The Micro-Empirics of Agglomeration Economies

Stuart S. Rosenthal
Department of Economics
and Center for Policy Research,
Syracuse University,
Syracuse, NY 13244-1020, USA
Phone: 315-443-3809; Email: ssrosent@maxwell.syr.edu
Web: www-cpr.maxwell.syr.edu/faculty/rosenthal/

and

William C. Strange
RioCan Real Estate Investment Trust
Professor of Urban Economics and Real Estate
Rotman School of Management
105 St. George St.
University of Toronto
Toronto, ON M5S 3E6, Canada
Phone: (416) 978-1949; Email: wstrange@rotman.utoronto.ca
Web: www.rotman.utoronto.ca/~wstrange/

Prepared for the Blackwell Companion to Urban Economics

April 13, 2004

*We are grateful for the financial support of the Connaught Fund at the University of Toronto, the Social Sciences and Humanities Research Council of Canada, and the Kaufman Foundation.

Abstract

This chapter considers evidence on the spatial concentration of economic activity. Two kinds of concentration are considered: the agglomeration of population into cities and the clustering of industries into specialized regions. The chapter considers the productivity advantages of city size and industrial concentration. It also looks at the geographic and organizational dimensions of these externalities, as well as their sources. In the course of this, the chapter discusses methodological issues that pertain to this kind of measurement. It concludes with implications for public policy.

1. Introduction

Economics is the study of the allocation of scarce resources. Urban economics focuses on the allocation of resources across space. In considering this sort of resource allocation, a striking fact becomes apparent immediately: economic activity is highly concentrated. More than 75% of Americans live in cities as they are defined by the Census Department, and yet these cities occupy only 2% of the land area of the lower 48 states. This story is not unique to the United States. Capital and labor are highly agglomerated in every developed county, and they are increasingly agglomerated in the developing world.

It is not just aggregate activity that is agglomerated. Individual industries are concentrated too. The top panel of Figure 1, for instance, presents the density of employment in the Wine industry (SIC 2084). As is well known, most of the country has little employment devoted to wine production. The most significant exceptions are California, Eastern Washington, and New York State, especially in the Finger Lakes region. The forces contributing to the spatial concentration of wine industry employment in these regions are not hard to grasp. All three regions have climates that support the growing of grapes. Because grapes are perishable, wine makers locate production facilities close to the source of the grapes in order to reduce transportation costs.

If the location of the wine industry seems easily explained, the bottom panel of Figure 1 presents more of a challenge. It shows the spatial concentration of the software industry (SIC 7371-3, 7375). Although this is an activity that could seemingly take place anywhere, it is clear from the figures that it does not. Once again, most of the country has little employment in these industries, while a relatively small number of counties account for a large fraction of software development. Moreover, these counties are not randomly scattered across the U.S. Instead, they

are disproportionately located in California (the Silicon Valley), Washington State (Microsoft's headquarters), the northeast (especially around Boston), and a small number of other areas around the country (including Minneapolis, Austin, and the research triangle area of North Carolina).

The macro pattern in the bottom panel of Figure 1 repeats itself in Figure 2, a map of the location of software producers in the vicinity of San Francisco (top panel) and Boston (bottom panel). As can readily be seen, in both metropolitan areas, activity is highly concentrated in a few areas. Yet there is no material input that is analogous to grapes. Something is going on that is leading to this kind of geographic concentration.

It is tempting to speculate that the nature of high technology production contributes to the spatial concentration of software development. Perhaps, ideas flow more readily when engineers have opportunities to interact. This may well be the case, but it does not seem to offer an explanation for Figure 3. Here, we present the spatial concentration of employment in the carpet manufacturing industry, both for the country overall (top panel) and for the area centered around the northwest corner of Georgia. Carpet manufacturing is a mature industry with a well established technology. This industry clearly is not as dependent on new ideas as is software. Carpet production does require raw materials, but the materials are easily transported, unlike grapes. Despite this, in the top panel it is clear that carpet production is heavily concentrated in the southeast of the United States, especially in the vicinity of the northwest corner of Georgia. Moreover, as with software development, spatial concentration at the macro level is mirrored at a more refined level of geography. In the bottom panel of Figure 3, carpet manufacturing is heavily concentrated in the northwest corner of Georgia. Clearly, something beyond locating near raw materials or some sort of high-technology learning from neighbors is taking place.

This chapter will consider the evidence on the forces that lead to agglomeration. These forces are usually referred to as agglomeration economies, although they are also known as external economies of scale. Economies of scale arise when an increase in the scale of activity reduces the long run cost per unit of output produced. *External* economies of scale exist when long run average cost falls in response to an increase in the size of a city or the size of an industry in a city. In contrast, *internal* economies of scale arise when average cost at a given factory declines in response to an increase in the level of activity at the factory. In the discussion to follow, we will focus on the agglomeration of industries that are at least somewhat footloose, like software or carpets, rather than industries where some locations have natural advantages, like the wine industry.

The chapter will consider a number of key questions. Are agglomeration economies restricted to individual industries like software and carpets or are their effects comprehensive, extending across all activities? Are the effects highly localized, as appears to be the case with software and carpets, or do the effects operate at a larger geographic scale? Does the effect of agglomeration differ for large and small firms? The empirical literature on agglomeration economies has gone a long way to answering these questions.

Another set of questions have only recently begun to be answered. These questions concern the sources of agglomeration economies. In his classic textbook, Marshall (1920) identifies three sources: input sharing, labor market pooling, and knowledge spillovers. An example of input sharing is when an apparel manufacturer in New York is able to purchase a great variety of relatively inexpensive buttons from a nearby company that specializes in button manufacturing. An example of labor market pooling is when a software company in the Silicon Valley can quickly fill a position by hiring one of the many skilled programmers already present

in the Valley. Similarly, a skilled programmer in the Valley can more easily find a new position without having to relocate. In both instances, labor pooling reduces search costs and improves match quality, providing valuable benefits for employers and workers. An example of knowledge spillovers is when the software company's programmers can learn the tricks of the trade from random interactions with other programmers in the Silicon Valley. What is the evidence on these sources? As of now, the answers to this question are suggestive rather than conclusive.

In discussing the measurement of agglomeration economies, this chapter also addresses methodology. The literature sometimes involves very precise structural econometrics. A good example of this is the estimation of the parameters of a production function describing how inputs are turned into products and services. These estimates are very tightly linked to economic theory, and they require highly refined data that is not always available. Because of limitations on data, other empirical papers on agglomeration economies employ reduced form methods. This involves estimating relationships that are implied by the connection between agglomeration and productivity, for instance the relationship between city size and growth. This kind of estimation can provide useful insights into agglomeration, even if it does not provide precise estimates of underlying structural parameters, as with the estimation of a production function.

The rest of the chapter begins with a discussion of the oldest debate on agglomeration: whether the effects depend on city size or only on the size of the own industry. Section 3 then considers the geographic scope of agglomeration economies, while Section 4 considers the sources of agglomeration economies. Section 5 considers the role of industrial organization and local culture Section 6 concludes by considering the relevance of the evidence on

agglomeration economies for public policy towards innovation, productivity, and local economic development.

2. Localization and urbanization

The oldest debate on agglomeration economies concerns whether they are related to the concentration of an industry or to the size of a city itself. The latter effect is known as an "urbanization economy," where city scale impacts productivity. The former is known as a "localization economy," where it is the size of a firm's own industry that matters. The idea that industrial localization can increase productivity goes back to Marshall (1920).

> When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from neighborhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously...Employers are apt to resort to any place where they are likely to find a good choice of workers with the special skill which they require...The advantages of variety of employment are combined with those of localized industries in some of our manufacturing towns, and this is a chief cause of their continued economic growth. (1920, 271).

The idea that a city's size or its diversity directly contributes to agglomeration economies is often attributed to Jacobs (1969), although the idea predates her work. Marshall (1920), for example, also recognized the value of urban diversity, both as a way to achieve domestic complementarity and to reduce risk:

> On the other hand a localized industry has some disadvantages as a market for labour if the work done in it is chiefly of one kind, such for instance as can be done only by strong men. In those iron districts in which there are no textile or other factories to give employment to women and children, wages are high and the cost of labour dear to the employer, while the average money earnings of each family are low. But the remedy for this evil is obvious, and is found in the growth in the same neighbourhood of industries of a supplementary character. Thus textile industries are constantly found congregated in the neighbourhood of mining and engineering industries, in some cases having been attracted

> by almost imperceptible steps; in others, as for instance at Barrow, having been started deliberately on a large scale in order to give variety of employment in a place where previously there had been but little demand for the work of women and children...A district which is dependent chiefly on one industry is liable to extreme depression, in case of a falling-off in the demand for its produce, or of a failure in the supply of the raw material which it uses. This evil again is in a great measure avoided by those large towns or large industrial districts in which several distinct industries are strongly developed. If one of them fails for a time, the others are likely to support it indirectly; and they enable local shopkeepers to continue their assistance to workpeople in it. (1920, p. 273-4)

It is not hard to see evidence consistent with both of these effects. The Silicon Valley is a well-known concentration of industry, in this case the computer industry, broadly conceived. Although the cost of labor and land in the Valley is very high, firms continue to do business there. This is entirely consistent with the idea of localization economies. One can find a good example of urbanization economies several hundred miles to the south in Los Angeles. Los Angeles does not have a single dominant industry in the way that the Silicon Valley does. Film and television production have a high profile, but they are only a small part of a diverse local economy that also includes employment in high technology industries like aerospace and old industries like apparel. The broad range of activities taking place in Los Angeles coupled with its large size are presumably part of the explanation for the city's continued growth. Jacobs (1969), for instance attributes Los Angeles success in generating "new work" in the postwar period to its diverse economy. Hughes Air spawned roughly 100 spinoffs according to her estimate, including some products that bear little resemblance to aerospace, such as sliding doors. In this case, the diverse local economy created synergies between the region's booming construction industry and aircraft manufacturing. Similar arguments have also been offered as explanations for New York City's strength relative to less diverse cities such as Pittsburgh (Chinitz (1961)).

Of course, economists are not satisfied with casual empiricism of this kind. To really understand agglomeration economies requires a more careful application of econometric techniques. Since agglomeration economies are by definition enhancers of productivity, it is natural to begin by looking at what we can learn by estimating a production function. Suppose that an establishment's production function may be written as g(A)f(l, n, m, k). f(·) is a traditional production function, defined on the inputs land (l), labor (n), materials (m), and capital (k). The variable A characterizes the establishment's environment, and so allows for the influence of agglomeration.

How would one estimate a production function? The first requirement would be to measure the various inputs, including employment, land, capital, and materials. Labor inputs are perhaps the easiest to measure, since many datasets provide counts of workers, hours worked, and proxies for skill level (e.g. education). Data on purchased materials are available in some datasets, but data on materials produced internally typically are not. Few datasets make available measures of land use and the stock of capital. Since omitted variables may bias the estimates obtained in a regression, finding a way to control for these inputs is a fundamental challenge when estimating production functions.

The second requirement is to control for agglomeration, the variable A introduced above. Several approaches have been taken. One is to include a measure of the city's population to capture urbanization economies and a measure of the employment in a particular industry to capture localization economies. This is a common approach. It is not however the only reasonable approach. Researchers have, for instance, also looked at urban diversity directly and at a city's specialization in a particular industry, as measured by the share of employment in that industry rather than the level.

Despite the challenges, a number of researchers have estimated production functions in order to evaluate the impact of agglomeration. Taken together, the conclusion from these studies is that doubling city size seems to increase productivity by an amount that ranges from roughly 3-8%. See Rosenthal-Strange (2004) for a review. Nakamura (1985), for example, considers the influence of agglomeration in Japan, while Henderson (1986) examines the effect of agglomeration in the U.S. and Brazil. Both estimate production functions separately for manufacturing industries, specifically Standard Industrial Classification (SIC) "two-digit" industries. Urbanization is proxied by total employment in the city. Localization is proxied by employment in the industry. While there is evidence of urbanization economies in several industries, there is evidence of localization economies in more. Some industries exhibit no evidence of external economies at all. Nakamura summarizes his work as finding that a doubling of industry scale leads to a 4.5% increase in productivity, while a doubling of city population leads to a 3.4% increase. Henderson finds almost no evidence of urbanization economies and substantial evidence of localization. In related work, Moomaw (1983) finds evidence of both. Overall, these studies are somewhat more favorable to the existence of localization economies than to urbanization economies. In addition, the results strongly suggest that one ought to estimate agglomeration economies separately for different industries, since there is such substantial variation across industries.

There are other ways to look for evidence of localization and urbanization economies. If agglomeration enhances productivity, labor demand will shift out. This will lead employment to grow more quickly and to higher wages. Accordingly, Henderson et al (1995) consider employment growth in the U.S. over the 1970 to 1987 period. They conduct their estimation separately for eight industries, three of which experienced rapid innovations in high-technology

during the period, and five that were mature industries with stable technologies. For the high-technology industries, they find that specialization of employment at the metropolitan level is not associated with faster employment growth within these industries. For the mature industries they find a positive effect of specialization. This result is parallel to Duranton and Puga (2001a), who use French data to show that while new industries evolve in diverse "nursery" cities, they move to specialized ones after reaching maturity.

Glaeser and Mare (2001) look at wages instead of growth. They find that wages are higher in larger cities – an urbanization effect. This urban wage premium is larger the longer a worker has stayed in a large city. Even when the worker moves to a smaller city, some of the urban wage premium remains. This seems to suggest that cities foster knowledge spillovers, a topic discussed further in Section 4 of this chapter.

Finally, Rosenthal and Strange (2003) examine the location decisions of new plants in a model of plant births. The intuition is that if agglomeration enhances productivity, additional plants will be drawn to agglomerated areas. The key findings are that diversity attracts new arrivals, and that localization economies are more important than urbanization economies for the six industries studied.

It is important to recognize that in all of the studies discussed above it is difficult to be certain about causality. Agglomeration causes workers to be more productive. But skilled workers may also be drawn to urban areas, both because of higher urban wages, and also because of consumption amenities associated with urban life (e.g. theater, restaurants, etc.). This complicates efforts to identify the impact of agglomeration on productivity. In studies that estimate production functions, this has proved especially challenging. Henderson (2003) addresses this issue by using econometric methods that rely on “instrumental variables,”

variables that are correlated with the agglomeration measures but which are exogenous to the dependent variable being analyzed. A similar approach is taken in Glaeser and Mare's (2001) analysis of urban wage rates. In studies that examine employment growth, economic conditions from up to twenty years in the past have been used to explain future patterns of growth (e.g. Henderson et al (1995), Glaeser et al (1992)). The motivation for this is that deeply lagged previous conditions are exogenous to future growth in employment. In birth studies (Rosenthal and Strange (2003)), a similar approach has been used, evaluating the location decisions of new arrivals based on the previous spatial distribution of economic activity. The assumption here is that entrepreneurs take as given the existing economic landscape when choosing where to locate a new establishment. It should be emphasized in conclusion that despite the challenges associated with identifying a causal effect of agglomeration, a clear consensus has emerged: agglomeration economies enhance productivity.

3. Geography

The productivity studies reviewed in the last section took particular and narrow approaches to geography. Most of them used political boundaries to define the extent of a city. This amounts to assuming that all firms in New York benefit from all other firms in the city. Whether the firm is nearby or far away makes no difference. The patterns in the lower panels of Figures 2 and 3 for software and carpet manufacturing strongly suggest that, at least for these industries, that is not the case. Instead, the patterns in these figures indicate that firms tend to be drawn to locations where activity in their industry is most concentrated. Although not conclusive by itself, this is consistent with the idea that firms benefit much more from own-industry activity in the immediate area than from activity farther away.

In a recent paper, Rosenthal and Strange (2003) examine this issue as part of their effort to provide a micro-level analysis of the geographic scope of agglomeration economies. The paper takes advantage of geocoding software and data that places firms in zipcodes, the same as used in Figure 2 in this chapter. This makes it possible to measure total employment and own-industry employment within a certain distance of an employer. Using these measures, it is possible to calculate the effects of the local environment on the number of firm births and on these new firms' employment levels for six industries (computer software, apparel, food processing, printing and publishing, machinery, and fabricated metals). Some of the results of this estimation are presented in Figure 4.

The figure graphically shows that agglomeration economies attenuate with distance. The level of employment chosen by newly arrived firms increases when employment increases in the firm's industry within one mile of the firm's zipcode. In the case of software, for example, the presence of 100 additional existing software employees within 1 mile of a given zipcode attracts new firms that add a total of 1.2 new software workers to that zipcode in the following year, everything else equal. On the other hand, the influence of existing employment in the own industry just five miles away has a much smaller effect, as does employment farther out beyond ten and fifteen miles. This pattern holds for computer software, food processing, apparel, machinery, and fabricated metals. Interestingly, it does not occur for printing and publishing, suggesting that this industry may be less sensitive to localization economies or that printing and publishing firms serve local markets.

These results are consistent with anecdotal evidence about industrial concentration. The Silicon Valley is a hotbed of productivity in the computer industry, as well as in other related fields. A number of explanations have been offered to account for this. Some of them involve

learning, where knowledge is a kind of local public good. Perhaps the most famous example of this is Steve Jobs' visit to the Xerox Corporation's Palo Alto Research Center, which is credited with suggesting a number of ways that Apple could improve its products, including the mouse and the object-oriented operating system. This kind of knowledge spillover depends crucially on physical proximity, as Tom Furlong of Digital Electronics Corporation notes:

> Physical proximity is important to just about everything we do. I have better relationships with Silicon Valley companies than I have even with my own company...because I can just get in the car and go see them....You never work on the same level if you do it by telephone and airplane. It's very had to work together long distance. You don't have a feel for who the people are, they are just a disembodied voice. (Saxenian, 1994, p. 157)

Thus, even in the industry most responsible for the so-called "death of distance," proximity matters.

Of course, nothing in these results directly supports the interpretation that agglomeration economies exist because of knowledge spillovers. There are many other potential explanations. The next section deals with this issue by looking at the sources of agglomeration economies.

4. The sources of agglomeration economies

It is not hard to see that understanding the sources of agglomeration economies is fundamentally important. Communities around the world look at the success of the Silicon Valley, and would like to enjoy that kind of success themselves. It is also not hard to see that becoming a Silicon Forest (Portland and Seattle) or a Silicon Desert (Phoenix) requires more than just Silicon and wishful thinking. It requires a critical mass of computer industry activity. And achieving this requires that the benefits of an agglomeration be available. But exactly what are these benefits?

There are many candidates. We will focus on the three that were identified by Marshall (1920): knowledge spillovers, input sharing, and labor pooling. The concentration of software depicted in Figures 2 and 3 is consistent with the presence of knowledge spillovers. In fact, the relationship between agglomeration and innovation is not particular to software. Looking across industries, Audretsch and Feldman (1996) show that innovations are highly concentrated spatially and that innovative industries are more likely to be geographically concentrated. Jaffee et al (1993) provide even more direct evidence. They show that an innovator is 5-10 times more likely to cite a patent from a firm in the same metropolitan area than from another firm elsewhere in the country, controlling for industry characteristics.

Input sharing involves local outsourcing. Suppose, for example, that an apparel manufacturer makes use of specialized buttons. If these buttons are produced under increasing returns to scale and transportation is costly, then the presence nearby of another apparel producer may allow both to purchase their buttons more cheaply. Evidence of local input sharing is provided by Holmes (1999). Central to his analysis is "purchased input intensity," equal to an industry's purchased inputs divided by sales. This measure captures the degree of outsourcing in an industry. Holmes finds that more concentrated industries have a higher value of purchased input intensity, which is consistent with the presence of input sharing. For instance, the pantyhose industry is concentrated in North Carolina, where 62% of the industry's employment is found. The purchased input intensity among pantyhose firms in North Carolina is 53%, compared to 40% input intensity among pantyhose firms throughout the United States. This pattern is repeated for other concentrated industries.

A third benefit of agglomeration is labor market pooling. This occurs when firms are able to acquire specialized labor by locating near other firms in the same industry. Krugman

(1991) has argued that the carpet industry, as highlighted in Figure 3, benefits from this. Pooling labor reduces risk for both workers and employers alike by reducing search costs and enhancing the match quality between workers and jobs. For example, if a carpet producer in a remote area were to fail, workers who had developed industry specific skills may have to relocate in order to find comparable jobs. This would not be the case, presumably, in the northwest of Georgia where carpet manufacturing reigns. In effect, agglomeration offers workers a sort of insurance. The converse holds for employers. If a key employee were to leave a company in an outlying area, the firm may find that individual difficult to replace. This would not be the case in areas where skilled individuals are plentiful.

Costa and Kahn (2001) provide particularly compelling evidence of one aspect of labor pooling, better matches between workers and employers in large cities. They show that couples in which both individuals have a college degree or more – referred to as "power couples" in the paper – have increasingly located in large metropolitan areas since 1970. This coincides with the dramatic increase in female participation in high-skilled occupations that took place during that period. Factors driving the locations of power couples are then analyzed by comparing their location decisions to those of other individuals and couples, both with and without college degrees. This enables Costa and Kahn to allow for the possibility that individuals seek out big cities for a variety of reasons, including a taste for urban amenities, marriage markets, and employment opportunities. Results indicate that power couples have increasingly gravitated towards big cities at least in part because it easier for both individuals to find high-skilled work.

Recent research has considered the influence of all these sources of agglomeration economies as part of a single model. This work involves analyzing the variation in agglomeration between industries as a function of industry attributes that serve as indicators of

the potential importance of the three benefits of agglomeration just discussed: knowledge spillovers, input sharing, and labor pooling. The basic strategy is to regress an industry specific index of agglomeration on proxies for the importance of agglomeration economies, where each industry is an observation. In Rosenthal and Strange (2001), for example, proxies for the importance of agglomeration economies include measures of how innovative the industry tends to be – as reflected in the pace of new product creation – and the use of both manufactured and service inputs. The model also includes variables that proxy the importance of labor market pooling, including the degree of labor specialization in the industry as measured by the number of manager's per production worker, and the educational characteristics of an industry's workforce. Additional controls are also provided to address the importance of transport costs and natural advantages since these factors also contribute to agglomeration for reasons unrelated to external economies of scale. Recall, for example, our discussion of the wine industry in Figure 1. The regressions are carried out using 4-digit SIC manufacturing industries as observations, a total of 459 manufacturing industries in all.

Results of this analysis suggest that all of the factors discussed above contribute to industrial agglomeration. The evidence is strongest for labor market pooling, with proxies having a positive impact on agglomeration at the state, county, and zipcode levels of geography. The proxies for knowledge spillovers also impact agglomeration positively, but only at the zipcode level. Reliance on manufactured inputs or natural resources – factors that cause industries to be sensitive to shipping costs – positively affect agglomeration at the state level but have little effect on agglomeration at lower levels of geography. The same is true for inventory-sales ratios, a proxy for the perishability of output, and a further indicator of the importance of shipping costs, as with grapes in the wine industry. In contrast, reliance on service inputs

reduces state-level agglomeration. Taking all of these results together, an interesting pattern emerges, with industry attributes sensitive to shipping costs (reliance on manufactured inputs, reliance on natural resource inputs, perishability of output) influencing agglomeration at the state level, knowledge spillovers impacting highly localized agglomeration, and labor impacting agglomeration at all levels of geography.

When the evidence reviewed above is taken as a whole, it is clear there is support for a range of different agglomerative forces. This means that any policymaker hoping to gild his or her community with Silicon cannot simply rely on one sort of incentive to attract the necessary critical mass. An industry cluster requires a number of different characteristics in order to succeed. The next section takes this story one step further, by looking at the role of a city's organization and culture in the building of a productive local business environment.

5. Industrial Organization

The issue is this: one can find locations that are similar in their local knowledge, labor market, and input market characteristics that diverge in their economic performance despite this similarity. The idea is due to Saxenian (1994). In her comparison of the differences in performance between the Silicon Valley and Boston's Route 128, she argues that local technological capabilities are not the fundamental source. The primary cause is instead the differences in local industrial organization and culture. The key difference is that the Silicon Valley is in some sense more entrepreneurial than Route 128. This point is made by Bernard Kalb, an entrepreneurial refugee from the Digital Electronics Corporation:

> There's a fundamental difference in the nature of thet industry between Route 128 and [the Silicon Valley]. Route 128 is organizes into large companies that do their own thing...It's very difficult for a small company to survive in that environment...The Valley is very fast-moving and start-ups have to move fast. The whole culture of the Valley is

> one of change. We laugh about how often people change jobs. The joke is that you can change jobs and not change parking lots. There's a culture associated with that which says that moving is okay, that rapid change is the norm, that it's not considered negative on your resume...So you have this culture of rapid decisions, rapid changes, which is exactly the environment that you find yourself in as a startup. (Saxenian, 1994, p???)

This seems to be a compelling difference between Boston and the Silicon Valley.

In order to understand whether this kind of difference manifests itself across the U.S. and in industries that are not as cutting-edge as the computer industry, Rosenthal and Strange (2003) look at firm births. Two tests are carried out. First, the local concentration of existing own-industry employment is partitioned according to the size of the establishment in which a local employee works. This allows the estimation of different agglomerative effects for a worker in a small firm compared to a worker in a large firm. The idea is that the small firm is likely to be more open to interacting with its neighbors, with a greater external effect being the predicted result. The second approach involves partitioning the data by whether the employee works at a subsidiary establishment or at an independent establishment. The latter is presumably more open, while the former is presumably more closed.

The results of this estimation are partly consistent with Saxenian. Adding an additional employee at a small firm typically has a positive effect on births and new firm employment. Adding the employee at a large firm typically does not. To the extent that small firms are more open, this result is consistent with Saxenian. The performance of the subsidiary/nonsubsidiary variable is unexpected. In this case, an extra worker at a subsidiary establishment has a larger effect on the attraction of new own-industry arrivals. This is not consistent with Saxenian, suggesting as it does that corporate establishments may have larger effects on the productivity of neighbors. In some sense, this may imply that the quality of the interactions with nearby

employees of subsidiary plants is greater than those of nearby independent plants. However, the reason for such quality differentials remains to be explored.

6. Conclusion

This chapter has considered the measurement of agglomeration economies. Because the chapter has also considered innovation, economic growth, and productivity, it is natural to conclude by discussing the policy implications of the research covered by the chapter.

The area of policy to which this research speaks most directly is local industrial policy. Some places are wealthy, having high incomes and low unemployment rates. Others are not. In the U.S., federal, state, and local governments have all taken steps to help the country's poor places. There are at least two forms that such policies have taken: policies to improve the economic environment in a general way and policies designed to attract particular industries or even particular firms. This is not the place to discuss general policies like the provision of physical infrastructure, the protection of person and property, the moderation of taxes, or improvements to education. All we can say is that there is evidence that these sorts of general policies can be successful in promoting prosperity.

The most important thing to remember when considering policies to attract specific industries or firms is that there appear to be strong forces at work leading to agglomeration. This is clear from the maps with which the chapter began. This should comfort a government trying to retain firms who are already located in an industry cluster. For instance, New York's Mayor Bloomberg is, as of this writing, not responding aggressively to threats from firms who are considering relocating outside of the city. Thus far, this has not led to a commercial exodus (*Economist*, March 13, 2004). On the other hand, the evidence that agglomeration matters

should worry a government attempting to attract firms to a less developed location, since it suggests that it is not easy to get an industry to locate somewhere it would otherwise not. At the very least, the existence of agglomeration economies means that in order to attract any firms at all, it may be necessary to attract a critical mass.

Unfortunately, this may not be easy to do. As noted earlier in the chapter, there are many different aspects of a location that may matter to firms. A well-intentioned policy could easily fail because it failed to attend to one or two of these. Also, industries differ, and the environment that helped the software industry grow in the Silicon Valley, or the carpet industry in Georgia, may not help some other industry in some other place. Finally, it may not be possible to duplicate elsewhere the circumstances that led to a successful agglomeration in another place. This appears to be the lesson of attempts to recreate a Silicon Valley-type cluster in northern New Jersey (Leslie and Kargon (1996)). This is not to say that government policy has never contributed to the formation of clusters. It certainly has, but the formation of clusters has been a side-effect rather than the primary goal of the policy. For instance, defense procurement helped the chemical industry to grow in 19th Century Germany and various high-technology industries to grow in post-World War II California. All of this suggests to us that specific policies designed to foster agglomeration or attract industries are risky to say the least. Ultimately, government must tread carefully, or its efforts may amount to attempting to develop a wine industry in the desert.

References

Audretsch, D.B. and Feldman, M.P.(1996), R&D spillovers and the geography of innovation and production, *American Economic Review* 86:3, 630-640.

Costa, D.L. and M.E. Kahn (2001), "Power Couples," *Quarterly Journal of Economics* 116: 1287-1315.

Chinitz, B. (1961), "Contrasts in Agglomeration: New York and Pittsburgh", *American Economic Association Papers and Proceedings* 51, 279-289.

Economist (2004), "The Mystery of Michael Bloomberg," March 13, p. 36.

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

Glaeser, E.L., and D. C. Mare (2001), "Cities and Skills," *Journal of Labor Economics* 19(2): 316-342.

Henderson, J. V. (1986), "Efficiency of Resource Usage and City Size," *Journal of Urban Economics* 19: 47-70.

Henderson, J.V. (2003), "Marshall's Scale Economies," *Journal of Urban Economics* 53: 1-28.

Henderson, J.V., A. Kuncoro and M. Turner (1995), "Industrial Development in Cities." *Journal of Political Economy* 103: 1067-1085.

Holmes, T. J. (1999), "Localization of Industry and Vertical Disintegration," *Review of Economics and Statistics*, Vol. 81(2): 314-25.

Jacobs, J. (1969), *The Economy of Cities* (New York: Vintage).

Jaffe, A. B. M. Trajtenberg, and R. Henderson (1993), "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations," *Quarterly Journal of Economics* 108: 577-598.

Krugman, P.R. (1991), *Geography and Trade*, (Boston: MIT Press).

Leslie, S.W. and R.H. Kargon (1996), "Selling Silicon Valley: Frederick Terman's model for regional advantage," *Business History Review* 70(4), 438-475.

Marshall, A. (1920), *Principles of Economics* (London: MacMillan).

Moomaw, R.L. (1983), "Is population scale a worthless surrogate for business agglomeration economies?," *Regional Science and Urban Economics* 13: 525-545.

Nakamura, R. (1985), "Agglomeration economies in urban manufacturing industries: a case of Japanese cities," *Journal of Urban Economics* 17: 108-124.

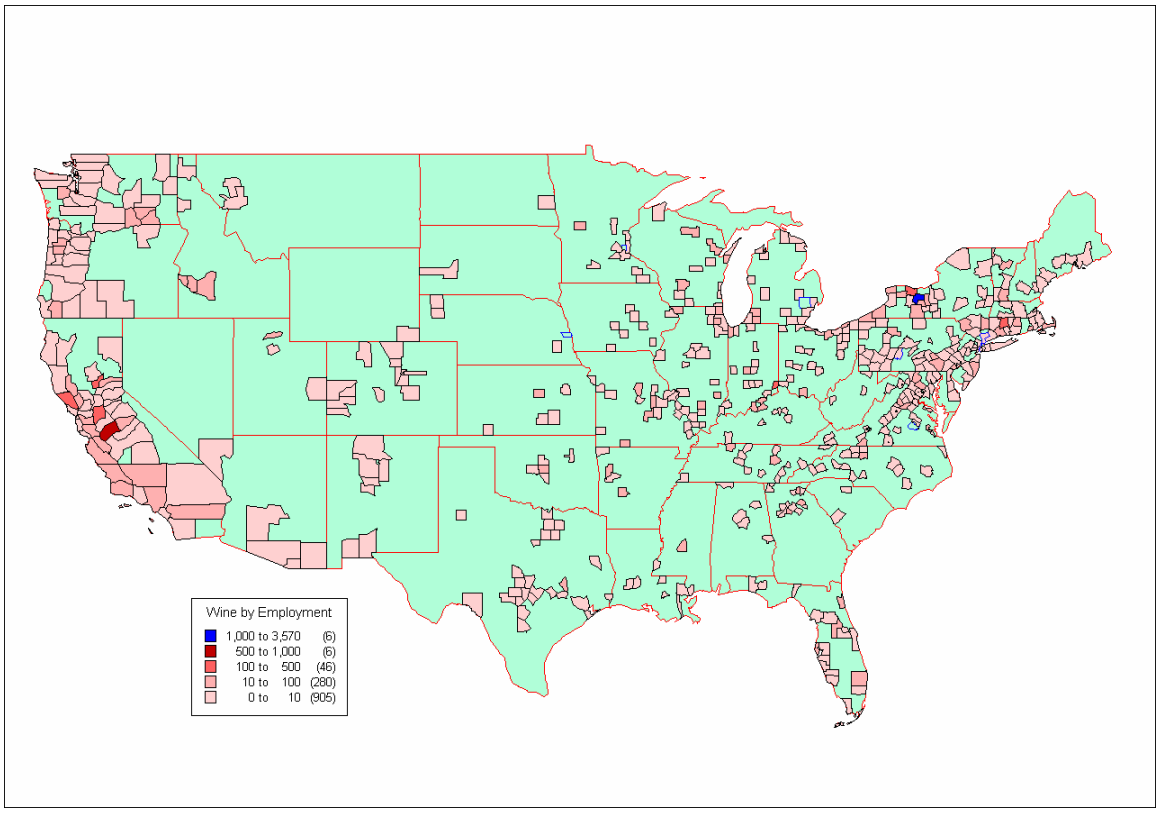
Rosenthal, S. S. and W. C. Strange (2001), "The Determinants of Agglomeration," *Journal of Urban Economics* 50: 191-229.

Rosenthal, S. S. and W. C. Strange (2003), "Geography, Industrial Organization, and Agglomeration," *Review of Economics and Statistics* 85 (2), May 2003. 377-393.

Rosenthal, S. S. and W. C. Strange (2004), "Evidence on the Nature and Sources of Agglomeration Economies," in J. V. Henderson and J.F. Thisse, eds., *Handbook of Urban and Regional Economics*, Volume 4, forthcoming.

Saxenian, A. (1994), *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge, MA: Harvard University.

Figure 1
Employment in the Wine (SIC 2084)
and Computer Software Industries (SIC 7371, 7372, 7373, 7375)



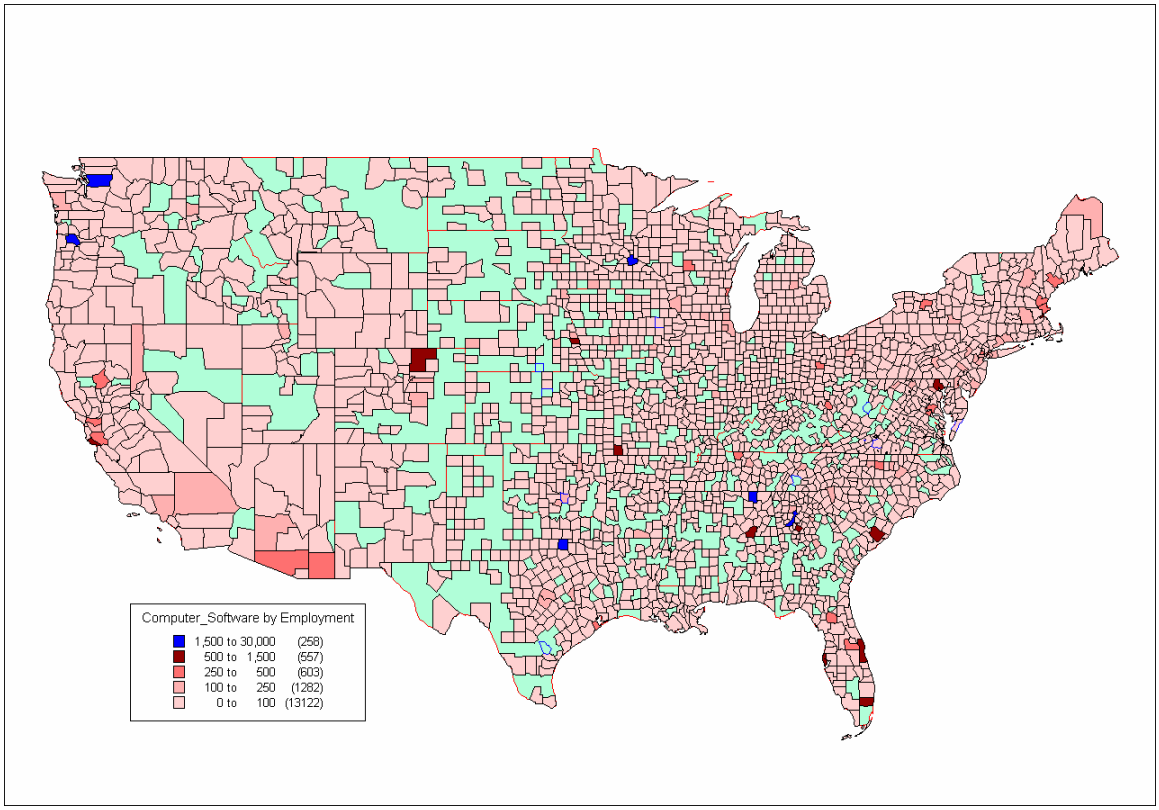


Figure 2
Employment in the Computer Software Industry (SIC 7371, 7372, 7373, 7375)
San Francisco and Boston

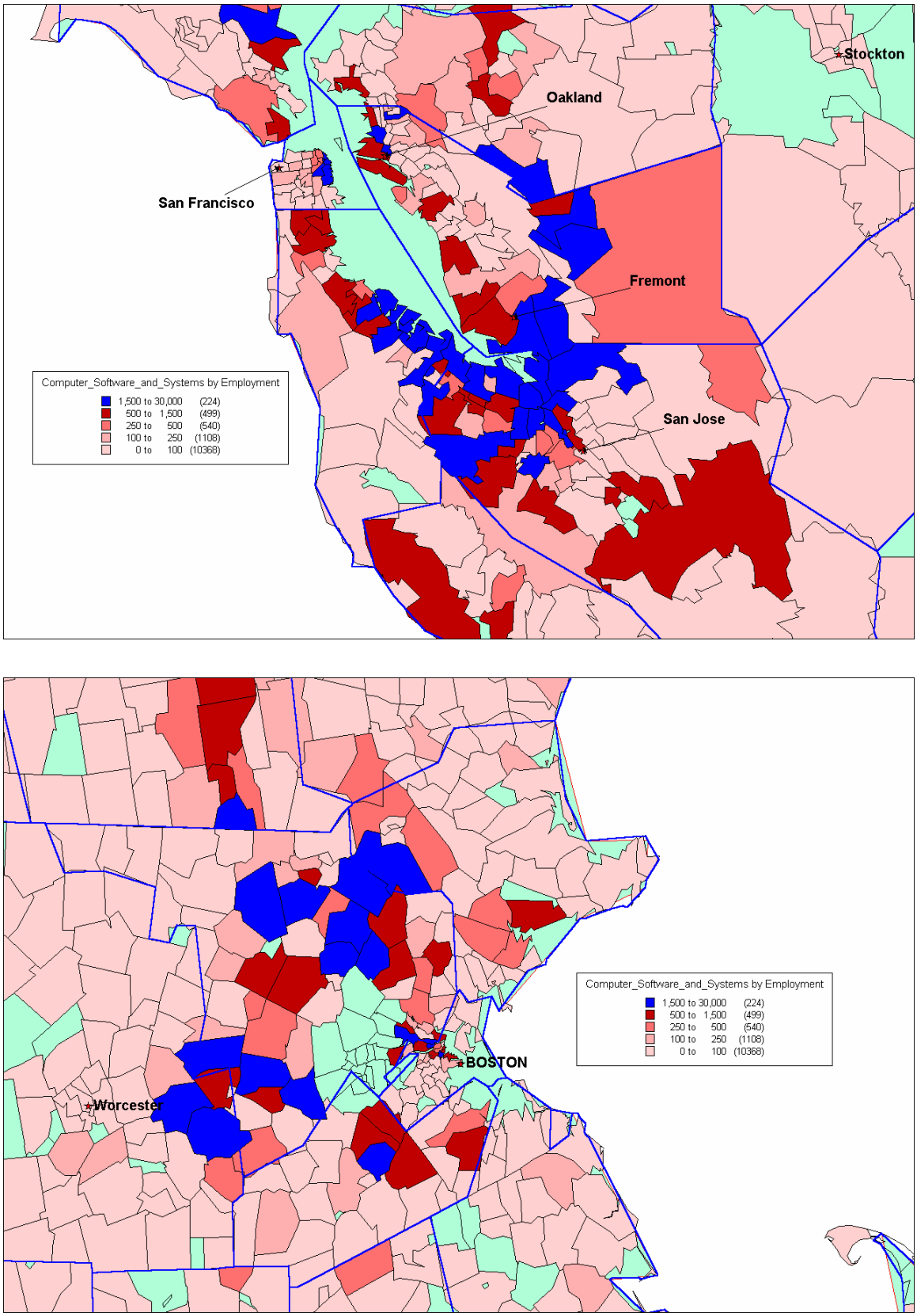
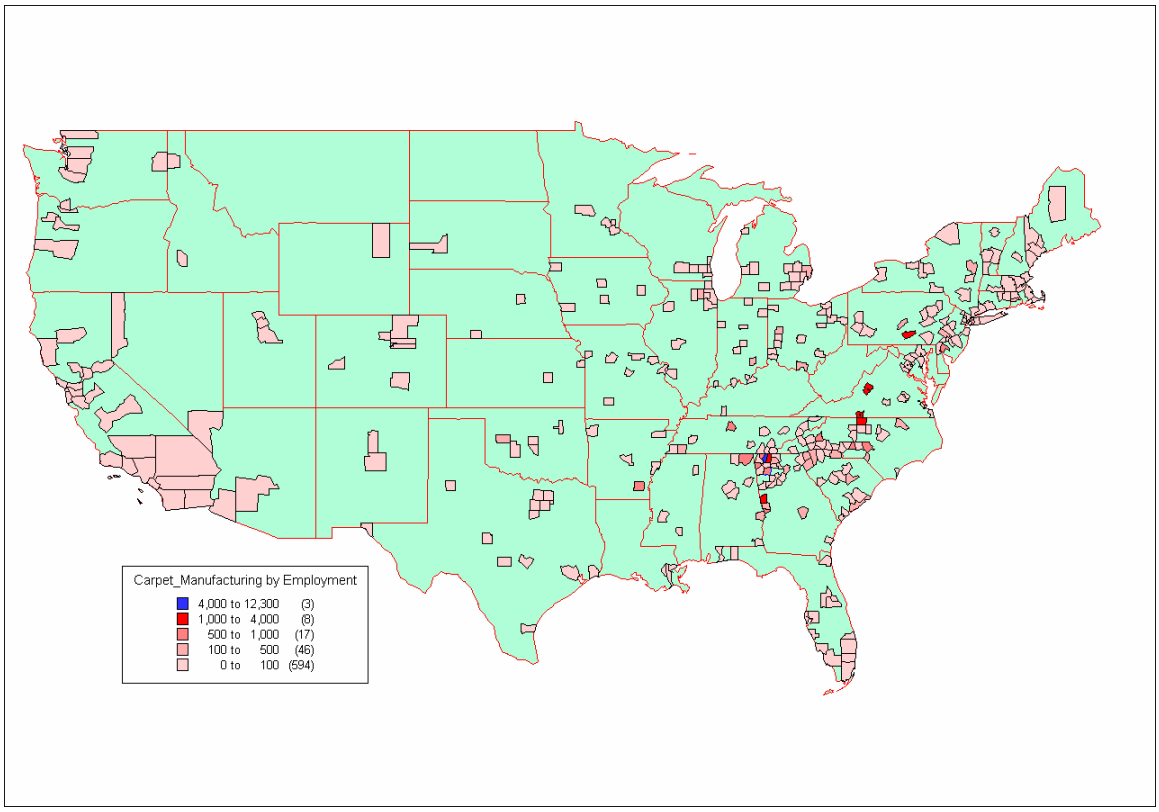


Figure 3
Employment in the Carpet Industry (SIC 2273)



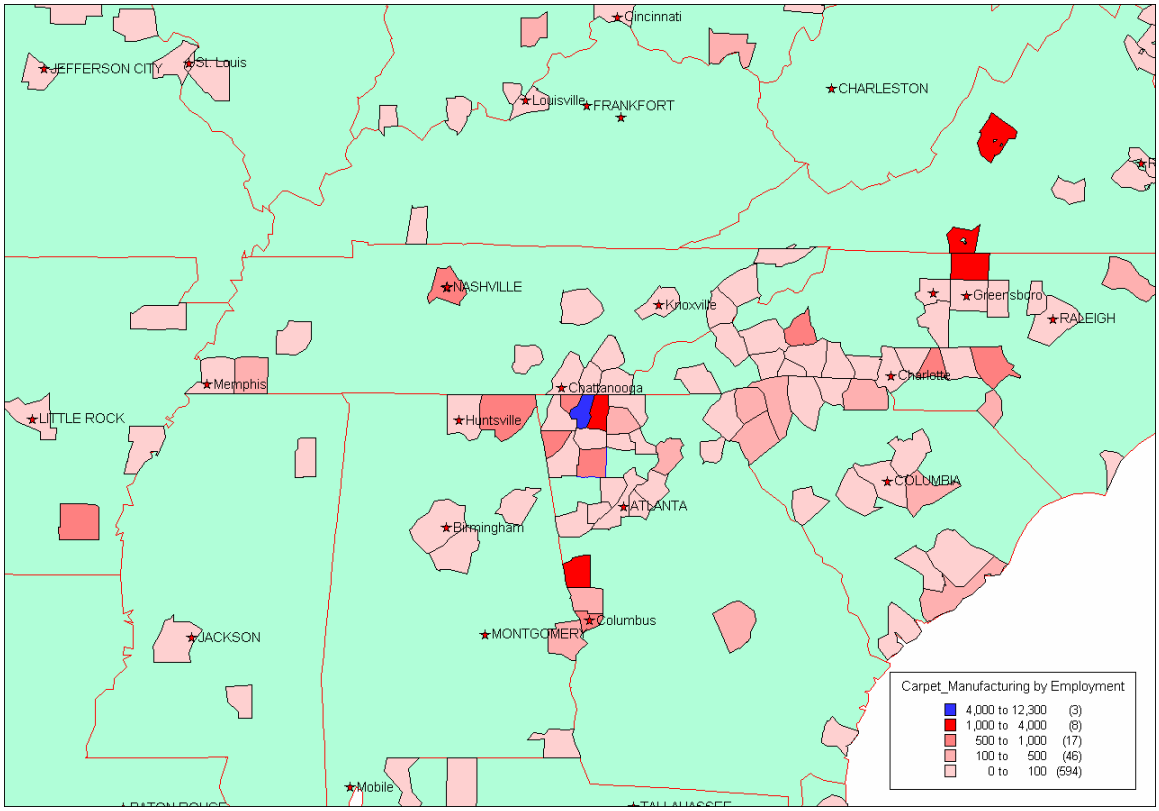
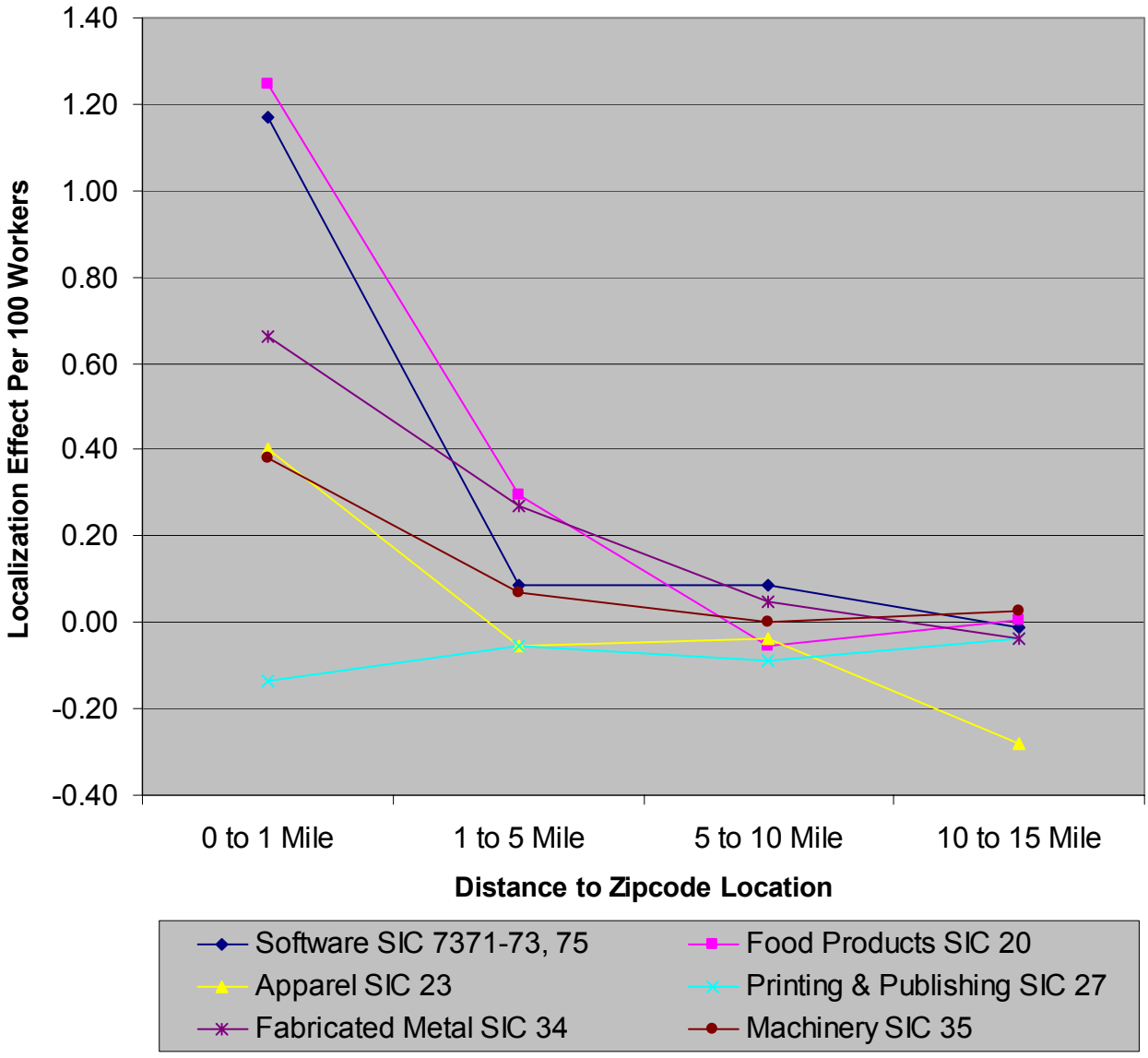


Figure 4: Localization Effects
(Source: Rosenthal and Strange, 2003)



Note: the localization effect measures the number of additional employees that a zipcode's new establishments would hire in response to the presence of an extra one hundred workers in the same industry at various distances from the zipcode