be the probability that location $j$ services location $k$. When I rewrite (11), location $j$ supplies itself if and only if

$$\frac{\phi}{qn_j} + \epsilon_j - \gamma n_j \leq \min_{l \neq j} (\epsilon_l - \gamma n_l + \tau).$$

When the standard logit arguments are used, the probability of this event is

$$p_{j,j} = \frac{n_j \exp[\gamma n_j - (\phi/qn_j)]}{\sum_{l \neq j} n_l \exp(\gamma n_l - \tau) + n_j \exp[\gamma n_j - (\phi/qn_j)]}.$$

Analogously, the probability that location $j$ services $k$ is

$$p_{j,k} = \frac{n_j \exp(\gamma n_j)}{\sum_{l \neq k} n_l \exp(\gamma n_l) + n_k \exp[\gamma n_k + \tau - (\phi/qn_k)]}.$$

The expected location quotient at $j$ is

$$\overline{\mathrm{LQ}}_j = p_{j,j}\frac{n_j}{n_j} + \sum_{k \neq j} p_{j,k}\frac{n_k}{n_j}. \tag{B1}$$

The second step in the proof is to write $\overline{\mathrm{LQ}}_j(\phi/q)$ as a function of $\phi/q$. Straightforward calculations show that $\overline{\mathrm{LQ}}_j'(\phi/q) > 0$ when evaluated at $\phi/q = 0$, which proves the claim. QED

*Proof of Proposition 2 (Sketch)*

From the analysis of the small-firm case, the limiting location quotient for small enough $j$ is

$$\lim_{q \to 0} \overline{\mathrm{LQ}}_j = \frac{1}{n_j} p_j = \frac{1}{n_j} \frac{n_j \exp(-\tau n_j)}{\sum_{k=1}^{J} n_k \exp(-\tau n_k)} = \frac{\exp(-\tau n_j)}{\sum_{k=1}^{J} n_k \exp(-\tau n_k)},$$

where $p_j$ is the probability that city $j$ is the location of the single office, and

$\gamma = 0$ is imposed. For a very large firm, with $q$ taken to infinity, the limiting location quotient from formula (B1) is

$$\lim_{q\to\infty} \overline{\mathrm{LQ}}_j = \frac{n_j}{n_j + (1-n_j)\exp(-\tau)} + \sum_{k\neq j}^{J} \frac{n_k}{n_k \exp(\tau) + (1-n_k)}. \tag{B2}$$

Using $n_1 = 0$ and taking inverses of these limits, I can show that when $n_J \leq 0.5$,

$$G(\tau) \equiv \frac{1}{\sum_{k=2}^{J} n_k/[n_k \exp(\tau) + (1-n_k)]} - \sum_{k=2}^{J} n_k \exp(-\tau n_k)$$

is strictly positive for small $\tau$. Straightforward calculations show $G(0) = 0$ and $G'(0) = 0$. Furthermore, $G''(0) > 0$ if and only if

$$H \equiv \sum_{k=2}^{J} n_k^2 + 2\left(\sum_{k=2}^{J} n_k^2\right)^2 - 3\sum_{k=2}^{J} n_k^3$$

is strictly positive. In the separate notes available on the Web (Holmes 2004), it is shown that $n_J < 0.5$ and that $n_j \leq n_{j+1}$ implies $H > 0$, which proves the claim. QED

## References

Black, Duncan, and Vernon Henderson. 1999. "A Theory of Urban Growth." *J.P.E.* 107 (April): 252–84.

Davis, Donald R., and David E. Weinstein. 1996. "Does Economic Geography Matter for International Specialization?" Working Paper no. 5706 (August), NBER, Cambridge, MA.

———. 1999. "Economic Geography and Regional Production Structure: An Empirical Investigation." *European Econ. Rev.* 43 (February): 379–407.

Eaton, Jonathan, and Zvi Eckstein. 1997. "Cities and Growth: Theory and Evidence from France and Japan." *Regional Sci. and Urban Econ.* 27 (August): 443–74.

Eaton, Jonathan, and Samuel Kortum. 2002. "Technology, Geography, and Trade." *Econometrica* 70 (September): 1741–79.

Eaton, Jonathan, Samuel Kortum, and Francis Kramarz. 2004. "An Anatomy of International Trade: Evidence from French Firms." Manuscript, Univ. Minnesota.

Ellison, Glenn, and Edward L. Glaeser. 1997. "Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach." *J.P.E.* 105 (October): 889–927.

Fujita, Masahisa, Paul Krugman, and Anthony J. Venables. 1999. *The Spatial Economy: Cities, Regions, and International Trade.* Cambridge, MA: MIT Press.

Fujita, Masahisa, and Jacques-François Thisse. 2002. *Economics of Agglomeration: Cities, Industrial Location, and Regional Growth.* Cambridge: Cambridge Univ. Press.

Glaeser, Edward L. 1999. "Learning in Cities." *J. Urban Econ.* 46 (September): 254–77.

Helpman, Elhanan, Marc J. Melitz, and Stephen R. Yeaple. 2004. "Export versus FDI with Heterogeneous Firms." *A.E.R.* 94 (March): 300–316.

Holmes, Thomas J. 2004. Separate appendix for "The Location of Sales Offices and the Attraction of Cities." Manuscript, Dept. Econ., Univ. Minnesota. http://www.econ.umn.edu/~holmes/papers/separate_appendix_sales_offices.pdf.

Holmes, Thomas J., and John J. Stevens. 2004. "Spatial Distribution of Economic Activities in North America." In *Handbook of Regional and Urban Economics*, vol. 4, *Cities and Geography*, edited by Vernon Henderson and Jacques-François Thisse. Amsterdam: North-Holland.

Lucas, Robert E., Jr. 2001. "Externalities and Cities." *Rev. Econ. Dynamics* 4 (April): 245–74.

Rosenthal, Stuart S., and William C. Strange. 2001. "The Determinants of Agglomeration." *J. Urban Econ.* 50 (September): 191–229.

U.S. Bureau of the Census. 1996. *USA Counties 1996*. CD-ROM. Washington, DC: U.S. Dept. Commerce.

———. 2000. *1997 Wholesale Trade Geographic Area Series*. Washington, DC: U.S. Dept. Commerce.

———. 2001. *1997 Economic Census*. CD-ROM. Washington, DC: U.S. Dept. Commerce.

U.S. Bureau of Transportation Statistics. 2000. *Public Use Airports*. Washington, DC: U.S. Dept. Transportation.