External economies:

How innovative small manufacturers compete[1]

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Abstract
Productivity among small US manufacturing firms is widely dispersed: the most productive 10% of manufacturing firms have at least 1 1/2 times the productivity of the median firm, even within narrowly-defined industries. Based on interviews and survey data on U.S. parts-manufacturing firms, we find that the most productive firms differ significantly from other firms in their ability to benefit from external economies. Location in an urban area is associated with a significant increase in productivity. The high-productivity urban firms compete in a different manner than do other firms. In particular, productive single-plant firms employ skilled urban product designers, and have CEO's that are active in networking. These external economies help them compete against rivals with lower land costs and lower wages.

While parts- makers that do product design are more productive in urban areas, they are not more likely to locate in cities, probably because their owners do not appropriate many of the productivity gains, since these firms pay a significant wage premium there. This pattern of results suggests the presence of a variety of market failures.

Key words: Networking, Agglomeration Economies, Urbanization Economies, Clusters, Industrial Districts, Social Capital

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1. Introduction

The landscape of manufacturing has been dramatically altered in the last 25 years by the outsourcing of much production from large manufacturers to smaller suppliers.[2] While some of that has taken the form of "offshoring" to distant lands, a substantial share of American manufacturing is still done by domestic supplier firms. And much of that manufacturing is of complex componentry that uses novel materials and equipment, drawing on the talents of engineers and skilled workers across a variety of firms.

This increased use of suppliers has changed in important ways the sources of productivity growth in manufacturing. For most of the 20th century, the key source of innovation was held to be the large corporation. The productivity of these enterprises rose based on their internal resources; their unit costs fell as the scale of the assets they owned grew, and as they were able to increase the rate of flow of inputs through those assets. Indeed, Alfred Chandler wrote that, "The distinctive feature of the modern industrial enterprise is its vertical integration"(1977: 1). In contrast to productivity based on such "internal economies", the fall in vertical integration brings renewed importance to Alfred Marshall's concept of "external economies", the phenomenon of a firm's productivity rising along with resources outside its boundary.

In this paper, we consider three forms of external economies: *clustering*, in which a plant's productivity increases when there are more plants nearby in similar industries; *urbanization*, in which a plant's productivity increases when there are more plants nearby in different industries, and *networking*, in which a plant's productivity increases when it increases its information-sharing with other firms (whether the firms are in similar or different industries, and whether they are nearby or not.) We look at complementarities between these external factors and firms' internal operations (corporate structure, use of skilled workers, participation in product design) in relation to innovative

[2] For most large manufacturers purchased parts now represent well over half of their total costs. (By contrast, direct labor is usually under 15% of total costs.)

outcomes (productivity, new product design).

To study these phenomena, we collected survey data in conjunction with the Michigan Manufacturing Technology Center. This dataset allows us to look inside small and medium-sized component manufacturing plants to examine how their networking strategies and production practices differ depending upon their location. We link this survey data with Zip Code Business Patterns data on these firms' neighbors to generate measures of urbanization and clustering. We draw on in-depth interviews and plant tours to aid our interpretation of results.

We find that plants in a mature industry (component manufacturing) benefit from economically and statistically significant agglomeration economies. In our sample, this benefit is most associated with location in an urbanized area and not with same-industry clustering. Our survey data allows us to measure interfirm networking directly. We find that such networking is associated with increased productivity, but only for single-plant firms. Successful multi-plant firms appear to rely more on information transfers within the firm. We also find that the extent of networking is not correlated with urbanization, and urban firms who network do not report higher perceived value of their information networks than less urban firms do.

Our data set also contains considerable information on firm production techniques and specialization. We find evidence that external economies affect plants' internal operations by facilitating information transfer between employees of different firms, and by creating pools of specialized labor that many firms can draw on.

We hypothesize that if one advantage of urban location is easier access to ideas, then urban location should complement idea-rich specializations like product design. We find that design-intensive plants do experience higher benefits from urbanization. But such plants that locate in urban areas must also pay substantial wage premiums, significantly greater than the urban wage premium associated with firms that do not do design. Perhaps for this reason, we do not find that firms that do product design are more likely to locate in urban areas, nor do design firms in urban locations appear to earn higher profits.

The finding of a wage premium for urban design firms is compatible with labor pooling as a channel by which product design ideas are transmitted to urban firms, because it suggests that urban areas may provide greater access to highly-skilled product designers .

We also find that firms' dependence on external environments to generate ideas, whether through networking or access to local skilled labor markets in product design, appears highly dependent on their internal structure. Multiple-plant firms appear to benefit less from networking, and also do not show as strong a relationship between design productivity and urban location.

Section 2 places our work within the context of previous literature. We describe our survey data in Section 3. Section 4 briefly describes what we learned from the fieldwork we conducted with firms experiencing different forms of external economies. some of the results of the qualitative interviews we performed in doing our research. Section 5 provides empirical results, as well as discussion of those results, and Section 6 concludes with some speculation about policy conclusions.

2. Literature

Our work draws on literatures both in regional economics and on interfirm networking.

The empirical literature in regional economics is truly vast (see Rosenthal and Strange, 2004 for a survey). It is nearly unanimous in finding that agglomeration positively affects productivity, wages, and rents. Sometimes this effect is associated mainly with location near similar firms (clustering), and sometimes it is more associated with location in diverse and dense urban areas (urbanization).

There is no lack of theoretical candidates to explain these results (see Duranton and Puga, 2004 for a useful classification). Economists since Marshall have postulated that knowledge spillovers are one of the major candidates for an explanation of why agglomeration economies exist.

There are of course other potential theoretical causes of such effects that have nothing to do with information exchange (e.g. geographic proximity to transportation hubs, shared access to natural resources). Since our survey provides direct evidence on information exchange, we wish to focus on information exchange explanations.

The simplest informational spillover stories emphasize the advantages that may come from physical proximity to new ideas being generated, which results in a greater likelihood of learning (Kuznets, 1962). Physical proximity presumably lowers the cost of informal social networking (Jacobs, 1969; Saxenian, 1994; Gordon and McCann, 2000). Glaeser (1999) formalizes the notion that skill and idea acquisition by urban workers can be more rapid because they interact with skilled peers more frequently in the denser urban environment. Urban workers are therefore more skilled and urban firms have access to a larger pool of skilled workers than non-urban firms do.[3]

Empirical examinations of the information exchange aspects of agglomeration have been less common. Jaffe (1993) finds that patent citations are geographically localized. A number of papers have examined correlations between rates of patent generation and urban density (Feldman and Audretsch, 1999; Carlino, Chatterjee, and Hunt, 2005). This research finds a positive relationship between city size and density and patenting. A larger number of labor economics papers have examined whether proximity to other educated workers leads to human capital spillovers and therefore higher wages (e.g. Moretti, 2004). Presumably, these spillovers occur through some form of information exchange between workers that leads to skill complementarities. This literature is almost unanimous in finding spillovers. However, neither the patent nor the wage literature can specify the exact mechanisms by which the presumed information sharing occurs.

We can use our survey evidence to directly examine one possible mechanism for

[3] Even if learning is not easier in cities, there are a number of reasons why more skilled workers might be found there. Pools of skilled workers can be larger in urban areas simply because there is a larger pool of workers overall, or skilled workers may be more attracted to urban amenities than are other workers (Krugman, 1991).

information sharing. We test the proposition that higher levels of information exchange through interfirm networking is one of the causes of the productivity benefits of cities. Because our survey directly asks about networking practices and ideas gained from it, we do not need to infer higher levels of information exchange from some other output (such as patents) that is presumed to result from networking.

There appears to be very little previous research that uses direct survey evidence to ask whether information exchange is more common in cities. Charlot and Duranton (2004) is an exception. Using a survey of French workers, they find that individual workers report levels of communication within the workplace that are significantly higher in larger and more educated cities. Their work differs from ours in that they look only at communication within the workplace, and not information spillovers across firms. Their survey is also quite different than ours, as it is at the worker instead of the firm level, does not ask about the perceived value of communication, and is not focused on manufacturing.

Overall, the work in regional economics is characterized by efforts to collect representative data, and to pay attention to issues of causal inference. However, as we have seen, the literature is weak on testing the mechanism by which external economies affect productivity.

In contrast, much of the literature on localized interfirm networking provides detailed direct evidence on the nature and effect of social networking by firms. For example, Saxenian (1994) studies the frequent interaction (and the high turnover) among workers in Silicon Valley, and shows how these factors created fertile ground for innovation. There is a large literature on industrial districts in Italy, in which very small firms cooperate and compete with each other in a highly productive manner. (See for example Brusco, 1982, 1986; Whitford). However the sample sizes are small, and often sample on the dependent variable (i.e., by studying only successful clusters). Another literature, on alliances, looks at non-local networking; the existence of various types of ties between firms (interlocking directorates, stock ownership, patent citations) is held to proxy for information exchange (Hoang; Zucker and Darby; Powell).

3. Data and Methods

In this paper, we try to unite the best of these literatures: a broad sample with a great deal of data about information transfer. We do not claim to have a natural experiment lurking in our data. Rather, we examine how internal firm strategies are correlated with external features of the firm's environment. Some strategies benefit more from having neighbors, or are affected less by congestion costs. Our goal in this paper is to explore what these activities might be.

Our research focuses on a group of firms we call component manufacturers. Firms in this sector fabricate and/or assemble goods made of metal and plastic, principally for sale to other manufacturers. The sector stands at the base of such industries as automobiles and other transportation equipment; industrial, farm, and construction machinery; electrical appliances; and medical instruments. It accounts for more than 10 percent of U.S. manufacturing employment. The sector is heavily concentrated geographically, with 45 percent of total employment in the Great Lakes states of Wisconsin, Illinois, Indiana, Michigan, and Ohio (compared with 36 percent of U.S. manufacturing generally). In contrast to the OEMs they serve, most of these firms have fewer than 500 employees. This sector is not considered "high-tech", though many firms carry out activities generally thought of as innovative, such as product design, hiring scientists and engineers, and using computers.

We collected both quantitative and interview data. To investigate quantitatively the role of external economies among these firms, we designed a special survey instrument that was combined with the ongoing performance benchmarking project managed by the Michigan Manufacturing Technology Center (MMTC). The MMTC project enlists a panel of component manufacturing plants to submit benchmarking data to the MMTC. The information submitted includes detailed data on revenues, costs, employment, wages, and production practices. The panel is not a random sample (firms must volunteer to participate), but comparisons with data from the Census of Manufactures show that it is representative of the component manufacturing industry in productivity, sales, and employment. While the sample is national, Michigan firms (both rural and urban) are over-represented. (See Figure 2 for a map showing the geographic distribution of our responses).

The survey data are carefully reviewed for consistency and reasonableness by MMTC staff. "Because of the more than 600 computer checks performed on each record following data entry, MMTC data are also cleaner than Census data, which in 1994 reported, improbably, nearly 5% of plants with *negative* value added" (Luria, 2000). If answers did not make sense, the staff worked with respondents to clarify the questions. For example, respondents initially often entered a figure for cost of goods sold in answer to a question about value-added. MMTC staff worked with firms to correct these entries (Luria, personal communication).

During the winter of 2003 we designed and submitted a supplemental survey to the MMTC panel firms that included detailed questions about the nature of their ties to other firms, including customers and competitors. Some 249 surveys were returned, for a response rate of 65%. Our analysis sample for this paper consists either of 614 firms (full MMTC benchmarking project sample) or 249 U.S. firms (the subsample that responded to our survey on networking).[4]

The following measures are derived from the full sample of 614 firms:

VAFTE is value-added per full-time equivalent worker. Value added is calculated by subtracting from sales a plant's non-wage expenses, including purchased materials, energy costs, insurance, etc. Full-time equivalent workers are calculated based on a weighted average of "typical weekly hours" in that year for shop personnel, and a 40-hour week for white-collar employees.

[4] Since some firms did not answer all questions, analyses in this paper often have fewer than 249 observations. We also omitted data from firms located in Canada.

KFTE is capital per full-time equivalent worker, where capital is the replacement value of the equipment used at the plant (both owned and leased).

EMP is total employment at the surveyed plant, including both shop and office workers.

PAYBEN is the plant's total payroll+total benefits divided by total FTEs.

NETMARGIN is equal to the (plant's revenue minus its cost of goods sold) divided by revenue.

DESIGNPCT is the percent of the plant's sales accounted for by products designed at that plant. The exact question asks, " Approximately what percent of sales were from jobs where you designed the part or assembly?"[5]

SKILLEDPCT is the percent of the plant's total workforce that is made up of skilled tradespeople (employees who have gone through a four-to-five year apprenticeship in their trade).

We also defined a number of variables based on our networking survey. These variables are only available for our 249 firm subsample who responded to this survey:

COMMEXTENT is a common factor derived from the responses to 9 separate questions on the <u>extent</u> of communication or networking with other firms engaged in by the respondent plant. The exact questions, response coding, and the factor analysis results are shown on Table 2.

COMMVALUE is a common factor derived from the responses to 6 separate questions on the <u>perceived value</u> gained through communication or networking with other firms.

As explained above and in Tables 2-3, the COMMEXTENT and COMMVALUE measures are based on a factor analysis of several survey questions. They are designed to measure both the extent of inter-firm contacts and the degree to which these ties are perceived as transferring valuable information to the firm.

We have linked the survey data to the U.S. Census Bureau's Zip Code Business Patterns file released in the year 2000. This file contains information on the number of establishments by

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[5] The question is thus somewhat ambiguous for multi-plant firms whether product design occurred at the surveyed plant, or at another location (it depends on whether the respondent interprets "you" as referring to the plant or the firm).

detailed industry in every zip code in the United States as of 1998. Merging the sample by zip code allowed us to measure urban density at the zip code level[6].

Our measures of agglomeration are based on this Zip Code Business Patterns Data. (See Table 1 for a summary of our variable definitions):

Total number of nearby plants (URBAN): For each respondent plant in the survey, we determined how many establishments with 10 or more employees were located within a ten mile radius of that plant's zip code.[7] We use this as our measure of urbanization. We use number of establishments rather than employment because Rosenthal and Strange (2003) show that small establishments contribute disproportionately (relative to their employment) to the quality of the economic environment as measured by entry of new firms.[8]

Number of nearby plants in same industry (CLUSTER). This was calculated in the same manner as the URBAN variable, except only plants in the same 3-digit industry as the respondent firm were counted. We used this as our measure of same-industry clustering. Note that this cluster measure relies only on the raw number of same-industry establishments in the area, not on whether an industry is over represented in a region compared to the rest of the nation.

Weighted employment at nearby suppliers and customers (SUPPLIERIND and *CUSTOMERIND)* .

[6] Most quantitative studies of agglomeration have been carried out using rather large geographic units of analysis, such as states (Dumais, Ellison, and Glaeser, 2002) or Metropolitan Statistical Areas (Moretti, 2004). Using these large units ensures that an important cluster is not split up (Dumais, Ellison, and Glaeser, 1997) but may miss important heterogeneity of the spaces within them. For example, Moretti (2004) finds faster productivity growth in industries located in cities that have larger increases in their share of college graduates, but is not able to distinguish among different plants in the same SIC located in different parts of the same metropolitan statistical area. We find that such plants do appear to differ from each other in the nature and quantity of agglomeration economies they experience, and in the production strategies they employ. Like Rosenthal and Strange (2003) we measure agglomeration at the zip-code level, but we are also able to look at productivity, wages, and profits of individual establishments. We find that these smaller units of analysis are important: productivity is higher for firms in more urbanized portions of the same MSA.

[7] The distance is determined using the distance between zip code centroids. For example, if the center of zip code 44118 is within ten miles of the center of zip code 44106, then firms in zip code 44118 are included in the cluster measure for a firm located in zip code 44106. As a practical matter, this means that the radius for the cluster distance is determined by the various zip code boundaries and is only approximately ten miles (it will almost always be somewhat greater). The regression results shown here include only establishments with 10 or more employees. (Our results did not change if we used all establishments).

[8] The Zip Code Business Patterns file did not include exact employment, but we could define an employment-weighted measure by assigning each plant the midpoint of its employment size category. This weighted measure was highly collinear with our plant count, and it did not significantly change our results to use it.

Following Glaeser (1997), we used the 1997 input-output tables to weight employment among 4-digit industries in the respondent's county. *SUPPLIERIND* measures the weighted employment in industries that supply the respondent's plant; *CUSTOMERIND* measures weighted employment in customer industries.

Several of the theories discussed above imply that the key source of economies associated with cities is the *heterogeneity* of the establishments they contain (not the quantity of establishments, which is captured by *URBAN*). Following Duranton and Puga (2004) we also defined the diversity of a plant's environment based on the as the inverse of a Herfindahl index of sectoral concentration of employment. First we computed the inverse of the sum of the shares of two -digit SICs for zip codes within a 10-mile radius of each establishment. We then defined *DIVERSITY* as the z-score of this measure, so the regression coefficient measures the effect of a one standard deviation change.

4. Qualitative Research

To understand better the linkages between information-based external economies and internal firm strategy, we conducted a series of intensive interviews. To select our interviewees, we looked for firms that made extensive use of external economies, and those who were located in environments with few such features. For the first group, in 2003 we randomly contacted 16 small component manufacturers that were members of Wire-net, an association of manufacturers in Cleveland, yielding a sample of 8 CEOs (and 3 of their engineers) who agreed to come to a focus group meeting, and to allow us to conduct extensive individual interviews and tour their plants, lasting 3-4 hours. For the second group, we randomly contacted 9 rural firms from a list provided by the Cleveland Advanced Manufacturing Program (now called MAGNET), and visited four. In addition, we drew on research conducted for another project (Helper and Kleiner 2003, 2010), at a manufacturer of sensors and actuators with four US plants, one in an urban area (but not in a cluster for its industry), two in a suburban , unclustered environment, and one in a clustered (but not urban) location. We visited these plants multiple times between 1995 and 2007, and surveyed their employees.

In this section, we provide examples from our interviews of information-based external economies and the mechanisms that appear to generate them. Figure 1 describes our conceptual framework, showing the overlap between three kinds of external economies (clustering, urbanization, and networking) and two mechanisms that generate them (information-sharing and labor pooling).

Clustering. One of our interviewees, an engineer at a Cleveland stamping firm, described how he figured out how to make a particularly difficult part. This part had a very deep draw (i.e., the metal had to be formed into a very deep cavity, which is difficult to do because of the extreme stretching of the material that occurs in the press.) He asked a number of people both at his firm and others, and found out that a person named John at a nearby stamping firm was an expert in designing such parts. John agreed to give some tips to him for free, in exchange for an implied promise that he would be more likely to tap John's firm as a supplier in the future.

Localization was important in this case for two reasons. First, the low costs of meeting due to geographic proximity meant that there was enough routine interaction among people in firms in similar lines of business that the engineer we interviewed was able to learn about John (whom he had not previously met). There was a serendipitous element to the search; the engineer simply asked everyone he met in the course of business, who might be able to help with a deep draw problem? Second, once he had located John, the costs of meeting him in person (a 10-minute drive to his plant) were also low.

A second type of information-based cluster advantage is in labor pooling. For example, we met a person with specialized forging knowledge who had been laid off from one forging shop, but quickly found a similar job in another forge. Similarly, a growing plant was able to hire trained mold machine operators that had lost their jobs at shrinking plants.

Urbanization. WIRE-NET, an organization of Cleveland businesses, set up a maintenance discussion group in which managers from a commercial printer, a maker of thermally conductive materials, a cosmetics manufacturer, and a vacuum-cleaner manufacturer all traded tips[9]. The diversity of businesses promoted frank discussion (since they were not competitors), and also yielded a variety of approaches. Proximity facilitated plant visits, which are key to understanding how maintenance procedures work in practice.

A second example came from a multi-plant sensor and actuator manufacturer. This firm has a plant in Boston and a plant in Ohio; these plants are in the same 4-digit SIC code, sell similar sensors to the same customers, and have production workers that appear to be doing the same jobs. Yet, the value-added per worker in the Boston plant is 50% higher. The Boston plant's profits are also higher, despite wages that are one-third higher. (Helper and Kleiner, 2003).

Three aspects of urbanization help explain this result. First, the large city is provides diverse employment opportunities for engineers and urban amenities, leading to a bigger labor pool. Second, customers and suppliers from diverse industries are located there, leading to improved opportunities for information-sharing. Both of these reasons make Boston a more conducive place to design high-tech, patentable products than small-town Ohio.

A third reason is the better integration of design and production resulting from improved "match quality" as more agents are trying to match (Duranton and Puga, 2004). The Boston plant manager argued that there are complementarities between design engineers and production workers, because together they can figure out how to work the bugs out of new products more quickly. In a plant that makes the same products repeatedly, it is possible to train just a few engineers to design a 'foolproof' production process, and have the rest of the workforce run the plant according to

[9] See www.wire-net.org

routines codified by these engineers. In contrast, if new product introductions are frequent, more unexpected events will arise, and the higher the payoff is to having each worker be able to solve problems. The production function in such plants takes on a multiplicative, "O-ring" character (Kremer, 1993). Thus, urban environments may be especially conducive to adopting a "high-road" production system that harnesses everyone's knowledge—from production workers to top executives—to produce high-quality, innovative products (Helper, 2009; Luria and Rogers).

Networking. Networking can involve proximity, as in the cluster and urban examples of information-sharing above. We also observed some forms of networking that did not depend on proximity. This seemed to be especially true at the CEO level, even for small firms. We found that the CEOs of even 25-employee firms travelled to China to pursue business contacts. When they wanted to explore new technology, top executives could afford to draw on geographically distant contacts. For example, one company president we talked to wanted to look into installing sensors on his stamping presses. He hired a consultant that he had read about in a trade magazine, and they chartered a plane for 3 days to visit plants around the nation where the consultant had installed similar technology. In this case, the president was learning from other firms, but these firms were not local.

External economies and corporate structure. Small firms and single-plant firms might be expected to benefit more from external economies than do larger, multiplant firms (Scherer, et. al 1975; Kelley and Helper, 1999). Large firms have entire departments dedicated to such tasks as recruiting new employees with specialized skills (and to convincing those employees to move to small towns far from home in hopes of steady, well-paid work[10]), buying new equipment, scanning for new technology--all things the small firms depend on relationships and serendipity for.

Both small and large firms appear to benefit from greater access to skilled labor in urban

[10] For example, Borg Warner (a multinational firm) found and hired an engineer who was leaving the Navy in California to work in its transmission plant in Blythedale, Arkansas, a tiny town surrounded by cotton fields 90 minutes from Memphis. (We interviewed both the engineer and his supervisor.)

areas. Small firms especially benefit from this in the performance of activities that are lumpy in time. For example, firms with only a few products do not need full-time product designers. We visited several firms in Detroit that had key design engineers who were either moonlighting or retired from jobs at large automakers or suppliers. Because of proximity to the small firm, the moonlighters could participate in meetings at 7:30 am or 5:30 pm, and still work a normal day at their primary employer. They charged the small firm half or less of their normal rate, in part because of the fun of working in a less-bureaucratic environment. "I can suggest things here that we'll do tomorrow that would never in a million years be approved at Visteon [a multi-billion dollar auto-parts maker], said one engineer participating in an early-morning meeting at a machine-tool producer with an innovative approach to cutting intricate tools. On the other hand, the meeting had to end when he needed to leave for work at his real job. Thus, the smaller firms don't have the expense of a corporate office, but also don't get the strong ties (Granovetter, 1973) that this hierarchy would provide. Instead, small firms depend on a sort of barter economy. The small firms can economize on the use of cash, but on the other hand cannot be sure of their command over resources.

Pitfalls. External *dis*economies also exist. Clusters can become ingrown (Grabher), urban areas can suffer congestion costs (Glaeser), and networking can become schmoozing without productivity benefit. Agglomerations of firms can be observed that do not yield economies; for example, firms may independently choose to locate near some unique resource (like a port or a railway), creating what looks like a cluster of firms, even though there is no interaction among them (Combes, et al, 2010). Or entrepreneurs that spin off from a parent firm might prefer not to move (Klepper, 2003).

Implications. Plants in urban areas will employ a strategy[11] that maximizes the benefits of external economies while minimizing the diseconomies. We hypothesize that urban plants are likely to benefit disproportionately from strategies that a) involve the use of specialized inputs (eg skilled workers) and b) involve seeking information from diverse sources (such as product design). Thus, we should see a complementarity between idea-intensive production in urban areas and performance. We should also observe a complementarity in use of particular strategies. For example, plants producing long runs of commodity products don't benefit as much from "ideas in the air" (Marshall), so will tend to locate in rural areas.

5. Results

We first present summary statistics and confirm that significant external economies exist for our sector. We then look for linkages between these economies and firms' adoption of idea-intensive operational strategies, namely hiring skilled workers and designing their own products (in contrast to receiving pre-made designs from customers). We also examine whether firms that seem particularly dependent on new ideas (design-intensive firms) gain special advantages from urban location, and if so whether these firms must pay unusually high wages to get these advantages.

Table 1 shows the definitions and sample means of the variables we analyzed. Table 2 shows the distributions of our measures of urbanization and of manufacturing clusters. The table shows there is substantial sample variation in both measures. Urbanization and clustering are quite significantly correlated, but the correlation coefficient is only .45.

Our first result, shown in Table 3, is that urbanized firms show superior productivity to those in less urbanized areas. This is a commonplace finding, but not all research distinguishes between urbanization and various measures of clustering based on proximity to similar firms or partners in the supply chain. The "urban" variable has a consistent and significant effect on value-

[11] By "strategy" we mean a set of complementary practices (Milgrom and Roberts 1995).

added per worker. By contrast, our various measures of clustering have no effect on productivity once urbanization is controlled for.[12] Neither the number of nearby same-industry establishments nor the supply-chain based measures of clustering in the *SUPPLIERIND* or *CUSTOMERIND* variables are associated with higher productivity once urbanization (as measured by number of nearby non-manufacturing establishments) is included. We also tested a variable measuring urban diversity in these equations. The results are not shown, but it also was not significant once urbanization was included.

These urbanization results are significant economically as well as statistically. For example, the results in column 2 imply that a move from the 25th to the 75th percentile on the urban variable (with other variables constant at their means) would increase productivity per worker by 13% or almost $8,800 per worker per year, even within the same 3-digit SIC code. Some of the impacts in other columns are even greater.

All of these results are completely robust to redefining the *URBAN* and *CLUSTER* variables on an employment-weighted basis. We also tested urban diversity, defined as a Herfindahl index of sectoral employment, as another alternative urbanization measure. We do not show these results as they were quite similar to Table 3 – the diversity measure on its own was significant, but became small and insignificant when placed in a regression with either our plant count urban measure or the employment-weighted one.

We also find that the urbanization variable remains significant when controlling for 2-digit or 4-digit SIC's, or with no SIC control. It holds when firms in SICs are removed one at a time, implying that urbanization effects occur broadly across SICs—they are not limited to a few industries.

Next, we consider the relationship between urbanization economies and inter-firm

[12] We get the same result if the cluster is defined at the three-digit SIC level or the two-digit level.

networking. As a measure of social networking and the learning that results from it, we included a set of 15 questions on the Critical Relationships Survey administered to a subset of our MMTC sample. These questions can be broken into two sections, one of which asks about the extent of social networking and the other about the perceived value of such networking. We asked firms to focus on networking with firms other than their key customers.[13]

We used factor analysis to reduce each section (on extent of networking and on perceived value of knowledge gained through networks) to a single variable. In each case, the primary factor could account for over 90% of the variance in the scale. The statistics from the factor analysis and the text of the survey questions are shown in Tables 4 and 5. We defined two variables. *COMMEXTENT* measures the extent of the firm's networks (Table 4), and *COMMVALUE* measures the value of information gained through networks as perceived by the survey respondent (Table 5). Both of these variables are the first factor (accounting for the great majority of the variance) from the relevant set of variables.

Table 6 shows the results of regressing firm productivity on the same variables used in Table 3, plus our social networking measures, using only the Critical Relationships Survey subsample. We present results mainly for the networking scale that measures the perceived value of information gained through networking, since this measure would seem to be the most relevant for productivity. In results not shown, we found that *COMMEXTENT* was not robustly related to productivity.

When productivity is simply regressed against *COMMVALUE* plus control variables for the sample as whole, there is no significant effect of the social networking variable. But modeling social networks in this way assumes that they will have similar effects for all firms in the sample. Based on previous research (Kelley and Helper, 1999), we believe that smaller and less "corporate"

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[13] Receiving help from customers in areas such as improving quality and inventory management is correlated with higher productivity.

firms are more likely to be affected by their external environment. Larger and more complex firms with an extensive corporate structure may take their lead from internally defined corporate strategies and procedures as opposed to learning through networking with external actors (Scherer et. al. 1975). When managers feel the necessity to move outside the corporate structure and network externally to learn new techniques, this can actually be a sign that the firm suffers from poor management.[14]

For this reason, we ran a separate regression for single plant firms, to test for differential impacts of external economies on different types of firms. Our only employment measure is employment in the specific establishment we are surveying; we do not have total employment for the entire corporation that owns the establishment. But we do have a yes or no question that asks whether the establishment is part of a multi-plant corporation. We have used the response to this question as our indicator of corporate structure. Some 47% of establishments responding to the Critical Relationships Survey belonged to a multi-plant corporation.

Columns 2 and 3 of Table 6 show that single-plant firms do show a positive correlation between productivity and the perceived value of information gained through networking with other firms. This effect is economically significant; the point estimate implies that an increase of 1 standard deviation in COMMVALUE increases productivity per worker by over 7%.

So successful networking is linked to productivity for single plant firms. We next ask how networking is related to our other measures of external economies. If networking is to help account for the urbanization effect then networking must be either easier or more productive in urban areas. The results in Columns 4 through 8 of Table 6 show that there appears to be no correlation between networking and urbanization in our sample, whether we use our extent or our perceived value measure. This result also holds true for single plant firms (columns 6 through 8). We tested the

[14] We do find that the communications value scale is negatively and significantly related to productivity for multiple plant firms; this result is not shown on the table.

robustness of this finding in many other regressions that we have not presented, and found very similar results. Regressions of the perceived value of communication on urbanization which controlled for the extent of communication also showed that when networking extent was held fixed, networking in urban areas was not perceived to be more valuable. As another test of whether networking was more productive in urban areas, we also regressed productivity against an interaction between urbanization and both of our networking variables; the coefficients on the interactions were not significant either singly or jointly. Similarly, we found no relationship between networking and clustering.

This lack of relationship is somewhat surprising. However, it is supported by our interview data. As discussed above, in our interviews we found that many CEOs traveled extensively, and had wide-ranging networks of contacts. (Most of the respondents to the networking survey were firm CEOs or plant managers). They often used non-geographically specific resources such as trade magazines to find networking partners.

In the final two tables, we examine the relationship between external economies and firms' operations. In particular, we look at whether firms that do extensive product design (a proxy for the importance of new ideas to their production process) have higher productivity in urban areas. If they do, then urban location does in fact appear to make ideas more accessible to these firms, even if the mechanism does not involve inter-firm networking by top management. This could occur if lower-level workers' networks are quite local[15]. It could also occur if skilled design workers are easier to find in cities. As discussed in Section 2 above, there are many theoretical reasons to think this might be the case, and it is well established that general worker skill measures tend to be higher in cities. It could also occur through shared access to a common resource, such as a university.

Table 7 shows that the productivity of firms which do high amounts of design work does

[15] This view was supported in our interviews; in answer to questions about non-local networking, the skilled tradespeople we interviewed mentioned either no such activity, or having driven once a few years ago to a conference a couple of hours away.

appear to benefit especially strongly from urban location.[16] This benefit appears to be most concentrated among single plant firms; single plant firms who do design work in urban areas show significantly higher productivity than those who are located outside of urban areas. The complementarity between product design and urban location for single plant firms is a very robust finding and a large and economically significant one. For example, an increase from 0 to 35% in the fraction of sales accounted for by products designed in-house is predicted to double the urban advantage experienced by single plant firms.

It is remarkable that this finding is robust to the inclusion of dummies for 131 CBSAs (Column 3).[17] We presented these results for illustrative purposes only, as the inclusion of over 100 independent variables in a sample of less than 300 single-plant firms is probably excessive. But it indicates that at least in this sample, urban density within a particular local area is correlated to design productivity. So these effects appear to be highly localized, at least judging from these CBSA results. This finding does not support the shared urban resource (e.g. university) explanation for higher design productivity in cities, since one would expect that such a resource would have common effects throughout the CBSA. It also suggests that our results are not due to particular conditions in a few cities.

The fact that we did not find a benefit for multi-plant firms could be due to their lesser dependence on their external environment, since it is often possible to transfer engineers and design personnel between plants in larger corporations, including plants outside of urban areas. It could also result from ambiguity in the question (respondents might have included design work done inside the firm but at another, less-urban, location). The relatively small sample size and high variance in the estimates might also have made it hard to find an effect for multi-plant firms.

In the final column of table 7, we test for the matching effect of being both design- and

[16] Product design intensity is defined as the percent of sales accounted for by products designed in-house. See section 3.
[17] Core based statistical areas; these are essentially MSAs but also include Micropolitan Statistical Areas centered around small rural cities with populations of less than 50,000.

skilled trades-intensive. That is, we test the idea of complementarity between product design (which creates a demand for de-bugging prowess) and a high percentage of skilled-trades employement (which creates a supply of de-bugging prowess).

Given the large productivity effects of urban location for single-plant firms that do design, it is surprising that we find no correlation between urban location and design intensity for either the entire sample or single plant firms (results not shown). This finding is very robust to the inclusion of additional controls (not shown); design intensive firms are not more urbanized.

One can get a sense for why this might be in Table 8. This table regresses wages and profit margins against urban location, design intensity, and the interaction between the two. Table 8 shows that urbanized firms pay higher wages (as is universally found in the literature), and on average earn higher profits. However, design intensive firms suffer an even larger wage penalty for locating in cities, as the coefficient on the design and urban interaction is quite large. This is especially true for single plant firms, where the point estimate is actually larger than the urban coefficient. Thus design-intensive firms choosing to locate in cities pay a much higher level of additional wages to do so than other manufacturing firms. Probably because of this high wage cost, there is no clear profit benefit for design firms in locating in urban areas (Column 6). Another piece of evidence comes from Table 7, in which the triple interaction among design, skill, and urbanization is negative, a result driven by the fact that skilled tradespeople do not seem to be more productive in urban areas. (However they are more expensive there).

The results in Table 8 may indicate that the complementarity between design and urbanization is due to the quality of the local labor force. Certainly it appears that workers capture many of the benefits from this complementarity. Figure 4 maps how wages vary with urbanization.

6. Conclusions

We have found significant external economies in our sample of US component manufacturers. Urbanization economies were particularly robust. We also tested for economies of localization and of diversity; these coefficients became insignificant when urbanization was included. We gathered survey data that allowed a direct test of the importance of interfirm networking by top management for productivity. We found a networking advantage for single-plant firms, an advantage that was not related to either clustering or urbanization. Our interviews with CEOs suggested that their networks were often not local, which can help to explain the finding that urbanization and networking are uncorrelated.

We were able to explain about 20% of the urban coefficient for single-plant firms by the greater productivity of design work by those firms if it is done in an urban area; a result that could be interpreted as supporting theories of agglomeration based on greater ease of learning new or innovative ideas in urban areas. Since most of the benefits of this complementarity between design intensity and urbanization appeared to be captured by workers, we hypothesized that it was due to more access to skilled design workers in cities.

In our final table, we found a robust result of higher profits in urban manufacturing. (See figure 5 for a map showing how profits vary with urbanization.) This may seem an anomalous result, but on closer examination it seems less so. First, the reports of the death of urban manufacturing have perhaps been exaggerated. According to Census data, the proportion of manufacturing establishments that are located in urban areas (as defined by the Census) was 53% in 1995, and 55% in 2001. Similarly, the MMTC data does not show a pattern of disinvestment in urban areas. Plants above the median on our urbanization variable have 18% of their equipment less than 5 years old, while 21% of equipment in plants below the median urban firms is less than 5 years old—an insignificant difference.

Second, our regressions capture the profitability of the average firm; equilibrium with mobile firms requires only that profits of the *marginal* urban and rural firms be equated. Inframarginal firms may earn positive profits. It may also be that success in an urban environment is more difficult (or more uncertain), in which case the higher profit margin reflects a managerial barrier to entry (or a risk premium).

Although we can't prove a causal link between external economies and productivity, we are able to rule out some non-causal explanations. The urban productivity advantage holds for a wide variety of cities, and even for location within cities (firms in areas with higher density are more productive). It may be that firms must be more productive to afford higher urban rents; we have shed some light on how they do this.

We close with some thoughts about policy implications. Precisely because they are external to firms, external economies are under-provided by markets, meaning there may be a role for policy to increase welfare. For example, to the extent that firms in urban areas pay higher wages as a result of labor pooling, this is a benefit to urban location not taken into account by firm decision makers. [18] Thus, incentives to firms to locate in urban areas could be welfare-enhancing. In general, US policy has not adjusted to the decline of an economic system based significantly on "internal economies' generated by large, vertically-integrated firms that financed training and upgrading investments out of oligopoly profits. In contrast to high-wage competitors like Germany or Italy, the US has relatively few supports for the kind of networking, coordinated investment in product design and de-bugging, and training that have very high payoffs in a world where external economies have taken on renewed importance.

[18] To the extent that wages are higher to compensate workers for perceived urban disamenities, there is no market failure. But, empirical research has not found strong evidence of these.

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TABLE 1: Variable Definitions

Variable Name	Definition	Mean (SD)
CLUSTER	Number of establishments (10+ employees) in same 3-digit industry within a ten mile radius of firm zip code.	21.8 (41.1)
URBAN	Number of establishments (10+ employees) located within a ten mile radius of firm zip code	3306 (3785)
SUPPLIERIND	Input-weighted average of employment among supplying industries in plant's county (including own industry)	2614 (3378)
CUSTOMERIND	Output-weighted average employment among customer industries in plants county (exclude own industry)	1279 (2169)
VAFTE	Value added (revenue minus costs) per full-time equivalent worker, in dollars	73156 (33034)
KFTE	Capital (value of plant and machinery) per full-time equivalent worker, in dollars	60079 (61888)
EMP	Total employment in the surveyed plant	91 (102)
PAYBEN	Average annual pay and benefits per FTE worker, in thousands of $	45.7 (16)
NETMARGIN	Revenue margin (revenue-costs/revenue)	.15 (.14)
SINGLEPLANT	Responding establishment represents the only plant or facility in the company (1=Yes, 0=No).	.529 (.50)
COMMEXTENT	Standardized (mean 0, SD 1) result of factor analysis for extent of communications (see Table 4)	
COMMVALUE	Standardized (mean 0, SD 1) result of factor analysis for perceived value of communications (see Table 5)	
PURCHSRV	Purchases of services divided by total sales	.10 (09)
PURCHGD	Purchases of goods divided by total sales	.29 (.17)
DESIGNPCT	Percent of sales volume accounted for by goods or parts designed in-house at the plant.	.22 (.34)

Many regressions use natural log of variables, indicated in tables by LN(variable name).

TABLE 2: Distribution of Clustering and Urbanization Variables

CLUSTER

Percentile in Distribution	Clustering Variable (Number of Nearby Same-Industry Establishments*)
10^{th} Percentile	1
25^{th} Percentile	2
50^{th} Percentile	7
75^{th} Percentile	23
90^{th} Percentile	61
Maximum	374

*Count of other establishments in the firm's 3-digit SIC (Standard Industry Classification) code located in zip codes within ten mile radius of plant zip code.

URBAN

Percentile in Distribution	Urbanization Variable (Number of Nearby Non-Manufacturing Establishments**)
10^{th} Percentile	129
25^{th} Percentile	465
50^{th} Percentile	1857
75^{th} Percentile	5082
90^{th} Percentile	8725
Maximum	38365

** Number of establishments (10+ employees) in zip codes w/in 10 miles of plant zip code.

TABLE 3: Urbanization, Clustering, and Productivity

Dependent Variable	LN (VAFTE)	LN (VAFTE)	LN (VAFTE)	LN (VAFTE)	LN (VAFTE)
Independent Variables	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
LN (KFTE)	.14*** (.0232)	.14*** (.0236)	.17*** (.0220)	.14*** (.0269)	.17*** (.0254)
LN (EMP)	.049** (.0199)	.51*** (.0197)	.042** (.0208)	.056** (.0226)	.045* (.0238)
LN (CLUSTER)	.049*** (.0123)	.011 (.0199)	-.037 (.0280)		
LN (URBAN)		.053*** (.0193)	.088*** (.0289)	.068*** (.0182)	.058*** (.0183)
LN (SUPPLIER)				.012 (.0186)	.015 (.0190)
LN (CUSTOMER)				-.017 (.0240)	-.025 (.0234)
Constant	9.25 (.241)	8.89 (.282)	8.49 (.304)	8.81 (.274)	8.747 (.300)
Industries			47 3-Digit SIC controls		43 3-Digit SIC controls
MSA controls					
Adjusted R-Square of Model	.1545	.1658	.2511	.1691	.2918
Model Sample Size	556	556	556	438	438

*** Variable significant at 1% level
** Variable significant at 5% level
* Variable significant at 10% level

TABLE 4: Extent of Communications Questions And Factor Analysis

"In this section, we are interested in how much you communicate on business issues with shops *other than* your key customers. These other shops might include your suppliers, competitors, minor customers, other nearby manufacturers, or other shops you know through industry connections.

In the past three years, to how many of these shops did the following statements apply?
[Response choices are 0 shops, 1 shop, 2-3 shops, 4-6 shops, 7 or more shops]

E1: Our managers and/or engineers socialize outside of work with their employees.
E2: Our engineers and/or skilled workers are comfortable calling them to discuss a manufacturing issue.
E3: We have helped them hook up with other shops to address a problem or respond to an opportunity.
E4: We share solutions to general business issues.
E5: We have toured their facility and/or they have toured ours.
E6: We have cooperated closely with them to solve our difficult technical and/or design problems.

Please give your reaction to each of the following statements about the types of interactions you have with these shops:
[1 = Strongly disagree, 7 = strongly agree]

E7: We don't really interact much with employees at shops that are *not* our important customers or suppliers.
E8: Our engineers and managers are well-connected to the industry "grapevine": they hear about innovative products or cutting-edge techniques before most people in the industry.
E9: We often receive information from former employees even after they have moved on to other shops.

	Factor 1	Factor 2	Factor 3
Eigenvalue	2.78	.48	.31
Proportion of Variance	.94	.16	.11
Factor Loadings – Questions	Factor 1	Factor 2	Factor 3
E1	.53	.37	.02
E2	.73	-.25	.06
E3	.71	.13	-.11
E4	.47	.33	-.11
E5	.68	-.13	-.12
E6	.74	-.33	-.05
E7	-.27	-.15	.05
E8	.35	.07	.39
E9	.22	.03	.32

Scale reliability coefficient (Cronbach's alpha): .78

Variable COMMEXTENT is the standardized (mean 0, SD 1) score for Factor 1.

TABLE 5: Perceived Value of Communication Questions and Factor Analysis

"In this section, we are interested in how much you communicate on business issues with shops *other than* your key customers. These other shops might include your suppliers, competitors, minor customers, other nearby manufacturers, or other shops you know through industry connections.

Please give your reaction to each of the following statements about the types of interactions you have with these shops:

[1 = Strongly disagree, 7 = strongly agree]

PV1: When we have a tough problem to solve, paid consultants are more helpful than our contacts at other shops.
PV2: We have rarely gotten any ideas that we would not have thought of ourselves from people other than our important customers.
PV3: We have learned a lot from shops other than our important customers about reducing setup time.
PV4: We have learned a lot from shops other than our important customers about reducing inventory.
PV5: We have learned a lot from shops other than our important customers about new products that we might introduce.
PV6: We have learned a lot from shops other than our important customers about new manufacturing processes.

Factor Analysis Results For Perceived Value of Communication

	Factor 1	Factor 2
Eigenvalue	2.39	.37
Proportion of Variance	.97	.15
Factor Loadings – Questions	Factor 1	Factor 2
PV1	.03	.42
PV2	-.22	.38
PV3	.84	-.15
PV4	.87	.04
PV5	.63	.17
PV6	.69	.06

Scale reliability coefficient (Cronbach's alpha): .68

Variable COMMVALUE is the standardized (mean 0, SD 1) score for Factor 1.

<u>TABLE 6: Networking, Productivity, and Urbanization (networking subsample)</u>

Sample	All Firms	Single Plant Firms	Single Plant Firms	All Firms	All Firms	Single Plant Firms	Single Plant Firms	Single Plant Firms
Dependent Variable	LN (VAFTE)	LN (VAFTE)	LN (VAFTE)	COMM EXTENT	COMM VALUE	COMM EXTENT	COMM VALUE	COMM VALUE
Independent Variables	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
LN (KFTE)	.153*** (.026)	.156*** (.036)	.165*** (.047)	-.072 (.073)	.11 (.07)	-.146 (.108)	-.009 (.106)	-.011 (.13)
LN (EMP)	.051* (.027)	-.02 (.037)	-.006 (.037)	.143* (.072)	.155** (.07)	.172 (.126)	.28*** (.104)	.283*** (.11)
LN (URBAN)	.063*** (.016)	.077*** (.021)	.078*** (.02)	–.026 (.044)	– .006 (.043)	–.067 (.066)	–.076 (.061)	-.061 (.062)
COMMVALUE	-.017 (.028)	.073** (.036)	.072** (.036)	—	—	—	—	—
COMMEXTENT	—	—	—	—	—	—	—	—
Constant	8.82 (.327)	8.92 (.51)	8.77 (.55)	.375 (.36)	-1.75 (.87)	1.40 (1.43)	-.502 (1.32)	-.59 (1.65)
Industry Controls	—	—	8 2 digit SIC controls	—	—	—	—	8 2 digit SIC controls
Adjusted R-Square of Model	.187	.217	.234	.014	.017	.027	.05	.011
Model Sample Size	214	113	113	214	214	110	113	113

*** Variable significant at 1% level
** Variable significant at 5% level
* Variable significant at 10% level

TABLE 7: Urbanization, Design, and Productivity For Single and Multiple-Plant Firms

Sample	All Firms	Single Plant Firms	Multiple Plant Firms	Single Plant Firms	Multiple Plant Firms
Dependent Variable	LN (VAFTE)	LN (VAFTE)	LN (VAFTE)	LN(VAFTE)	LN(VAFTE)
Independent Variables	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
LN (KFTE)	.157*** (.02)	.145*** (.027)	.174*** (.03)	.201*** (.036)	.068 (.05)
LN (EMP)	.045** (.018)	.042* (.024)	.094** (.039)	.046 (.029)	.068 (.044)
LN (URBAN)	.051*** (.014)	.029 (.019)	.064*** (.024)	.029 (.026)	.106** (.042)
DESIGNPCT	–.121 (.29)	–1.1*** (.42)	.27 (.51)	-4.01*** (1.03)	1.76* (1.03)
DESIGNPCT * LN(URBAN)	.04 (.035)	.146*** (.049)	–.005 (.06)	.476*** (.12)	-.153 (.12)
URBAN * SKILLEDPCT	—	—	—	.079 (.19)	-.42 (.38)
DESIGN* SKILLEDPCT	—	—	—	10.7** (4.6)	-15.5 (10.5)
URBAN * DESIGN* SKILLEDPCT	—	—	—	-1.26** (.62)	2.09 (1.35)
Constant	8.77 (.25)	9.12 (.34)	8.22 (.44)	8.62*** (.47)	9.2*** (.603)
Industry Controls	45 3-Digit SIC controls	23 3-Digit SIC controls	—	23 3-Digit SIC controls	16 3-Digit SIC controls
Adjusted R-Square of Model	.42	.29	.23	.31	.37
Model Sample Size	562	205	109	205	109

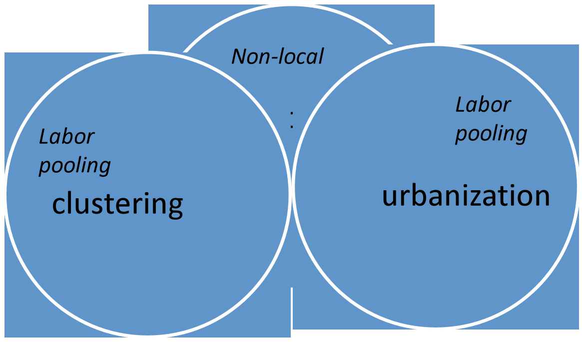
*** Variable significant at 1% level
** Variable significant at 5% level
* Variable significant at 10% level

TABLE 8: Impact of Urbanization and Design on Pay and Margins

Sample	All Firms	All Firms	All Firms	All Firms	Single Plant Firms	Single Plant Firms
Dependent Variable	LN (PAYBEN)	NET MARGIN	LN (PAYBEN)	NET MARGIN	LN (PAYBEN)	NET MARGIN
Independent Variables	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
LN (KFTE)	.093*** (.015)	-.008 (.007)	.099*** (.016)	-.005 (.008)	.106*** (.022)	-.022* (.011)
LN (EMP)	.052*** (.014)	.003 (.007)	.059*** (.015)	.004 (.008)	.058*** (.021)	-.007 (.01)
LN (URBAN)	.046*** (.009)	.015*** (.004)	.041*** (.011)	.013** (.005)	.036** (.015)	.013* (.007)
DESIGNPCT	___	___	-.118 (.19)	.005 (.098)	-.21 (.30)	-.17 (.15)
DESIGNPCT * LN(URBAN)	___	___	.049* (.026)	.0007 (.014)	.066* (.04)	.022 (.02)
Constant	2.23 (.19)	.112 (.094)	2.23 (.19)	2.12 (.19)	2.12 (.27)	.312 (.137)
Industry Controls	17 2 Digit SIC Controls	16 2 Digit SIC Controls	17 2 Digit SIC Controls	17 2 Digit SIC Controls	15 2 Digit SIC Controls	14 2 Digit SIC Controls
Adjusted R-Square of Model	.27	.01	.33	.01	.29	0
Model Sample Size	523	497	478	453	298	282

*** Variable significant at 1% level
** Variable significant at 5% level
* Variable significant at 10% level

Information-based External Economies



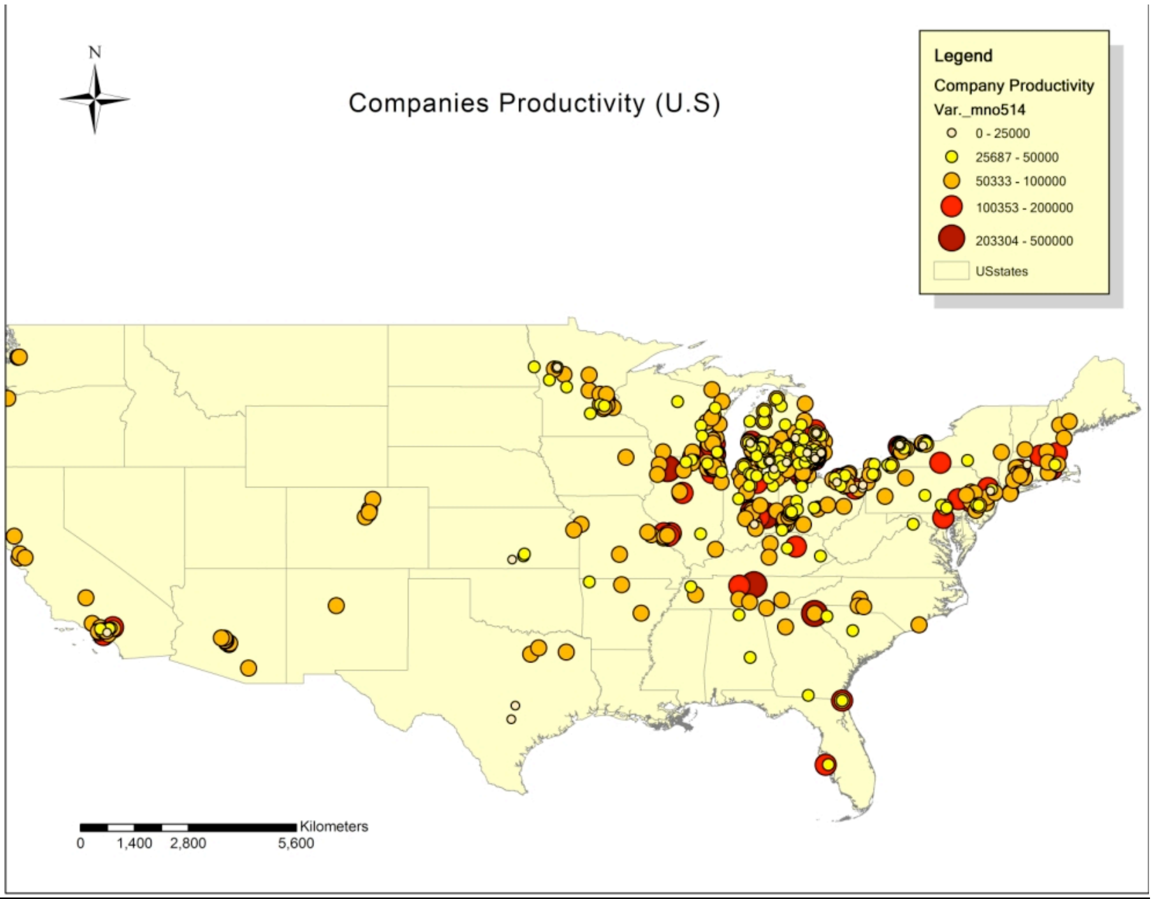


Figure 2: LOCATION AND PRODUCTIVITY OF FULL MMTC SAMPLE

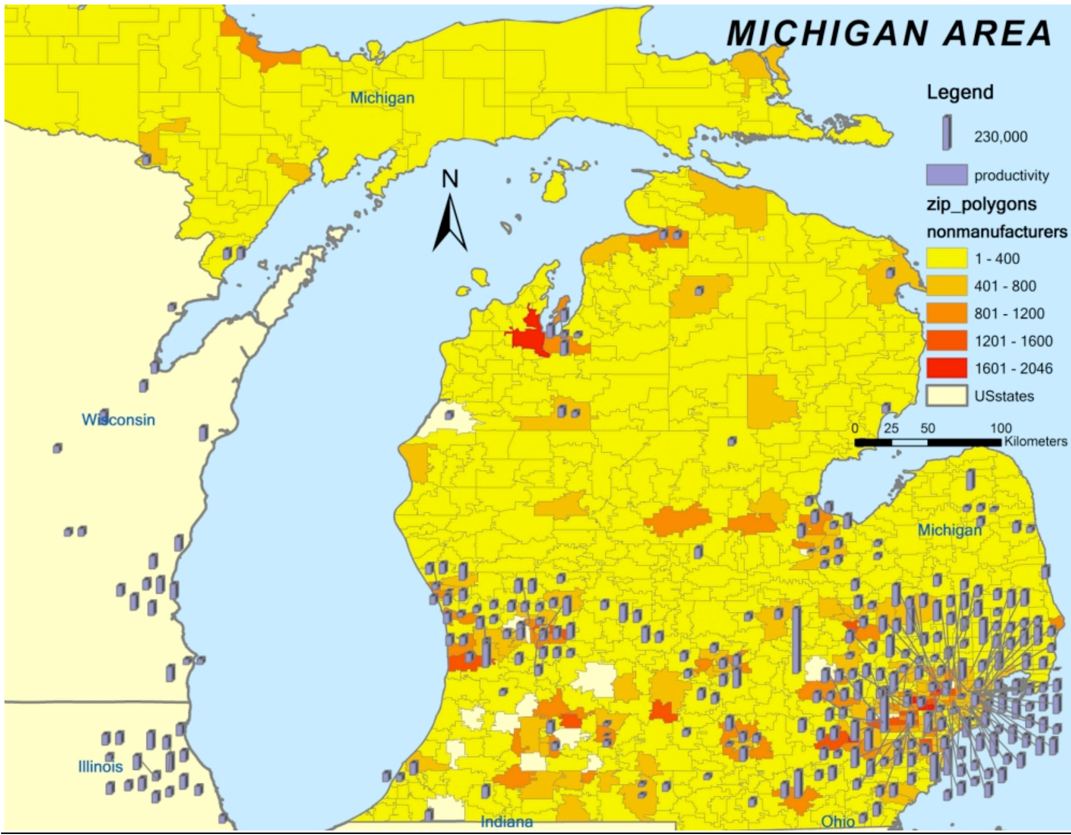


Figure 3: LOCATION AND PRODUCTIVITY OF MICHIGAN SAMPLE
Note: location of blue bar reflects location of a survey respondent; height of blue bar reflects respondent plant's productivity; surrounding color (yellow or red) indicates number of nonmanufacturing establishments in the zip code.

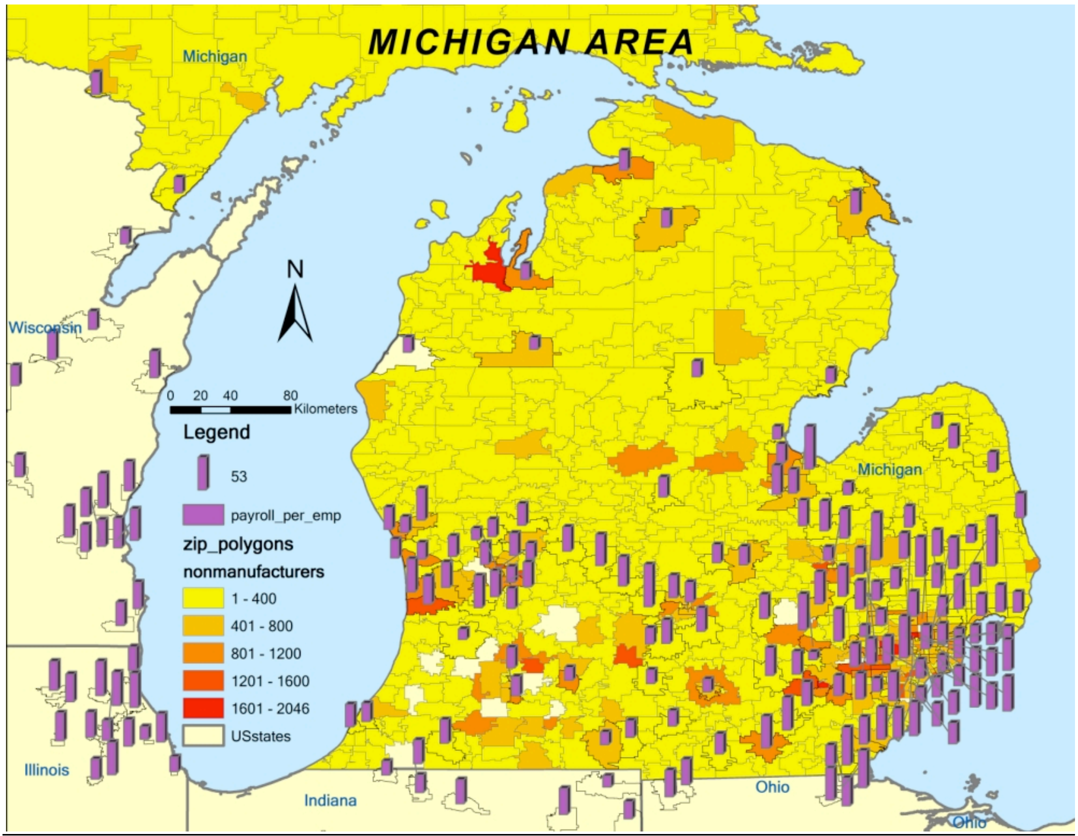


Figure 4: LOCATION AND PAY OF MICHIGAN SAMPLE

Note: location of blue bar reflects location of a survey respondent; height of blue bar reflects respondent plant's annual payroll per employee (in thousands, including benefits); surrounding color (yellow or red) indicates number of nonmanufacturing establishments in the zip code.

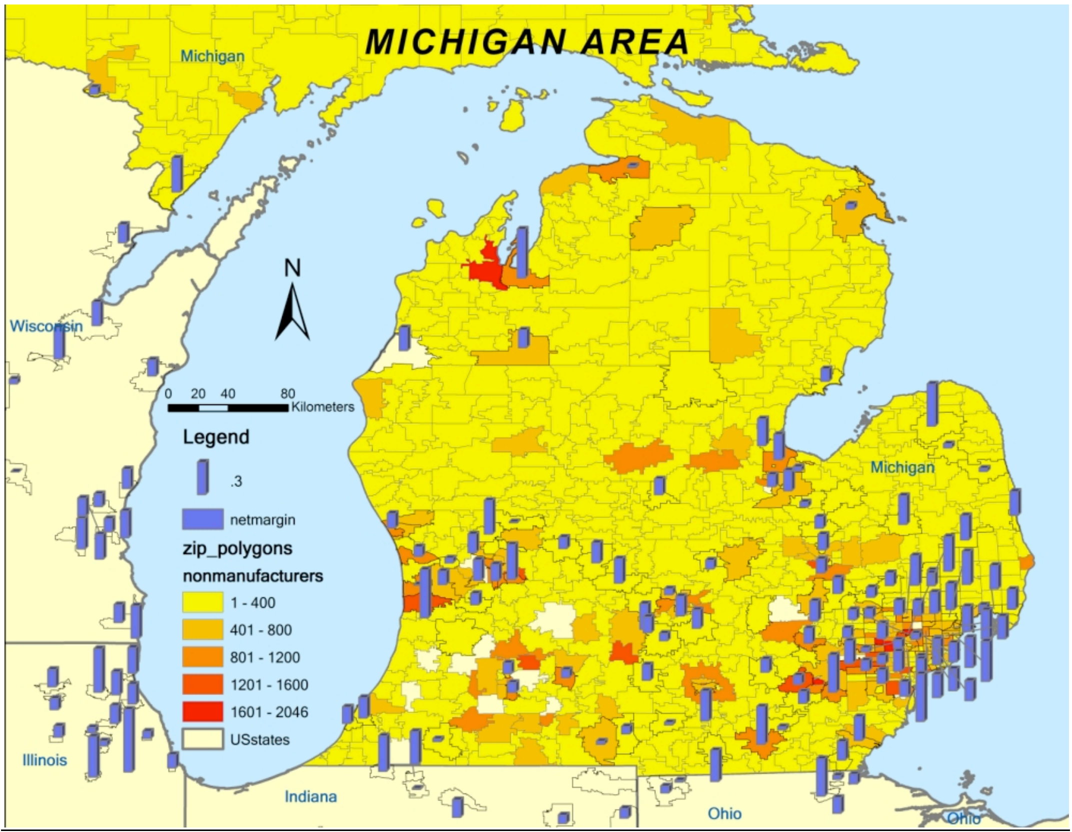


Figure 5: LOCATION AND PROFITS OF MICHIGAN SAMPLE

Note: location of blue bar reflects location of a survey respondent; height of blue bar reflects respondent plant's net profit margin; surrounding color (yellow or red) indicates number of nonmanufacturing establishments in the zip code