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EDITORIAL TRANSITIONS AND THE DEVELOPMENT OF *THE INDUSTRIAL GEOGRAPHER*

Since the establishment of *The Industrial Geographer* in 2003, the journal has existed to provide a quality outlet for theoretically-informed, empirically-based research in economic geography. This general mission has not changed, and will not change in the foreseeable future. However, the specifics of how we achieve our goals as a journal are always up for debate, revision, and retargeting.

This is as it should be. As a reflection of ongoing research in our field, *The Industrial Geographer* needs to be aware of, and responsive to, change in economic geography. However, change for the sake of change is not helpful. The change we seek to guide as editors of the journal is driven by two questions we ask ourselves, and through this editorial, our readership and the broad economic geography community:

1. What can *The Industrial Geographer* do to be an attractive venue for publication of research that truly contributes to the advancement of economic geography?
2. What can *The Industrial Geographer* do to encourage the development of dialogue in the field, including but also going beyond the traditional article focus of academic journals?

Space and time prohibit an exhaustive discussion of the background behind these questions, but we would like to pass along a few thoughts related to each.

First, related to attracting quality, field-advancing research, we believe one key element is continuing to increase the exposure of geographers to *The Industrial Geographer* as an important publication venue. To this end, we will extend the Association of American Geographers annual meeting special session series sponsored by the journal, begun at the 2008 Boston annual meetings, to the 2009 Las Vegas meeting and beyond. The goal of these sessions is to bring together some of the leading researchers in economic geography to present on some of the most important current topics of investigation in the field. The sessions are a first step in building a connection between the kinds of in-depth discussions emerging at AAG meetings and the research you are seeing published in this journal. We are pleased to acknowledge editorial board member Jim Wheeler's central role in our session preparations for 2009. Jim has already confirmed some truly excellent presenters, with more to come. Please look for at least one session sponsored by the *The Industrial Geographer* in the upcoming AAG meeting schedule.

Second, related to encouraging the development of dialogue in the field, we believe one key area of need in economic

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geography focuses on the promotion of what might be called an increased "intergenerational exchange" of ideas and research priorities in economic geography. Not to label particular ages or years, but we think that the field would benefit greatly if, to avoid a more specific term, "established" economic geographers had a greater opportunity to share research ideas, insights, and recommendations gained over the decades with economic geographers who are still early in their careers. To balance and round out this dialogue, we also think it would be helpful if "early-career" economic geographers were to have a focused venue for discussion of the emerging research problems, ideas, and opportunities they see as most important. We think *The Industrial Geographer* is well-positioned to promote this kind of dialogue.

What does this mean in terms of specifics? We would like to intentionally leave much of this undefined for the present, in the hope of spurring on discussion with you, our readers. However, a couple of thoughts related to any initiative by *The Industrial Geographer* in this area include:

- Traditional forms of journal presentation (i.e. an article format) can, and probably should, be an important part of this dialogue.

- At the same time, as an online and open-access journal, *The Industrial Geographer* has some particular advantages in developing *richer* and *more immediate* interactions through the journal's web presence.

The editors of *The Industrial Geographer* will continue to advance plans related to intergenerational exchanges of ideas, but we invite you to be part of the process. We know that challenges continue to exist for the journal, not the least of which is the many high-quality publication venues that continue to flourish in economic geography. We firmly believe that competition is a good thing, that *The Industrial Geographer* can continue to grow by providing a unique contribution to the field, and that one of the best ways for us to make this contribution is to build our connection to the economic geography community. As a reader and member of this community, feel free to give input related to any of the ideas the above, or anything else connected to the journal, to either of the co-editors. Please let us know what you think. Our e-mail addresses are listed below.

Lastly, this issue marks the beginning of the work of Murray Rice as co-editor of the journal along with Ron Kalafsky, who is continuing in his co-editor role. *The Industrial Geographer* thanks Bill Graves for his service to the journal over the past couple of years as co-editor. We're grateful that Bill will continue to contribute his expertise by staying on as a member of the editorial board.

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WOMEN'S WORK: THE HOME, THE WORKPLACE, AND THE SPACES BETWEEN

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ABSTRACT

This paper explores women's travel behaviors during their commutes from home to work. The type of women's work being examined in this study is the rapidly developing customer information services industry – call centers. As in most of the industry, the call centers in this study employ a largely female workforce. The underlying assumption of this analysis is that an investigation of the routes linking female call center agents' workplaces to their homes will provide information on women's lives in both sites. The study location is Albuquerque, New Mexico, while the data for this study comes from a survey of call center employees and from interviews with call center managers.

Key words: gender, commuting, labor, call centers

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Introduction

Before the rise of large scale industrialization home and workplace were one and the same. Most families lived on farms or in rooms to the rear or over the establishments they operated (Neth, 1994, Hall et al., 1986). Other than to nearby fields there was almost no commuting to work. The domestic sphere and the sphere of the formal economy almost completely overlapped. Industrialization distanced the home from the place of paid labor. The workplace, the home, and the routes linking them constitute the geographies of the modern economy (England 1991; Bauder, 2001; Bloomfield and Harris, 1997). For women, even more so than industrialization, the rise of the service sector dominated economy widened the space between domestic labor in the home and wage labor in the formal economy. Sixty years ago few women spanned this space, today the circuit from home to work and back is a given for most women.

This study explores the trips linking women's homes to their jobs. It examines the commutes from home to work of women employed in a female dominated service sector occupation – call center agent. This study presumes that these women's varying travel distances and times to work reflect the gendered labor and gendered roles they perform inside and outside of the home. What follows is a probing of the distances and durations of these commutes.

The study begins with a review of the gendered journey to work literature and a general description of call centers and call center agents. This is followed by a description of the Albuquerque, New Mexico labor market, the study site for this research. Tying into this description is an account of how the data for this study was gathered. The exploration of gendered commuting begins with a detailed examination of female agents travel times and distances to work. The paper concludes with a discussion of what these findings tell us about these women's work lives and home lives.

Previous Studies on Gendered Work

Empirical feminist researchers have been drawn to the juncture that binds home to workplace (Cope, 1998; England, 1993; Hanson and Pratt, 1988a, 1988b, 1991, 1992, 1995; Mattingly, 1999; McLafferty and Preston, 1991, 1997; Johnston-Anumonwo, 1997; Dyck, 1989, 1990; Gilbert, 1998; Kwan, 1999a, 1999b). This interest is due in large part because commuting explicitly links women's work in the informal economy (the home) to their work in the formal economy (wage labor) (Sayer, 1997; Massey, 1997; Gibson-Graham, 1996; Law, 1999). The spatial entrapment thesis is one of the early theorizations to emerge from this body of work. It puts forth that the demands of wage labor and the demands of the home collide when women, bound to their roles in the home, are hobbled in their physical and economic mobility to and within the workplace (Pickup, 1984).

Much work has gone into attempting to validate the spatial entrapment thesis. In one of the earlier studies on the subject, Hanson and Johnston investigated the trip distances of Baltimore commuters (1985). Not only did they examine the travel behaviors of men and women, but they also examined the travel behaviors of men and women situated within various household contexts – single/married; without children/with various numbers of children; and with children of various ages. They found that in the aggregate men traveled further to work than women, single men and single women traveled approximately the same distance to work, and, surprisingly, there was no significant difference in the travel behaviors of married mothers and married non-mothers. While male workers' longer travel distances support the spatial entrapment thesis, the lack of a difference between women with children and those without suggests that the spatial entrapment thesis is not as elegant a theorization as originally thought.

The findings of Rutherford's and Wekerle's analysis of household survey data from suburban Toronto intimate an explanation as to why Hanson and Johnston failed to discover a significant difference between the travel behaviors of female spouses with children and those without: Most female dominated occupations are essentially the same (1988). They are the same in that wages vary little between them. Consequently, why would a woman travel far from her home to work at a job that pays her approximately the same wage as another closer to home? Their study implies a gendered occupational structure, which, in financial terms, limit women's sets of distinct employment alternatives.

The work of McLafferty and Preston injected another element of complexity into the study of gendered commuting (1991). Using the New York Consolidated Metropolitan Statistical Area as a case site, MacLafferty and Preston employed US Census data to "investigate whether gender differences in commuting exist for the two main minority groups in the New York area, blacks and Hispanics" (1991: 1). They found that not only do Blacks and Hispanics commute longer than their racial and ethnic male counterparts, but they also have longer commutes than both White female and male workers. Their findings denote the non-universality of womanhood and further highlight the simplicity of the spatial entrapment thesis.

The two most comprehensive studies of gender, work, and commuting are those published in the mid-1990s by England (1993), and Hanson and Pratt (1995). They are comprehensive in that they both employ multiple sets of data and multiple methods to try to arrive at an explanation for gendered differences in travel to work behavior. In a direct testing of the spatial entrapment thesis, England chose suburban Columbus, Ohio as a study site. She gathered and analyzed data from interviews with personnel managers and clerical workers, and used business directory data to compare travel behavior between married men, married women, and single women. The results from England's study ran "counter to the theoretically and intuitively appealing entrapment thesis" (1993: 236). She came to this conclusion when her interviews with employers failed to develop a link between firm location choice and gendered labor pools, when her interviews with clerical workers revealed that married women – directly contradicting the entrapment thesis – traveled further to work than single women, and when her quantitative analysis of married women's commuting behaviors revealed that they were more similar to their husbands than to single women commuters.

Building on England's research, Hanson's and Pratt's study of gender, work, and commuting in Worcester, Massachusetts, also takes a triangulated approach by using multiple sources of data and various methods of analysis (1994, 1995). They employed US Census journey-to-work data, a survey of workers in 620 households, and interviews with local employers and workers. They uncovered strong interdependencies between workplaces and residents for certain groups of female workers. Interdependencies between female segregated occupations and spatially female concentrated employment in which "well-educated, part-time employed mothers of young children" comprise the primary employment pool (1995: 222). They also found that working women encumbered with household responsibilities tend to work closer to their homes than female workers with fewer household responsibilities (1995: 223).

The findings of these and other studies reveal the process or processes underlying gendered home to work and back travel behavior to be persistently recondite. The only statement, which can be made with any conviction, is that certain women spent less time in transit to work than certain other women. More specifically, White, middle-class, married, working mothers tend to work closer to their homes than their non-White, non-middle-class, non-married, non-female counterparts. Perhaps the greatest contributions these studies make is in their paring down of the spatial entrapment thesis. These studies also suggest that perhaps instead of trying to valid or invalid a particular theory that a more open-ended, exploratory approach is a more appropriate approach. This body of work reveals that there is a great deal that is not known about the relationship between women's work in the home and their work for wages. The ensuing analysis scrutinizes the link between women's homes and their places of employment.

Women's Work: Center Agents

Call center agents engage in emotional labor. Hochschild in her seminal work The Managed Hart defines emotional labor as the "management of feelings to create a publicly observable facial and bodily display" (1983: 7). However in terms of call center labor, labor in which bodies are not displayed but suggested via disembodied voices, James' more general definition is most appropriate: "labor involved in dealing with other peoples' feelings…. a core component… [of which is] the management of feelings within social processes" (1989: 21). James goes on to assert that emotional labor has been associated with women whereas the repression of emotions while engaged in labor has distinguished the work of men (1989: 22-25). Leidner in her examination of interactive service workers note how the gender social expectations associated with emotional labor acts to constrain workers gender identities:

> *In order to construct routines for interactions, especially scripts, employers make many assumptions about what customers like, what motivates them, and what they consider normal interactive behavior. Some of the assumptions employers make concern how men and women should behave. Once these assumptions about proper gender behavior are built into workers' routines, service recipients may have to accept them in order to fit smoothly in the service interaction.* (1991: 156)

The call center industry quickly arrived at the realization that women sell. The industry has transformed performances of femininity and female sexuality into commodities that are sold alone side airline tickets, hotel reservations, and timeshares (Foreseth, 2005). In some cases female agents are encourage to flirt with clients, but more often women are expected to utilize their inherent 'soft skills' (their caring skills) to persuade customers to either buy a product or service, or assist customers with their after purchase inquiries (Brannan, 2005; Fernandez et. al., 2005: 894-895). Seventy percent of residential call center (centers serving households) agents are women, while only 47 percent of large business call center (centers serving firms) agents are women (Batt. et. al, 2004: 17).

Call centers have been described as 'white collar sweatshops', 'electronic Panopticons', and 'dark satanic mills' (Taylor and Bain, 1999; Fernie and Metcalf, 1998; Richardson et. al., 2000; Kinnie et. al., 2000, Brannan, 2005). While hyperbolic these descriptions reflect the pressure-filled, repetitive, low wage environment that many call center agents, or 'customer service representatives' as they are commonly known in the industry, work (Belt et. al, 2002: 28-29). Call centers come in two forms: inbound (e.g. telephone reservations, support services) and outbound (e.g. telemarketers). There are approximately 115,000 call centers in the United States employing more than 5 million people (Feinberg et. al., 2000: 132; McDonald, 2000). Though not an "official" government classified industry until 1973, call center activities generate more than $800 billion in revenue a year in the United States (Richardson et. al., 2000: 360; Prabhaker et. al., 1997: 223).

This industry would be inconceivable without the interdigitation of telephone and computer technology. Call centers are hives of mostly female workers electronically plugged into computer and phone systems that aids them in their performance of white-collar assembly line labor – they are cyborgian fusions of humans and machines. (Mullings, 1999: 298-299; Bonds, 2006: 31-34). Most call center agents' work spaces are small cubicles packed into large warehouse type spaces. The agents wear telephone headsets and sit in front of computer screens from which they recite industry developed scripts to potential customers (Brannan, 2005). They receive and keypunch customers' information into computer databases. While this is taking place, center supervisors electronically monitor agents' performances (Holman et. al., 2002). Supervisors randomly listen in on the agents' conversations with customers to check their tone of voice, helpfulness, enthusiasm, and the speed with which agents get through calls (Winiecki, 2007). Most calls at outbound centers are computer automatically 'power dialed' allowing an agent to make as many as 80 calls in the span of an hour (Taylor and Bain, 1999: 108). Many of these calls end when the agent is hung-up on, while in a significant number of other telephone exchanges agents are verbally abused or sexually harassed[5].

The rapid growth of call centers in Europe and North America over the past two decades has been driven by the cost savings that accrue from economies of scale (Belt et. al., 2002: 28; Bishop et. al. 2003). Instead of each unit of a firm engaging in customer communication, changes in telecommunication and computer technology enable functions to be combined and located away from the actual site of production (Mullings, 1999: 295; Glasmeier and Borchard, 1989; Warf, 1989, 1993; Howland, 1993). Additionally, many firms now outsource this customer communication functions to third-party call centers (Richardson et. al., 2000: 361). Consequently, there is less of a need for skilled high-cost employees because the technology allows for consolidation and footlooseness. This footlooseness enables call centers to locate almost anywhere and because the only essential requirements for employment are an ability to speak English relatively clearly and keyboard skills, call centers seek out low cost labor locations (Cowie, 2007; Friginal, 2007). This is why New Mexico, a state with the sixth lowest per capita income in the U.S. in the year 2000 ($17,261), has witnessed a rapid growth in call centers.

Albuquerque

Albuquerque, New Mexico was chosen as a study site because: 1) It is home to a small but expanding concentration of call centers, 2) the Southwest is a growth region for call centers largely due to its abundant supply of low cost labor (Figure 1), and 3) Albuquerque's call center alliance, an informal group consisting of call center directors, serendipitously presented an opportunity to access the call centers used in this study.

Albuquerque, New Mexico's largest city, has a population of approximately 472,000. The region has a median household income of $39,100, yet, as in most other parts of the nation, the average female worker in Albuquerque earns only 68 percent of what her average male counterpart earns (U.S. Census, 2000). This discrepancy is principally due to the gendered nature of certain occupations (Cohen and Huffman, 2003). An example of this occupational ordering is displayed in the 2005 American Community Survey of the U.S. Census Bureau for Albuquerque. Workers in the professional, scientific, and technical services industries (rational/reasoning occupations) have average annual incomes of more than \$45,700; while those working in educational, health care and social assistance services (caring/emotional occupations) earn approximately \$27,900 a year. In Albuquerque 60 percent of professional, scientific and technical services employees are male and these men on average earn \$22,700 more than women in these fields. Sixty-four percent of educational, health, and social assistance services workers in the region are female, yet men working in this female dominated profession earn \$4,500 more than their female co-workers (\$31,400 versus \$26,900).

The Politics of Data Gathering

One manager informed us that "[His center] get[s] a lot of married people, single mothers with children, families. There is a whole new breed out here, generally speaking, married, settled down." Another joked that an ideal employee was, "[A] beautiful woman obviously with bilingual skills, [and] spirit." These quotes reveal the type of labor force that call centers generally seek out – women with soft skills (Belt et. al., 2000; 2002).

To understand this female dominated industry and its spatial relationship to its workers' residences, a survey of call center

Figure 1: Albuquerque call center advertising for agents.

agents was conducted. The Albuquerque call center alliance acted as a means of ingress to individual call centers and their directors. As an incentive to participate in this study, call center directors were offered a summary of the results from the findings of the survey. Of the thirty call center directors contacted, six granted permission (20% response rate) for on-site surveys (see note 2).

A few of the directors in the alliance were reluctant to grant access to their employees. The reasons given included: 1) they did not have the time, 2) they had to protect their employees, 3) the survey information would not tell them anything that "they did not already know," 4) they were the leading call center in the region and if information from the study was shared with other centers, they could lose their competitive advantage, and 5) in one case a director was on vacation at the time leaving no subordinate authorized to grant permission. Of the six centers that granted access, several wanted to preview the questionnaire to "protect their employees." After previewing the questionnaire, two of the directors objected to three of the questions, the first two being: "Have you ever been a member of a labor union?" and "Has anyone ever approached you about unionizing?" These directors stated that any question regarding labor unions had to be removed before access to their employees would be granted. Similarly, England experienced this same sensitivity by management to issues surrounding unions and unionization in her study of clerical workers (1993: 231). The third question that some directors found objectionable regarded race/ethnicity. One center director stated that the question had to be made optional and printed in bold. Because female travel behavior was the focus of this study, we acquiesced to the directors' requests and made the necessary modifications.

The inspiration for much of the questionnaire came from the back office, call center, and spatial division of labor literatures. Key questions included: distance traveled to work, time spent in transit to work, sex, age, marital status, wage, household income, job tenure, and number of children in the household. Both travel time and travel distances were chosen as dependent variables in this study. The survey was conducted during seven days in June of 2000. Out of the approximately 500 employees at the six centers, 365 completed the survey, a response rate of 73 percent. Of the 365 questionnaires completed, 334 were usable[6]. Only 77 of the respondents were male. Males working in female dominate occupations are currently a topic of increasing interest, but because female travel behavior is the focus of this research the 77 male respondents were dropped from the analysis (Bird, 2003; Tichenor, 1999, 2005; Williams, 2004). The high level of response was due in large measure to center directors strongly encouraged employee participation. Similarly, most directors instructed their supervisors to allow employees time away from the phones in rotating shifts to take part in the survey.

Women at Work, on the Road, and at Home

As the work of McLafferty and Preston demonstrated, it should not be assumed that all groups of women will exhibit the same travel behaviors (1991). Women differ in the social situations in which they choose and in which they find themselves. Table 1 shows how the female agents differ in their work and home lives. Most of these women earn around $11 an hour with hourly wages increasing with job tenure. Only a few of these agents have been employed at their call centers for more than 50 months (more than four years). Most of these workers range in age from their mid-30's to their early-40s. Less than half are married (44.7%), while more than half (55.2%) are parents. The workers at these centers are equally divided among White and Hispanic women. This is a low-wage workforce composed primarily of middle-aged women many of whom are either single parents or married without children. The question that will be explored is how these differences between groups of women affect their travel to work behavior. Figure 2 provides some clues.

Figure 2 displays travel distances and travel times for seven groupings of female call center agents. The times and distances suggest that household income and agent's marital status seem to be the greatest determinants of travel time and distance to work. The two groups of women who travel the farthest and longest to work (groups 6 and 7) have in common marriage and households of more than $30,000 a year. Of course there is a link between marriage and household income – husband's salary. The correlation between marital status and household income is 0.799. What is striking about this distribution of agents is that married agents whose incomes combined with their husbands' still do not reach the $30,000 a year level (group 3), travel the shortest distances and times to work of any of the other groups. The four remaining

Female workers' household status		Wage (per hour)	Number of children	Age	Job tenure (months)	Ethnicity White	Hispanic	Other
Single / no children / household income below $30,000	25th percentile	$8.83	0	24	4.5			
(number = 57)	**Median**	**$9.98**	**0**	**30**	**18.0**			
	75th percentile	$11.15	0	48	52.5			
	Percent					44.6	41.1	14.3
Single / no children / household income above $30,000	25th percentile	$8.84	0	29	11.5			
(number = 22)	**Median**	**$13.00**	**0**	**41**	**60.0**			
	75th percentile	$16.50	0	58	125.8			
	Percent					31.8	54.5	13.6
Single / parent / household income below $30,000	25th percentile	$8.79	1	31	7.0			
(number = 46)	**Median**	**$10.87**	**2**	**38**	**29.5**			
	75th percentile	$11.35	3	47	57.8			
	Percent					36.4	45.5	18.2
Single / parent / household income above $30,000	25th percentile	$11.00	1	30	44.5			
(number = 17)	**Median**	**$12.91**	**2**	**37**	**54.0**			
	75th percentile	$15.94	2	47	83.5			
	Percent					37.5	43.8	18.8
Married / no children / household income below $30,000	25th percentile	$8.05	0	25	5.0			
(number = 1)	**Median**	**$8.05**	**0**	**25**	**5.0**			
	75th percentile	$8.05	0	25	5.0			
	Percent					not reported		
Married / no children / household income above $30,000	25th percentile	$9.49	0	29	9.0			
(number = 35)	**Median**	**$10.94**	**0**	**40**	**44.0**			
	75th percentile	$12.98	0	51	84.0			
	Percent					52.9	35.3	11.8
Married / parent / household income below $30,000	25th percentile	$8.35	2	27	6.0			
(number = 15)	**Median**	**$9.98**	**2**	**36**	**20.0**			
	75th percentile	$11.14	3	47	50.0			
	Percent					20.0	66.7	13.3
Married / parent / household income above $30,000	25th percentile	$8.83	1	33	12.3			
(number = 64)	**Median**	**$11.46**	**2**	**41**	**47.5**			
	75th percentile	$12.92	3	49	86.5			
	Percent					45.9	45.9	8.2

Table 1: Demographic data for surveyed female call center agents in the Albuquerque MSA

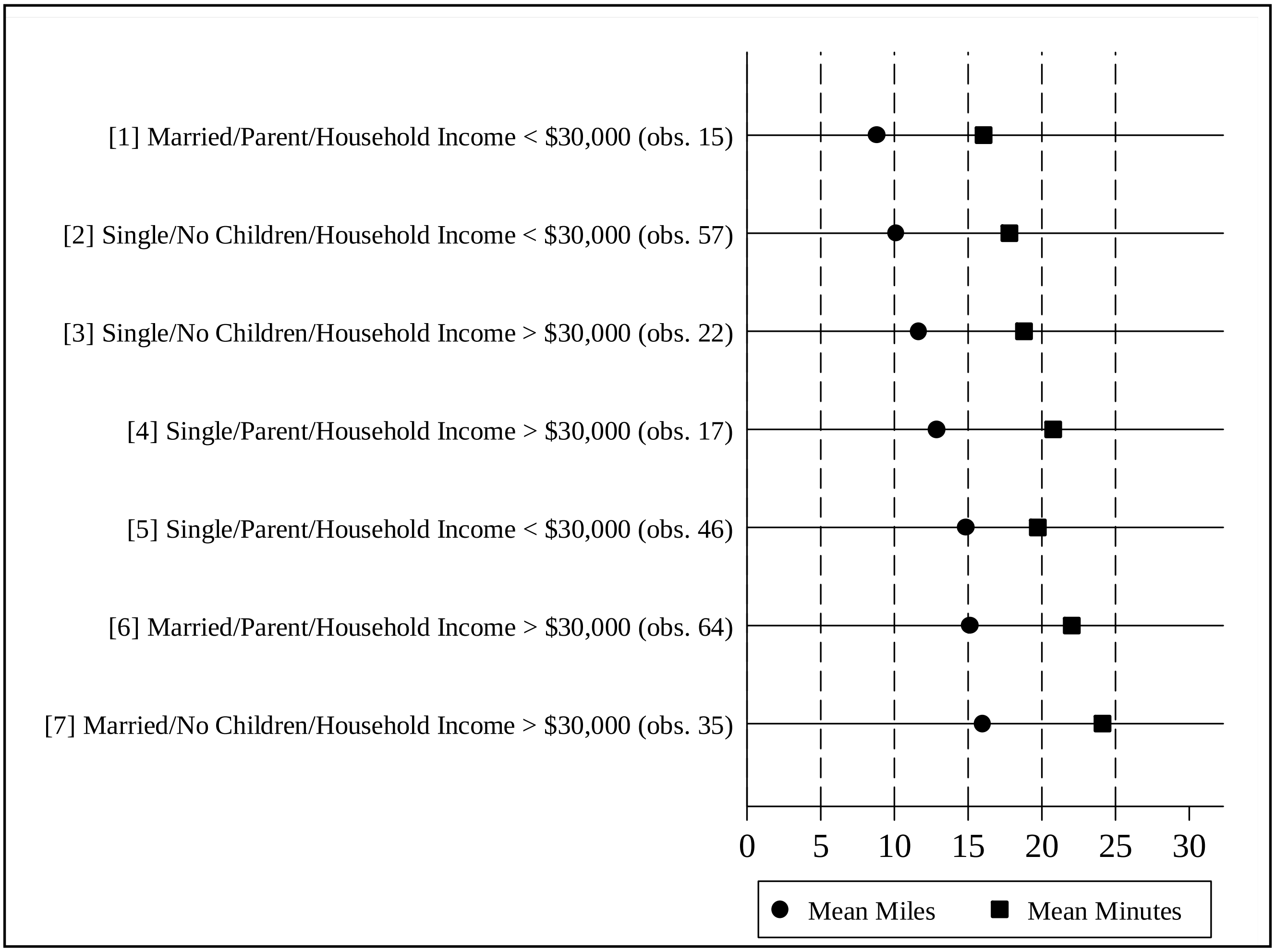

Figure 2: Comparison of female call center employees' mobility by family type and household income.

groups of agents (groups 2, 3, 4, and 5) are composed entirely of single women. These single agents travel on average 13 miles, one-way, to their jobs and their commutes take from around 17 to 20 minutes to complete. Also single mothers commuter slightly longer and slightly farther than single women without children. From this data it would appear that marriage and household income play a leading role in determining agents' travel behaviors. Table 3 examines this role in more depth.

Tables 2(a) and 2(b) show the results of two regression analyses where miles to work and minutes to work are, respectively, the dependent variables. The explanatory variables included in these models are hourly wage, number of children, age, months on the job, and marital status. Household income is not included in either of these models because of its high correlation with marital status. Thus marital status is a measure of both family type and household financial resources. Also included in these models is an interaction term measuring the effect of being married with children. Because interaction terms tend to be highly correlated with other explanatory variables variance inflation factors (VIFs) were calculated. VIFs of greater than 10 are a sign of collinearity, while mean VIFs considerably greater than one are signs of multicollinearity (Chatterjee and Hadi,

Regression Analysis (Female workers only)					
Dependent Varable	Observations	R^2			
Miles	222	0.048			
Explanatory Variables	Coefficent	P-Value	Variance Inflation Factors (VIF)	95% Confidence Intervals Lower	Upper
Wage	0.124	0.662	1.55	-0.372	0.621
Number of Children	1.073	0.182	2.33	-0.508	2.655
Age	-0.025	0.681	1.24	-0.147	0.096
Job Tenure (in months)	0.009	0.554	1.55	-0.023	0.043
Marital Status	6.339	0.001	2.05	2.605	10.073
Married with Children (number of)	-2.522	0.023	3.71	-4.689	-0.356
Constant	10.023	0.001		4.086	15.960
mean (VIF)			2.07		

Table 2(a)

Regression Analysis (Female workers only)					
Dependent Varable	Observations	R^2			
Minutes	227	0.076			
Explanatory Variables	Coefficent	P-Value	Variance Inflation Factors (VIF)	95% Confidence Intervals Lower	Upper
Wage	0.162	0.521	1.54	-0.335	0.660
Number of Children	0.458	0.567	2.34	-1.119	2.036
Age	0.043	0.477	1.24	-0.077	0.164
Job Tenure (in months)	0.001	0.924	1.55	-0.031	0.034
Marital Status	7.042	0.000	2.03	3.353	10.730
Married with Children (number of)	-2.341	0.034	3.68	-4.501	-0.180
Constant	14.356	0.000		8.435	20.282
mean (VIF)			2.06		

Table 2(b)

Table 2: a) Regression analysis results where miles to work is the dependent variable.
b) Regression analysis results where minutes to work is the dependent variable.

2006). The calculated VIFs indicate that collinearity is not a problem in the model and the mean VIFs of 2.07 and 2.06 suggest that multicollinearity is also not a concern.

The only two explanatory variables that are statistically significant in either of the models are marital status and the interaction term, married with children (Preston et al., 2000). In the miles to work model being married increases female call center agents commutes by 6.3 miles, yet being married with children reduces their commutes by 2.5 miles per child. Similar results are seen in the minutes to work model. Being married increases agents' commutes by seven minutes, while being married with children reduces these commutes by 2.3 minutes per child. Interestingly, neither of the two work related explanatory variables – wage and job tenure – had any effect on commuting behavior. It seems that the home and women's role in the home are the primary determinates of commuting behavior; however, these women's jobs do play are role in their travel behaviors in an elliptical manner.

As Rutherford and Wekerle note and as suggested in Table 1, there is not much variation in paid women's work – female dominated occupations. This lack of variation in wages may explain the narrow range of variation in travel miles and minutes seen in Figure 2 as well as the low explanatory power and statistically insignificant wage variables found in Tables 2(a) and 2(b). There may be little reason to travel very far or very long for a job that pays a low starting wage and where this wage increases slowly with job tenure. Essentially, women working in women's work appear to be trapped not only by their obligations in the home but also by the nature of their labor in the workplace.

DISCUSSION

The primary findings from this analysis of gendered travel times and travel distances to work is that at least in the context of commuting to women's work (female dominated occupations) that it is women's varying roles in the home that produce variations in travel behavior. This is not to suggest the jobs that these women are commuting to are irrelevant. Women's work in itself is a type of spatial trap. Those limited to this type of work, call centers being an example, are faced with a narrow range of job opportunities. This lack of opportunities probably intensifies the role that domestic context plays in travel to work behavior.

Butler maintains that gender is a performance compelled by a masculinist discourse of ideal Womanhood (Nelson, 1999: 331; Gregson and Rose, 2000: 434; Jackson and Scott, 2001; Butler 1990, 1993). This discourse positions woman as man's Other: his helpmate, mother, wife, the mother of his children, secretary, nurse, housekeeper, nanny, etc. The roles that women perform become what women are – helpmates, mothers, wives, … . Yet, Woman is not a monolithic subjectivity – women enact varying performances of womanhood. Butler makes the point that these differences in women's performances of womanhood derive from 'slippages' in gendered performances of identity, inexact copies of the ideal performance (Butler, 1990: 143; Nelson, 1999: 339).

What Butler is suggesting is that feminine gender in its various slippages is often indirectly defined in relation to the male. For example what makes being a call center agent women's work, places that employ few men, and by extension undervalued? Why is it that many low income women without husbands or with husbands who provide limited financial resources to the household find that they are constrain both occupationally and spatially? Why do women often still need the presence of a man in order to gain economic and spatial mobility? Why is it the presence or absence of men that often defines the situations in which women find themselves?

The findings of this study suggests it is these slippages in gendered performances, or put another way, these different ways of being a woman – married or single, mother or childless, depending on a husbands financial resources or financially on one's own, working in a female-dominated occupation or not, and all the various permutations of these alternatives – reacts with women's work – low paying, auxiliary, emotional labor – to produce suppressed expressions of travel behavior to work. These findings beg the question: what are the travel behaviors of women employed in non-women's work? What this means for a theory of gendered travel behavior is that such a theory (or more likely, theories) cannot be developed without gaining a better understanding of women in their multiplicity as well as the often hidden role that the presence or absence of men play in the performances of female gender.

NOTES

1. While the term reproductive labor comes from the Marxist literature and refers to unpaid labor within the home and the family, Heidi Nast has questioned the need to distinguish between productive and reproductive labor (Revisiting/Revisioning Contributions to Feminist Geography, 99th Annual Meeting AAG, New Orleans, 2003). Rather than producing commodities such as shoes, cars, watches, banking services, agricultural products, and "Happy Meals," households produce assets such as meals, laundry services, capital resources, education, emotional support, human beings, and, hopefully, properly socialized citizens.

2. There are discrepancies between the Census data and the data gathered for this study, the most glaring being the Census's reporting only twelve call centers in the Albuquerque MSA and the thirty call centers approached in our study. This discrepancy is due to the recent acknowledgement of the existence of this industry (see note 3) and the difficulty in actually defining what is a call center. For example, a stand-alone, third-party call center is simple to identify but a call center that is embedded within a marketing department or consumer service department of a multinational firm is more difficult to define. All thirty of the call centers in this study are embedded within large firms.

3. Call Centers did not become a government-recognized industry until the 1997 Economic Census. It was then that the federal government switched from the more than sixty-year-old Standard Industrial Classification (SIC) system to the North American Industry Classification System (NAICS), which was developed in conjunction with Mexico and Canada. Before the NAICS call center functions were spread and embedded among various SIC categories. The NAICS was developed in part to account for new industries such as call centers. (U.S. Department of Labor, Occupational Safety & Health Administration, www.osha.gov/oshstats/naics-manual.html)

4. While writing this paper one of the authors, ironically, made a reservation to stay at a hotel in Albuquerque. When the call center agents read back the information he had given her, she mistakenly had booked him into a hotel chain other then the one he had requested. From this mistake, it became obvious that she worked for a third-party call center whose clients included these two hotel chains and probably several others. This incident also highlights the constant mental juggling that is part of call center labor.

5. One of the authors worked for a year as a supervisor in an academic call center. This call center supported social and behavioral science survey research. The author witnessed firsthand the toll this type of work can take on call center employees. After a succession of rejections, many of them hang-ups, workers would often have to take breaks to recompose themselves. When they returned, they would ask for 'easy calls' – certain characteristics of respondents make them more likely to take part in a phone survey than others. On bad nights when employees got few or no responses, many would go home depressed. For a description of customer sexual harassment of

call center workers, see Sczesnt and Stahlberg (2000).

6. Eighteen surveys were discarded for one of two reasons. One, they were shift managers and thus skewed the numbers in terms of salary; or two, they were paid an annual wage instead of per hour and thus their hourly wage could not be calculated accurately.

REFERENCES

Batt, R., Colvin, A., Katz, H., and Keefe, J., 2004. Telecommunications 2004 Strategy, HR practices & performance: Cornell-Rutgers Telecommunications Project. *Center for Advanced Human Resources Studies Working Paper Series*, Working paper 04 – 18, www.ilr.cornell.edu/CAHRS/.

Belt, V., Richardson, R., and Webster, J. 2000. Women's work in the information economy: the case of telephone call centres. *Information, Communication, and Society* 3: 366-385.

Belt, V., Richardson, R., and Webster, J., 2002. Women, social skill and interactive service work in telephone call centres. *New Technology, Work and Employment* 17: 20-33.

Bishop, P., Gripaios, P., and Bristow, G. 2002. Determinants of call centre location: evidence for UK urban areas. *Urban Studies* 40: 2751-2768.

Bloomfield**,** A. V., and Harris, R. 1997. The journey to work. *Historical Methods* 30(2): 97-110.

Bonds, A. 2006. Calling on femininity?: gender, call centers, and restructuring in the rural American west," *ACME: An International E-Journal for Critical Geographies* 5: 28-49.

Brannan, M.J. 2005. Once more with feeling: ethnographic reflections on the mediation of tension in a small team of call centre workers. *Gender*, *Work* & *Organization* 12: 420-439.

Butler, J. 1990. *Gender Trouble: Feminism and the Subversion of Identity*. London: Routledge.

Butler, J. 1993. *Bodies that Matter: On the Discursive Limits of "Sex"*. London: Routledge.

Chatterjee, S., and Hadi, A.S. 2006. *Regression Analysis by Example, Fourth Edition*. New York: Wiley.

Cohen. P.N., and Huffman, M.L. 2003. Operational segregation and the devaluation of women's work across the U.S. labor market. *Social Forces* 81: 881-908.

Cope, M. 1998. Home-work links, labor markets, and the construction of place in Lawrence, Massachusetts, 1920-1939. *Professional Geographer* 50: 126-140.

Cowie, C. 2007. The accents of outsourcing: the meanings of "neutral" in the Indian call centre industry. *World Englishes* 26: 316-330.

Dyck, I. 1989. Integrating home and wage workplace: women's daily lives in a Canadian suburb. *The Canadian Geographer* 33: 329-341.

Dyck, I. 1990. Space, time, and renegotiating motherhood: an exploration of the domestic workplace. *Environment and Planning D* 8: 459-483.

England, K.V.L. 1991. Gender relations and the spatial structure of the city. *Geoforum* 22: 135-147.

England, K.V.L. 1993. Suburban pink collar ghettos: the spatial entrapment of women? *Annals of the Association of American Geographers* 83: 225-242.

Feinberg, R.A., Kim, I.-S, Hokama, L., de Ruyter, K., and Keen, C. 2000. Operational determinants of caller satisfaction in the call centre. *International Journal of Service Industry Management* 11: 131-141.

Fernandez, R.M., and Sosa, M.L. 2005. Gendering the job: networks and recruitment at a call center. *American Journal of Sociology* 111: 859-904.

Fernie, S., and Metcalf, D. 1998. (Not) hanging on the telephone: payment systems in the new sweatshhhops'," *Discussion Paper No. 390*, Centre for Economic Performance.

Forseth, U. 2005. Gender matters? Exploring how gender is negotiated in service encounters. *Gender*, *Work* & *Organization* 12: 440-459.

Gibson-Graham, J.K. 1996. *The End of Capitalism (as we knew it): A Feminist Critique of Political Economy*. Oxford: Blackwell.

Gilbert, M.R. 1998. 'Race', space, and power: the survival strategies of working poor women. *Annals of the Association of American Geographers* 88: 595-621.

Glasmeier, A., and Borchard, G. 1989. From branch plants to back offices: prospects for rural services growth. *Environment and Planning A* 21: 1565-1585.

Hall, J.D., Korstad, R., and Leloudis, J. 1986. Cotton mill people: work, community, and protest in the Textile South, 1880-1940. *American Historical Review* 91(2): 245-287.

Hanson, S., and Pratt, G. 1988a. Reconceptualizing the links between home and work in urban geography. *Economic Geography* 64: 299-321.

Hanson, S., and Pratt, G. 1988b. Spatial dimensions of the gender division of a local labor market. *Urban Geography* 9: 180-202.

Hanson, S., and Pratt, G. 1991. Job search and the occupational segregation of women. *Annals of the Association of American Geographers* 81: 229-253.

Hanson, S. and Pratt, G. 1992. Dynamic dependencies: a geographic investigation of local markets. *Economic Geography* 68: 373-405.

Hanson, S., and Pratt, G. 1994. On *Suburban Pink Collar Ghettos: The Spatial Entrapment of Women?* by Kim England. *Annals of the Association of American Geographers* 84: 500-504.

Hanson, S. and Pratt, G. 1995. *Gender, Work, and Space*. New York: Routledge.

Hochschild, A.R. 1983. *The Managed Heart: Commercialization of Human Feeling*. Berkeley: University of California Press.

Hochschild, A.R. and Machung, A. 2003. *The Second Shift*. New York: Penguin.

Howland, M. 1993. Technological change and the spatial restructuring of data entry and process services. *Technological Forecasting and Social Change* 37: 185-196.

Jackson, S., and Scott, S. 2001. Putting the body's feet on the ground: towards a sociological reconceptualization of gendered and sexual embodiment. In *Constructing Gendered Bodies*, eds. Backett-Milburn, K. and McKie, L., New York: Palgrave.

James, N. 1989. Emotional labor: skill and work in the social regulation of feelings. *Sociological Review* 37: 15-42.

Johnston-Anumonwo, I. 1997. Race, gender, and constrained work trips in Buffalo, NY, 1990. *Professional Geographer* 49: 306-317.

Kwan, M.-P. 1999a. Gender, the home-work link, and space-time patterns of nonemployment activities. *Economic Geography* 75: 370-394.

Kwan, M.-P. 1999b. Gender and individual access to urban opportunities: a study using space-time measures. *Professional Geographer* 51: 210-227.

Law, R. 1999. Beyond 'women and transport': toward new geographies of gender and daily mobility. *Progress in Human Geography* 23: 567-588.

Leidner, R. 1991. Serving hamburgers and selling insurance: gender, work, and identity in interactive service jobs. *Gender and Society* 5: 155-177.

McDonald, M. 2000. Laughing all the way to the (phone) bank. *U.S. News & World Report,* May 29.

McLafferty, S., and Preston, V. 1991. Gender, race, and commuting among service sector workers. *Professional Geographer* 43: 1-15.

McLafferty, S. and Preston, V. (1997). Gender, race, and the determinants of commuting: New York in 1990. *Urban Geography* 18: 192-212.

Massey, D. 1997. Economic/non-economic. In *Geographies of Economies*, eds. Lee, D, and Wills, J., London: Arnold.

Mattingly, D. 1999. Job search, social networks, and local labor market dynamics: the case of paid household work in San Diego, California. *Urban Geography* 20: 46-74.

Mulling, B. 1999. Sides of the same coin? coping and resistance among Jamaican data-entry operators. *Annals of the Association of American Geographers* 89: 290-311.

Nelson, L. 1999. Bodies (and spaces) do matter: the limits of performativity. *Gender Place, and Culture: A Journal of Feminist Geography* 6: 331-353.

Neth, M. 1994. Gender and the family labor system: Defining work in the rural Midwest. *Journal of Social History* 27(3): 563-578.

Pickup, L. 1984. Women's gender-role and its influence on their travel behavior. *Built Environment* 10: 61-68.

Prabhaker, P., Sheehan, M.J., and Coppett, J.I. 1997. The power of technology in business selling: call centers. *Journal of Business & Industrial Marketing* 12: 222-234.

Pratt, G., and Hanson, S. 1991. Time, space, and the occupational segregation of women: a critique of human capital theory. *Geoforum* 22: 149-157.

Preston, V., Rose, D., Norcliffe, G., and Holmes, J. 2000. Shift work, childcare and domestic work: divisions of labour in Canadian paper mill communities. *Gender, Place, and Culture* 7: 5-29.

Richardson, R., Belt, V., and Marshall, N. 2000. Taking calls to Newcastle: the regional implications of the growth in call centres. *Regional Studies* 34: 357-370.

Rutherford, B. and Wekerle, G. 1988. Captive rider, captive labor: spatial constraints on women's employment. *Urban Geography* 9: 173-193.

Sayer, A. 1997. The dialectic of culture and economy. In *Geographies of Economies*, eds. Lee, D. and Wills, J., London: Arnold.

Sczesnt, S., and Stahlberg, D. 2000 Sexual harassment over the telephone: occupational risk at call centres. *Work & Stress* 14: 121-136.

Shulman, B. (2003) *The Betrayal of Work: How Low-Wage Jobs Fail 30 Million Americans*. New York: The New Press.

Taylor, P. and Bain, P. 1999. 'An assembly line in the head': work and employee relations in the call centre. *Industrial Relations Journal* 30: 101-117.

Tichenor, V. J. 1999. Status and income as gendered resources: the case of marital power. *Journal of Marriage and the Family* 61: 638-650.

Tichenor, V. J. 2005. Maintaining men's dominance: negotiating identity and power when she earns more. *Sex Roles* 53: 191-205.

United States Census. 2004. www.census.gov.

United States Department of Labor, Bureau of Labor Statistics. 2004. www.bls.gov/data/

Warf, B. 1989. Telecommunications and the globalization of financial services. *Professional Geographer* 41: 257-271.

Warf, B. 1993. Back office dispersal: implications for urban development. *Economic Development Commentary* 16: 11-16.

Williams, C. 2004. The glass escalator: men who do women's work. In *Gender and Work in Today's World: A Reader*, eds. Sacks, N.E., and Marrone, C., Cambridge, MA: Westview Press.

Winiecki, D.J. 2007. Subjects, subjectivity, and subjectification in call center work. *Journal of Contemporary Ethnography* 36: 351-377.

SPATIAL CLUSTERING OF VENTURE CAPITAL-FINANCED BIOTECHNOLOGY FIRMS IN THE U.S.

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ABSTRACT

Biotechnology is a knowledge-intensive industry that requires a large amount of capital for research and development. The Biotechnology Industry Organization indicates that approximately one fourth of the industry financing comes from venture capital, which provides not only money but also managerial guidance to biotechnology firms. This paper focuses on biotechnology businesses that are financed by venture capital and examines their geographic distribution pattern across United States metropolitan areas. Based on data from 2006, we found that there is a highly concentrated pattern of these biotechnology firms in a few metropolitan areas. Using Poisson regression, we found that, these biotechnology venture activities are highly clustered in urban centers where there is socio-economic diversity. Such firms are also located in close proximity to research universities, institutes and/or hospitals, where there is a strong life science research base and a large pool of life scientists. These firms also cluster in areas where there are large pharmaceutical companies, venture capital providers and entrepreneurial spirit as well.

Key words: biotechnology, venture capital, cluster

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INTRODUCTION

Biotechnology is the subfield of biological science that is linked to such research areas as genetic engineering and recombinant DNA technology; thus it is applied in a wide range of industries. According to a survey by the United States Department of Commerce (2003), firms that label themselves as "biotechnology" fall into over 60 North American Industry Classification System (NAICS) codes. Due to this wide application and especially its success in pharmaceutical production (United States Department of Commerce 2003), biotechnology is becoming more commercialized. According to the Biotechnology Industry Organization (2007), by the year 2005, there were 1,415 biotechnology companies in the United States, most of which were highly concentrated in a few geographic areas. This pattern has raised great interest in location analysis for the biotechnology industry (Kenney 1986; Audretsch and Stephan 1996; Feldman 2000; Audretsch 2001; Cortright and Mayer 2002).

As a knowledge-intensive industry, biotechnology commercial activities need a large infusion of capital dedicated to research and development (United States Department of Commerce 2003). One important way that biotechnology firms get funded is through venture capital financing (Biotechnology Industry Organization, 2007), which is specialized in high-growth, high-risk and high-technology firms in the form of equity rather than debt (Black and Gilson 1998). In 2005, almost one fourth of biotechnology industry financing came from venture capital (Biotechnology Industry Organization 2007). In general, although venture capital accounts for a small fraction of total corporate finance in the United States, it plays a crucial role in technology innovation and economic growth in the national economy (Global Insight 2007). Major public technology firms, such as Microsoft, Genetech and Google, all received venture capital financing at their start-up stages (Gompers and Lerner 2006; Global Insight 2007; Neis 2007). In the biotechnology industry, commercial activities are claimed to have emerged out of university labs because of venture capital (Kenney 1986; Boehm and Schuehsler 2003). As venture capital is an equity investment until the company matures, the investors' fate is bound to the firms in which they invest. As experienced entrepreneurs, venture capitalists are usually actively involved in a biotechnology firm's development during the early critical stage by becoming board members and advisers on potential strategic partnerships (Kenney 1986; Munroe et al. 2002). They can also act as a "coach" to help a company establish a business plan (Boehm and Schuehsler 2003). Very often, a venture capitalist provides not only cash but also contacts, information, advice and a set of networks in the region that prove to be very important to the success of the ventures they fund (Rind 1981; Saxenian 1996). These resources, therefore, provide venture capital backed firms advantages over non-venture capital backed firms. Furthermore, when compared to non-venture capital backed firms, venture capital backed firms are usually newer; more focused to new technologies and thus more likely to make technology breakthroughs and to boost economic growth (Black and Gilson 1998; Kortum and Lerner 2000; Neis 2007). The relationship between these firms and venture capitalists is also a circular process, as the greater the innovation, the greater venture capital investment to come in the future (Gompers and Lerner 2006). From an economic perspective, evidence has shown that venture backed companies outperformed their non-ventured counterparts in both job creation and revenue growth (Global Insight 2007). For instance, between 2003 and 2005, the annual growth rate of jobs among venture capital backed companies was 4.1 percent, more than three times faster than the 1.3 percent for total private sector employment for the same time period; similarly, the annual sales growth rate was 11.3 percent for venture capital backed companies, compared to 8.5 percent for all U.S. companies (Global Insight 2007). At the regional level, venture capital is viewed as an important economic infrastructure for regional economic development (Florida and Smith 1993).

The purpose of this study is to investigate the spatial clustering of biotechnology firms that are financed by venture capital. For convenience, these firms are referred to as biotechnology ventures or venture firms / activities / businesses in this study. We aim to establish theoretically-informed statistical models to explain the geography of these biotechnology venture firms. Despite the interest in the biotechnology industry as a whole, very few studies have focused on biotechnology firms that are financed by venture capital. We believe that our study will add insights applicable to the fields of location analysis and regional economic development.

CLUSTERING OF BIOTECHNOLOGY VENTURE ACTIVITIES

This study investigates the spatial distribution of biotechnology venture firms that are financed by venture capital investment. Biotechnology firm data came from the MoneyTree survey in 2006. The MoneyTree survey is a quarterly study of venture capital investment activity in the United States. It has been used in other studies on venture capital (Green 2004). In this database, the phrase "biotechnology companies" refers to developers of technology promoting drug development, disease treatment, and a deeper understanding of living organisms (PricewaterhouseCoopers 2007). All these venture capital recipient companies are private and new. Venture capitalists in this database come from a variety sources, including professional venture capital firms, small business investment companies (SBICs), venture arms of corporations, institutions and investment banks (PricewaterhouseCoopers 2007). PricewaterhouseCoopers database also includes other investors, such as angels, corporations, and governments, as long as their financing rounds are qualified and verified. This database has been widely used in venture capital studies (Zook 2002; Green 2004; Wonglimpiyarat, 2005)

All biotechnology firms that received venture capital investment in 2006 were investigated in our study. Therefore, our sample does not include biotechnology firms that have received venture capital in years other than 2006. Using zip code centroids, biotechnology ventures were integrated into the geographic information system (Figure 1). Overall, three hundred biotechnology companies in the United States received venture capital investment during the time frame under study. This figure represents slightly more than twenty percent of all biotechnology firms (Biotechnology Industry Organization 2007). As indicated in Figure 1, there is a strong pattern of clustering in the Bay Area and the northeastern part of the U.S.

Biotechnology venture businesses were then aggregated according to metropolitan boundaries, where there is more homogeneity and economic connectivity than for individual municipal boundaries (Cortright and Mayer 2002). Among all biotechnology venture firms studied, 292 (97%) were located inside 370 metropolitan areas. Table 1 presents the top ten metropolitan areas, ranked by the number of biotechnology ventures. San Francisco, the home of biotechnology industry, ranked number one. In 2006, 48 (16%) firms in San Francisco received venture capital investment. San Francisco was followed by Boston, with 37 venture capital funded firms. In third place was San Diego, a fast growing and well recognized biotechnology

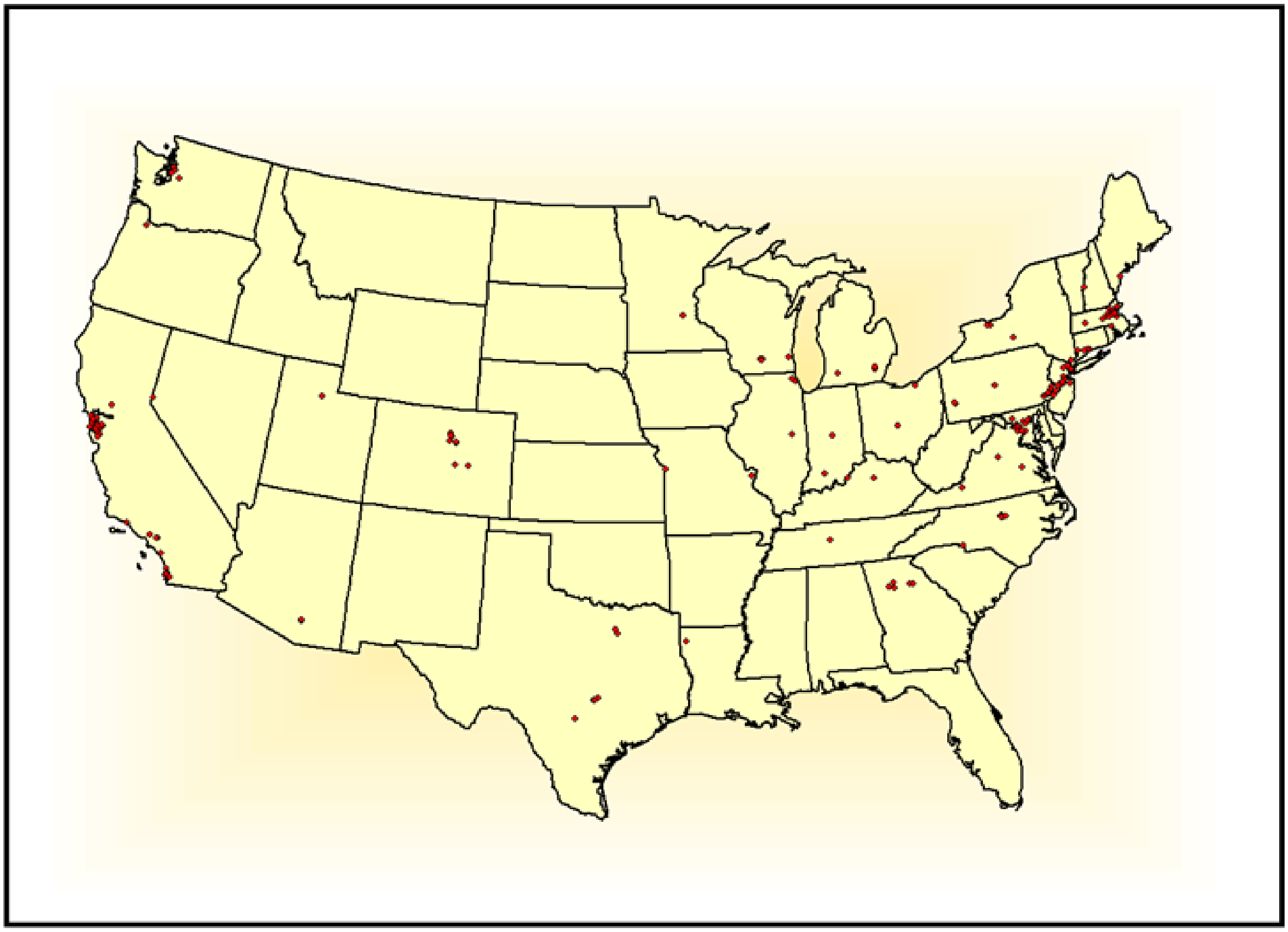

Figure 1: Location of venture capital financed biotechnology firms in 2006

center. Washington D.C. was fourth and Philadelphia ranked fifth. These top five metropolitan areas accounted for 45 percent of all biotechnology venture businesses.

LOCATION FORCES IN BIOTECHNOLOGY INDUSTRY

We assume that the geographic clustering of venture capital financed biotechnology businesses follows a similar geographic pattern as the overall biotechnology industry. In the following section, we first review cluster theory and then the location forces for biotechnology business clustering.

Why Cluster?

Geographers have always been eager to explain the uneven spatial distribution of industries and the regional disparity of economic development. One popular explanation of industrial concentration in space is the industrial cluster model, offered by Porter (1990, 1998). In his model, Porter (1990, 1998) defines industrial clusters as "geographic concentrations of inter-connected companies and institutions in a particular field, linked by commonalities and complementarities". Porter states that innovation is enhanced through close contact between various players in a cluster, including businesses, universities, infrastructures and government agencies.

Table 1: Biotechnology Ventures for the Top Ten Metropolitan Areas

Rank	Metropolitan areas	# of Ventures	Share of Total %
1	San Francisco-Oakland-Fremont, CA	48	16.4%
2	Boston-Cambridge-Quincy, MA-NH	37	12.7%
3	San Diego-Carlsbad-San Marcos, CA	21	7.2%
4	Washington-Arlington-Alexandria, DC-VA-MD-WV	20	6.8%
5	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	19	6.5%
6	San Jose-Sunnyvale-Santa Clara, CA	17	5.8%
7	New York-Newark-Edison, NY-NJ-PA	15	5.1%
8	Baltimore-Towson, MD	12	4.1%
9	Seattle-Tacoma-Bellevue, WA	11	3.8%
10	Los Angeles-Long Beach-Santa Ana, CA	8	2.7%

Industrial clusters are especially linked to the concepts of innovation process, innovative milieu, regional innovation systems and learning regions, knowledge economy, and learning economy etc (Antonelli 2000; Martin and Sunley 2003; Coenen et al. 2004). As indicated by Marshall in the late 19th century, the benefits for businesses to cluster can be explained through scale economy, specialized labor pooling, knowledge and technology spillover, and decreased transaction costs (Marshall 1890; Hotelling 1929; Czamanski and Ablas 1979; O'hUallachain 1984; Porter 1990; Feser and Bergman 2000; Feser and Lugar 2003). In our study, we focus more on the latter two aspects, technology spillover and transaction costs.

High labor mobility is one important reason for knowledge and technology spillover within an industrial cluster (Saxenian 1994; Fosfuri and Ronde 2003). The clustering of firms in a similar industry makes it easy for workers to change jobs for higher salary or promotion, as they do not have to travel long distances for job interviews and may not need to relocate homes after job transfer. Labor mobility then facilitates the exchange of information, technology and knowledge among different firms or organizations, raising the likelihood that newer ideas and products will be developed (Fosfuri and Ronde 2003). The high turnover rate in the Silicon Valley is one good example of technology spillover through labor mobility within industries (Saxenian 1994). This spillover effect, however, is argued to occur in circumscribed geographic areas and decays with increasing physical distance (Almeida and Kogut 1999).

Antonelli (2000) states that clustering of technological changes is attributable to the decreased transaction costs among economic agents. He argues that technological knowledge is fragmented among different institutions, and that more economic institutions bring out higher degrees of productivity. This process is facilitated by geographic proximity (Antonelli 2000). The benefits of decreased transaction costs could be further understood through the concepts of tacit knowledge communication and face-to-face contact (Antonelli 2000; Martin and Sunley 2003; Coenen et al. 2004; Zook 2004). In contrast to codified knowledge that could be learned through textbooks, learning of tacit knowledge often needs regular face-to-face interactions (Almeida and Kogut 1999; Sainsbury 1999; Desrochers 2001; Pinch et al. 2003). It is even argued that effective communication can only be transmitted via personal contact in limited spaces (Lawson and Lorenz 1999). There are several ways that face-to-face contact creates an economic advantage (Almeida and Kogut 1999; Sainsbury 1999; Desrochers 2001; Pinch et al. 2003). First of all, it allows more in-depth and speedy feedback among economic agents and facilitates collective learning (Lawson and Lorenz 1999). It also helps build trust and incentives in economic relationships, which further decreases transaction costs. Furthermore, it facilitates socialization within a professional network, where participants share a pool of technological knowledge, which further stimulates cooperation, competition or innovation (Storper and Venables 2004); therefore, Storper and Venables (2004) argue that face-to-face contact is central to the coordination of the economy, even in modern society that is experiencing tremendous reduction in transportation costs and more efficient communication.

Spatial clustering within the biotechnology industry, it is argued, results from the concentration of specific location factors, such as life science knowledge, venture capital availability, large pharmaceutical firms, entrepreneurship and urban diversity (Kenney 1986; Florida 2003; Audretsch and Stephan 1996; Feldman 2000). In the following sections, we will review the importance of these location forces.

Public Research Base

One highlighted characteristic of the biotechnology industry is its reliance upon public life science research base (Kenney 1986; Audretsch and Stephan 1996; McMillan et al. 2000; Dalpe 2003; Oliver 2004). Before the first biotechnology firm, Genetech, was established in San Francisco in 1977, practitioners of genetic engineering were almost without exception located around universities and research institutes (Kenney 1986). Since then many new biotechnology firms have formed and maintained strong ties with academic researchers. For example, the founding scientists of Genetech, Biogen and Immulogic all retained their university affiliations (Powell et al. 2002). In most cases, a university faculty's involvement in biotechnology businesses can only occur when their biotechnology firms are physically close to universities due to the tacit nature of knowledge (Audretsch and Stephan 1996; Feldman 2000).

Life science universities or institutions also provide a quality labor force (Kenney 1986; Lawson and Lorenz 1999; Feldman 2000). According to a survey of biotechnology industries in 2003, 55 percent of their labor force is comprised of life scientists, who usually hold a Ph.D. degree (United States Department of Commerce 2003). Apparently, areas that are geographically close to life science research institutions enjoy an advantage with better access to trained graduates or post-doctorate students. In reality, it has been reported that a large portion of biotechnology firms recruited their employees from the local labor market. In Boston, for instance, it was reported that 50 percent of biotechnology scientists in the industry came from local universities (Audretsch and Stephan 1996). University scientists often prefer to work locally after school or training because of family situations and local connections (Feldman 2000).

One important characteristic of life science research universities is that, as non-profit institutions, they are highly dependent on public funding, the largest amount being from the National Institute of Health (NIH) (Cooke 2003). Without substantive funding from NIH, it may not be possible for universities and institutions to make breakthroughs in the research of genetics and cellular processes (Cortright and Mayer 2002). However, NIH funding is highly competitive. Only those proposals that stand out in the evaluation of significance, approach, innovation, investigator, and environment will be funded. As a result, the amount of NIH funding has also been used to measure the strength of life science research capability (Cortright and Mayer, 2002).

Venture Capital

In the introduction section, we discussed the importance of venture capital for biotechnology firms. The focus here is on the geography of venture capital. Geographically, venture capital investments have been highly concentrated in space for decades (Green 2004; Gompers and Lerner 2006). Leinbach and Amrhein (1987) found that the Pacific Southwest, New England and Gulf Coast/Southwest regions attract the largest volumes of venture capital. In the late 1990s, more than one-third of venture capital was invested in the state of California (Gompers and Lerner 2001). In the biotechnology industry particularly, heavy investment of venture capital has been infused into California and Massachusetts, including San Francisco, San Diego and Boston (Cortright and Mayer 2002; Green 2004; Gompers and Lerner 2006).

Demand for venture capital from high technology firms has greatly shaped this spatial pattern (Florida and Smith 1993; Mason and Harrison 2003; Gompers and Lerner 2006). As discussed earlier, high technology firms prefer to locate close to each other to reap the benefits of clustering, including scale economy, specialized labor pooling, knowledge and technology spillover, and decreased transaction costs (Marshall 1890; Hotelling 1929; Czamanski and Ablas 1979; O'hUallachain 1984; Porter 1990; Feser and Bergman 2000; Feser and Lugar 2003). Geographic proximity between venture capital investors to biotechnology firms then are beneficial to both parties for the following reasons. First, the process of venture capital investment is highly selective and it is not uncommon for a single venture capital firm to receive thousands of funding requests (Jeng and Wells 2000). Besides firm-specific characteristics (Boehm and Schuehsler 2003), geographic proximity between firms and venture capitalists decreases information asymmetry and, thus, enhances the possibility of receiving funding (Gifford 1998). Second, when funding decisions are made, venture capitalists are usually engaged in their portfolio companies' management operations. Geographic proximity, or face-to-face contact, then reduces transportation and opportunity costs and facilitates transfer of technical skills and managerial experience between investors and investees (Mason and Harrison 2003). Studies have shown that venture capital firms favor investees close to their offices (Powell et al. 2002; Mason and Harrison 2003). The following is a quotation from an interview conducted by Zook (2002) that illustrates the importance of geographic proximity between investors and investees from an entrepreneur's perspective:

> *You can't be anywhere. To start companies you need to raise capital and investors would prefer to make investments locally because they have to spend time with the companies. I know some venture firms that say, 'if I can't drive there within an hour, I don't make the investment.' Especially in an early stage company, you want to have regular contact with the company, so access to capital drives a lot of decisions.*

This spatial concentration pattern may change over time. Myrdal (1957) proposed that capital investment is cumulative and that spatial unevenness deepens. Thompson (1989), however, provides a contrasting perspective. He argues that there might be a spatial diffusion or the trickle down effect in venture capital investment over time to peripheral areas to seek new investment opportunities. For instance, Green (2004) found a short period of venture capital diffusion after the dotcom bubble burst.

Entrepreneurship

Broadly speaking, entrepreneurial spirit is especially important for innovation and a knowledge-based economy. Schumpeter (1942) states that innovation and technological change of an economy comes from entrepreneurs. Following Schumpeter, it is argued that entrepreneurial spirit is vital to the effectiveness of markets and the increased productivity of the economy (Kirzner 1997; Jenner 1998). The finding that entrepreneurial spirit leads to greater economic growth has been well-established for technology innovations at not only the national level, but at local levels as well (Kreft and Sobel 2005).

In the biotechnology industry, securing funds from venture capitalists is not an easy task. Findings or brilliant ideas in university labs will not attract money and turn into products without a clear and thorough business plan. For a biotechnology firm, especially during its early stage of development, entrepreneurial skill and knowledge are needed to convince investors that a given proposal will be profitable (Witriol 2004). When the company gets started, entrepreneurs are mostly responsible for recruitment and management (Witriol 2004). Without talented entrepreneurs, life science findings may not be able to move out of university labs and survive in the competitive business environment.

In biotechnology, entrepreneurial spirit exists not only in venture capitalists and business managers, but also among academicians. University scientists can reap monetary benefits from intellectual property by starting businesses (Feldman 2000). One measurement of entrepreneurship in both academics and industry is patents, which are widely used to protect intellectual properties (Besen and Raskind 1991; Oliver 2004). The protection of scientific inventions through patents not only indicates interest in product commercialization but also signals involvement of scientists in commercial activities (Feldman 2000; McMillan et al. 2000; Dalpe 2003; Oliver 2004). For small firms, patenting is especially important, as they develop their intellectual property and often sell the technology to larger firms (Cortright and Mayer 2002). There have been some concerns over the use of patent data, for instance, in the way they are structured and collected (Desrochers 1998). It was also found that patents are often granted to venture backed companies early in their development and there might be multiple filings (Kortum and Lerner 2000; Neis 2007). Therefore, patents may not provide an accurate picture regarding innovative activities, but represent for innovation potentials (Desrochers 1998). Despite these concerns, the ability to patent is still perceived as a reflection of the most direct and visible outcome of the entrepreneurial process in innovation (Feldman 2000; McMillan et al. 2000; Dalpe 2003; Oliver 2004; Kreft and Sobel 2005).

Anchoring Effects from Large Pharmaceutical Firms

A large proportion of biotechnology firms are engaged in pharmaceutical research and development (United States Department of Commerce 2003). Many of them can move quickly during drug discovery, but when it comes to development, preclinical work, and human trials, they may not have sufficient financial or human resources to complete these tasks (Boehm and Schuehsler 2003). Alternatively, if they align themselves with large pharmaceutical firms that are regarded as anchors in a regional economy (Feldman 2002), they can get not only monetary supports, but also gain access to experienced executives in pharmaceuticals regarding product commercialization applications and procedures (Gwynne and

Page 2004); therefore, there is a recognized one-way technology and knowledge spillover from large pharmaceutical anchors to small biotechnology firms (Westlund 2000; Audretsch 2001).

This technology spillover exists even if there is no direct alliance between small biotechnology firms and large pharmaceutical companies (Westlund 2000; Audretsch 2001; Feldman 2002). Anchor firms usually provide a large pool of skilled labor and possess an established customer and supplier base (Feldman 2002). These may bring beneficial externality effects to small biotechnology firms if they are located close to anchor firms. Furthermore, when there is a regional anchor with a sophisticated expertise in new drugs, start-up firms may be more likely to specialize in that direction (Feldman 2002). Over time, a cluster may develop around a specialized expertise. Anchor firms may be beneficial to the regional innovative system as well, since large pharmaceutical firms are found to be more capable of establishing collaborations with research universities, fund their research projects and exploit their research results (Dalpe 2003). Consequently, innovation in science is encouraged and supported, and the knowledge and technology transfer from science to industry is facilitated. In empirical studies, the Milken Institute (2004) suggests that San Diego, for example, needs more biotechnology anchor firms to stabilize biotechnology industry development in the region.

Urban Attraction

Spatially the biotechnology industry is also found to be located near large population centers (Schweitzer et al. 2006). Numerous studies indicate that large urban centers are, in general, favorable places for industry development (Hoover 1948; Isard 1956; Isard et al. 1959; Swann and Prevezer 1996). Urban advantages include easier access to infrastructure, value chain linked industries, accounting and legal services, urban amenities, large pool of workers, and a population with high purchasing power (Hoover 1948; Vernon 1966).

In a modern society, the importance of backward and forward linkages and transportation costs in urban areas is fading (Gordon and McCann 2000; Storper and Venables 2004). However, the diverse social, economic and intellectual environment in large urban settlements still makes them centers of innovation and creativity (Florida 2003). In the creativity class argument, for example, Florida (2003) states that the emerging geography of the creative class is dramatically affecting the competitive advantage of regions across the United States. The core creative class includes scientists, engineers, architects, educators, writers, artists, and entertainers. The creative class also includes a broader group of creative professionals in business, finance, law, health care and related fields. The more diverse the urban center is, the greater the advantages it enjoys in economic development.

Storper and Venables (2004) offer further explanations on how highly populated areas possess an economic advantage in a modern society. They argue that, urban areas, with higher population densities, enjoy an advantage from geographical proximity, or face-to-face contact among the different agents in the economic production. Face-to-face contact facilitates socializing, learning, and communication between workers; it also helps build trust in economic relationships and provides psychological motivation (Storper and Venables 2004).

HYPOTHESIS

Informed by literature, we expect that biotechnology venture businesses that are financed by venture capital investment have similar demands for specific locations as the biotechnology industry as a whole. Therefore, we developed the following hypotheses regarding the spatial clustering of biotechnology venture businesses. We hypothesize that there are more biotechnology venture businesses in metropolitan areas where there is 1) a concentration of life-science research 2) proximity to venture capital providers 3) entrepreneurial spirit 4) closeness to large pharmaceutical companies and 5) an urban agglomeration economy.

DATA AND VARIABLES

The number of biotechnology venture businesses for each of 370 metropolitan areas in the U.S. is the dependent variable in this study. Ten independent variables are used as proxies for non-commercial life science research base, venture capital providers, entrepreneurial spirit, anchor impact from large pharmaceutical companies, and urbanization economies.

Life science research base is measured through five variables: the number of research universities with active life science research, the number of life science research institutes, the number of hospitals that are active in life science research, the amount of NIH funding grants between 2003 and 2005, and the number of life scientists in 2006. Data came from NIH website and the Bureau of Labor Statistics. Data on the number of venture capital providers came from the MoneyTree survey database in 2006. The majority of venture capital providers are professional venture capital companies and the rest are investment banks, large pharmaceutical companies, government agencies, universities, and even individuals. Entrepreneurial spirit is measured by patents and patent holders. These data were collected through a keyword search of "biotechnology" in the abstract section between 1995 and 2005 from the U.S. Patent and Trademark Office. Although our search does not exhaust all patents related to biotechnology, it provides a good representation of the patents that are directly applied in biotechnology industry. Large pharmaceutical firms or anchor establishments refer to those companies with 500 or more employees. This number comes from the United States Small Business Administration, where the standard size for small business in manufacturing is less than 500. Data came from the 2005 County Business Patterns. The last variable is metropolitan population. Data for metropolitan areas came from the 2000 census. All data were integrated into the geographic information system and aggregated into 370 metropolitan areas according to the 2003 Census definition. For convenience, definitions of all variables are provided in Table 2.

METHODS

This research employs several methods to investigate the importance of various location forces on the geographic clustering of venture capital financed biotechnology firms. Examination of the extensive literature on the subject of biotechnology firms provides hypotheses and supports for conclusions. New empirical analyses add to this knowledge base.

Statistical descriptions and tests were performed on the dependent and independent variables. Correlation analyses among all variables were applied and a principal component analysis (PCA) was conducted to reduce data redundancy. Location factors generated from PCA results then became the new independent variables for further regression analysis. A Poisson regression was then performed to estimate the counts of biotechnology venture companies in each metropolitan area. The same technique is used by Schweitzer et al. (2006). We assume that the probability (p) of having a certain number of biotechnology companies (k) in each metropolitan area is

$$p(Y = k \mid X_1, X_2, ..X_n) = \frac{e^{-\mu(X)}\mu(X)^k}{k!},$$

$k = 0, 1, 2, 3, \ldots$

For the expectation μ, $\log(\mu) = b_0 + b_1{*}X_1 + b_2{*}X_2 + \ldots + b_n{*}X_n$

and $\mu = \exp(b_0 + b_1{*}X_1 + b_2{*}X_2 + \ldots + b_n{*}X_n)$.

In the above equation, $X_1, X_2, \ldots$ and X_n refer to the location factors from PCA results. K refers to the number of biotechnology ventures each metropolitan area hosts and e is the constant in a natural logarithm. The maximum likelihood method was used to estimate the parameters of the regression model for $\log(\mu)$.

RESULTS

Descriptive Statistics

Table 3 provides some descriptive statistics of dependent and independent variables in the study. All but the metropolitan population variable are highly skewed. This suggests that both biotechnology venture activities and biotechnology related location factors are highly concentrated in very few metropolitan areas.

Table 2: Definition of Variables (spatial unit: metropolitan)

Variables	Definition
Dependent Variable	
Biotechnology Ventures	Number of biotechnology firms that received venture capital investments in 2006
Independent Variables	
Life science research universities	Number of universities active in life science research between 2003 and 2005
Life science research institutes	Number of institutes active in life science research between 2003 and 2005
Hospitals with life science research	Number of hospitals active in life science research between 2003 and 2005
NIH	Amount of NIH grants between 2003 and 2005
Life scientists	Number of life scientists in 2006
Venture capital providers	Number of venture capital providers to biotechnology firms in 2006
Patent	Number of patents between 1995 and 2005
Patents inventors	Number of patent holders between 1995 and 2005
Pharmaceutical Anchors	Number of large pharmaceutical firms with over 500 employees in 2005
Population	Metropolitan population in 2000

Correlation Results

The results of correlation analyses among dependent and independent variables are presented in Table 4. The dependent variable, number of biotechnology ventures, is most highly correlated with the number of venture capital providers (r=0.84), the amount of life science research institutes (r=0.80) and the amount of life scientists (r=0.79). Its relationship with other variables is positive and significant.

The independent variables are correlated within themselves as well. The life science research university variable is highly related to the metropolitan population variable (r=0.90), the pharmaceutical anchor variable (r=0.81), the venture capital provider variable (r=0.79), and the hospital variable (r=0.78). The life science research institutes variable is highly correlated with the life scientist variable (r=0.84) and venture capital provider variable (r=0.76). The hospital variable is also highly correlated with the population variable (r=0.76). There is high positive correlation coefficient between the venture capital providers variable and the pharmaceutical anchor variable (r=0.74) as well. Furthermore, there is no surprise that patent variable is highly correlated with the patent inventor variable (r=0.84). High correlation coefficients among all variables further suggest that there is a network of resources in biotechnology innovative activities.

Table 3: Descriptive Statistics

	Mean	Median	St. dev	Kurtosis	Skewness	Mini	Max
Biotechnology Ventures	0.78	0	3.93	81.01	8.30	0	48
life science research universities	1.33	0	3.47	95.48	8.33	0	48
life science research institutes	0.60	0	2.68	67.38	7.62	0	31
Hospitals with life science research	0.26	0	1.04	90.11	8.14	0	14
NIH (in millions)	194.97	0	722.82	53.68	6.38	0	8375
Life scientists	256.86	0	988.20	54.03	6.75	0	10700
Venture capital providers	0.68	0	3.14	72.64	7.88	0	36
Patent	0.10	0	0.61	193.24	12.52	0	10
Patents inventors	0.26	0	1.34	76.74	8.02	0	16
Pharmaceutical Anchors	0.20	0	0.83	108.50	8.89	0	12
Population (in thousands)	5797	4162	6529	8.84	2.64	502	35874

Table 4: Correlation Results

		1	2	3	4	5	6	7	8	9	10	11
Biotechnology Ventures	1	1	0.55	0.81	0.40	0.66	0.79	0.84	0.54	0.69	0.51	0.46
Life science research universities	2		1	0.68	0.78	0.56	0.44	0.79	0.35	0.32	0.81	0.90
Life science research institutes	3			1	0.51	0.69	0.84	0.76	0.44	0.48	0.55	0.65
Hospitals with life science research	4				1	0.38	0.31	0.62	0.25	0.22	0.71	0.76
NIH	5					1	0.68	0.56	0.31	0.38	0.41	0.50
Life scientists	6						1	0.60	0.38	0.49	0.32	0.48
Venture capital providers	7							1	0.61	0.66	0.74	0.73
Patent	8								1	0.84	0.37	0.37
Patents inventors	9									1	0.39	0.33
Pharmaceutical Anchors	10										1	0.76
Population	11											1

Note: all significant at 0.01 level

PCA Results

Due to the high correlation among independent variables, a principal component analysis (PCA) was conducted to overcome the multicollinearity problem and to reduce data redundancy. PCA produced three rotated factors, which represented 92 percent of all variance in the original ten independent variables. Factor loading of each independent variable on the new factor are presented in Table 5. In the first factor, which captures 70 percent of all the variance among the independent variables, the highest loading comes from the life science research universities variable. Three other variables, hospitals with life science research variable, metropolitan population variable and pharmaceutical anchors, also have large contributions. Therefore, the first factor represents an urban factor with strong life science education, hospital research and pharmaceutical anchoring effect. In the second factor, the highest loading comes from the life scientists variable, science research institutes variable and NIH variable. This factor represents a strong life science research base. In the third factor, highest loading comes from the patent inventor variable and patent variable. It also has a contribution from the venture capital provider variable. This factor could be interpreted as an entrepreneurship and venture capital factor.

Table 5: Principal Component Analysis Results

	Factor1	Factor2	Factor3
Life science research universities	0.742	0.079	-0.055
Hospitals with life science research	0.704	-0.030	-0.068
Population	0.693	0.083	-0.028
Pharmaceutical Anchors	0.692	-0.078	0.099
Life scientists	-0.114	0.736	0.027
life science research institutes	0.164	0.596	0.016
NIH	0.105	0.519	-0.026
Patents inventors	-0.064	0.060	0.767
Patents	0.027	-0.048	0.752
Venture capital providers	0.424	0.156	0.313

Poisson Regression Results

As the dependent variable in this study is highly skewed and most metropolitan areas possess little or no biotechnology venture activities (Table 3), the use of Ordinary Least Square regression on such a distribution will produce biased estimates and invalid inferences (Maddala 1983). Alternatively, a Poisson regression was performed (Schweitzer et al. 2006). Results from Poisson regression are presented in Table 6. With no surprise, all three factors have significant and positive impacts upon the dependent variable. This result leads to the conclusion that biotechnology venture activities are located where there are large urban centers with strong life science education, hospital research and pharmaceutical anchoring effect, where there is a strong life science research base, and where there is strong entrepreneurship and a large number of venture capital providers.

CONCLUSIONS AND DISCUSSIONS

This study investigated the spatial clustering of biotechnology firms that are financed by venture capital. All proposed hypotheses are supported through statistical analysis, indicating that biotechnology venture activities are clustered in urban centers, where there is a strong life science research base, a large pool of life scientists, large pharmaceutical firms, many venture capital providers and a strong entrepreneurial spirit. This conclusion on the biotechnology venture firms is consistent with studies on the biotechnology industry as a whole (Schweitzer et al. 2006).

There is no surprise that biotechnology venture activities are located in urban centers. This finding is consistent with Schweitzer et al. (2006) and gives further support for the creative class argument (Florida 2003). With a large concentration of talent, technology, and tolerance, a favorable environment exists for new ideas and technological breakthroughs (Florida 2003). An urban environment also provides more geographic proximity between various economic agents (Storper and Venables 2004), facilitating the communication of tacit knowledge in biotechnology industry (Dalpe 2003).

Biotechnology venture activities are also found to be located close to a strong life science research base with a large pool of life scientists. While previous studies have focused on the attraction of research universities (Schweitzer et al. 2006), we also included life science research institutes and hospitals. Besides the strong statistical evidence of co-location between life science research universities and biotechnology firms at metropolitan level, detailed examination of firm locations and firm founders provide additional insights. For instance, within 5 miles, there are 19 biotechnology venture companies around Stanford University, 32 companies around MIT and Harvard, and 33 companies around California State University at San Diego. This geographic proximity enables university faculties to be directly involved in biotechnology businesses.

Our hypothesis that proximity to venture capital providers increases the number of biotechnology venture businesses is supported by statistical results as well. Venture capital is not only important in terms of financial support, but also important in the sense that venture capitalists provide insights, managerial skills and entrepreneurial spirit to newly established biotechnology companies. This proximity encourages people with ideas to communicate and collaborate with people with fiscal resources and business expertise. It is important to note that, in reality, most biotechnology venture firms receive investment from multiple sources. In such cases, there is almost always one local venture capital firm involved in the new biotechnology business. One biotechnology firm, Microbia, Inc., for instance, located in Cambridge, received 75 million venture capital investments from six investors in the first quarter of 2006. Among five identified investors, one is located in Cambridge, one in Dallas, one in Waltham, MA, one in Boca Raton, FL, and the other one in New York. The finding is also consistent with the co-investment argument in the studies on venture capital, where it is found that if a firm secures investment from a lead investor, other investors would follow and infuse more money into the investee company, resulting in an accumulated money influx (Timmons and Bygrave 1986; Powell et al. 2002).

The hypothesis that entrepreneurial spirit is important for biotechnology venture activities is also supported. Using patents and patent holders as proxies for entrepreneurial spirit, this study finds that when there are more patents filed in biotechnology and/or more patents holders in biotechnology, there are more biotechnology venture firms. Entrepreneurial spirit is one key link to attract venture capital

Table 6: Poisson Regression Results

Dependent variables	Estimates	Chi-square	Pr > ChiSq
Factor1 - urban factor	0.139	59.72	<0.0001
Factor2 - life science research factor	0.401	479.65	<0.0001
Factor3 - entrepreneurship factor	0.243	215.46	<0.0001

investment and lead the scientific findings into commercial activities.

This study also finds strong support for the anchor effect from large pharmaceutical companies. Large pharmaceutical companies have more insights regarding the direction of the industry in the long run, provide a large pool of skilled labor, subcontract research to small biotechnology firms, and even provide venture capitals to firms or fund university research projects (Westlund 2000; Audretsch 2001; Feldman 2002). Furthermore, large pharmaceutical companies provide training for employees who become potential entrepreneurs in biotechnology companies.

We hope that our research has helped to elucidate the geographic location of biotechnology firms that are highly dependent on venture capital investment and the role that life science research base, proximity to venture capital providers, large pharmaceutical firms, entrepreneurial spirit, and urban diversity play. It remains for future research to investigate how the spatial distribution pattern has changed over time and whether venture capital backed firms behave differently from non-venture capital backed firms.

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REFERENCES

Almeida, P., and Kogut, B. 1999 Localization of knowledge and the mobility of engineers in regional networks. *Management Science* 45 (7):905-917.

Antonelli, C. 2000 Collective knowledge communication and innovation: the evidence of technological districts. *Regional Studies* 34 (6):535-547.

Audretsch, D. B. 2001 The role of small firms in U.S. biotechnology clusters. *Small Business Economics* 17:3-15.

Audretsch, D. B., and Stephan, P. E. 1996 Company-scientist locational links: the case of biotechnology. *The American Economic Review* 86 (3):641-652.

Besen, S. M., and Raskind, L. J. 1991 An Introduction to the law and economics of intellectual property. *The Journal of Economic Perspectives*, 5 (1): 3-27

Biotechnology Industry Organization. 2007 Biotechnology industry facts. http://bio.org/speeches/pubs/er/statistics.asp

Black, B.S. and Gilson, R.J. 1998 Venture capital and the structure of capital markets: banks versus stock markets. *Journal of Financial Economics* 47, 243-77.

Boehm, T., and Schuehsler, H. 2003 Where do biotechnology venture capitalists go from here? *Techno Venture Management*. http://www.thebiotechclub.org/industry/articles/articles/2003_WhereDoBiotech.pdf

Coenen, L., Moodysson, J and Asheim, B. T. 2004 Nodes, networks and proximities: on the knowledge dynamics of the Medicon Valley Biotech Cluster. *European Planning Studies* 12 (7):1003-1018.

Cooke, P. 2003 The evolution of biotechnology in three continents: Schumpeterian or Penrosian? *European Planning Studies* 11 (7):757-763.

Cortright, J., and Mayer, H. 2002 Signs of life: the growth of biotechnology centers in the U.S. http://www.brook.edu/dybdocroot/es/urban/publications/biotechnology.pdf

Czamanski, S., and Ablas, L. A. d. Q. 1979 Identification of industrial clusters and complexes: a comparison of methods and findings. *Urban Studies* 16:61-80.

Dalpe, R. 2003 Interaction between public research organizations and industry in biotechnology. *Managerial and Decision Economics* 24:171-185.

Desrochers, P. 1998 On the abuse of patents as economic indicators. *Quarterly Journal of Austrian Economics* 1(4), 51-74.

Desrochers, P. 2001 Geographical proximity and the transmission of tacit knowledge. *The Review of Austrian Economics* 14 (1):25-46.

Feldman, M. P. 2000 Where science comes to life: university bioscience, commercial spin-offs, and regional economic development. *Journal of Comparative Policy Analysis: Research and Practice* 2:345-361.

Feldman, M. P. 2002 The locational dynamics of the U.S. biotechnology industry: knowledge externalities and the anchor hypothesis. In *The Empirical Implications of Technology-Based Growth Theories*. Groningen, the Netherlands: Dutch interuniversity research group. http://www.eco.rug.nl/~los/TEG2002Pap/Feldman.pdf

Feser, E. J., and Bergman, E. M. 2000 National industry cluster templates: a framework for applied regional cluster analysis. *Regional Studies* 34 (1):1-19.

Feser, E. J., and Luger, M. I. 2003 Cluster analysis as a mode of inquiry: its use in science and technology policymaking in North Carolina *European Planning Studies* 11 (1):11-24.

Florida, R. 2003 *The rise of the creative class: and how it's transforming work, leisure, community and everyday life*: Perseus Books Group.

Florida, R., and Smith, D. F. 1993 Venture capital formation, investment, and regional industrialization. *Annals of the Association of American Geographers* 83 (3):434-451.

Fosfuri, A., and Ronde, T. 2003 High-tech clusters, technology spillovers, and trade secret laws. In *Centre for Industrial Economics Discussion Papers*. Institute of Economics, University of Copenhagen. http://www.econ.ku.dk/CIE/Discussion%20Papers/2003/pdf/2003-02.pdf

Gifford, S. 1998 Limited entrepreneurial attention and economic development. *Small Business Economics* 10:17-30.

Global Insight. 2007 Venture impact: the economic importance of venture capital backed companies to the U.S. economy: National Venture Capital Association. Third edition. http://www.nvca.org/pdf/NVCA_VentureCapital07.pdf

Gompers, P. and Lerner, J. 2006 *The Venture Capital Cycle*. 2nd edition. The MIT Press.

Gordon, I. R., and McCann, P. 2000 Industrial clusters: complexes, agglomeration and/or social networks? *Urban Studies* 37 (3):513 - 532

Green M. B. 2004 Venture capital investment in the United States 1995-2002. *The Industrial Geographer* 2(1):2-30

Gwynne, P., and Page, G. 2004 Biotechnology development: geography is density. *Science* May 7.

Hoover, E. M. 1948 *The Location of Economic Activity*: McGraw-Hill

Hotelling, H. 1929 Stability in competition. *The Economic Journal* 39 (153):41-57.

Issard, W. 1956 *Location and space economy*. Cambridge: MIT press.

Isard, W., Schooler, E. W., and Vietolusz, T. 1959 *Industrial complex Analysis and regional development*. New York: John Wiley.

Jeng, L. A., and Wells, P. C. 2000 The determinants of venture capital funding: evidence across countries *Journal of Corporate Finance* 6:241-289.

Jenner, R. A. 1998 Endogenous Schumpeterian growth, the productivity slowdown, and entrepreneurial dynamics. *Small Business Economics* 11 (4):343-351.

Kenney, M. 1986 *Biotechnology: the university – industrial complex*. Boston: Yale University Press.

Kirzner, I. M. 1997 Entrepreneurial discovery and the competitive market process: an Austrian approach. *Journal of Economic Literature* 35 (1):60-85.

Kortum, S. and Lerner, J. 2000 Assessing the contribution of venture capital to innovation. *The RAND Journal of Economics* 31, 674-92

Kreft, S. F., and Sobel, R. S. 2005 Public policy, entrepreneurship, and economic freedom. *Cato Journal* 25 (3):595-616.

Lawson, C., and Lorenz, E. 1999 Collective learning, tacit knowledge and regional innovative capacity. *Regional Studies* 33 (4):305-317.

Leinbach, T., and Amrhein, C. 1987 A geography of venture capital in the U.S. *The Professional Geography* 39:146-158

Maddala, G. S. 1983 *Limited-dependent and qualitative variables in econometrics*. Cambridge: Cambridge University Press.

Marshall, A. 1890 *Principles of economics*. London: MacMillan.

Martin, R., and Sunley, P. 2003 Deconstructing clusters: chaotic concept or policy panacea? *Journal of Economic Geography* 3:5-35.

Mason, C. M., and Harrison, R. T. 2002 The geography of venture capital investment in the UK. *Transactions of the Institute of British Geographers* 27 (4):427-451.

McMillan, S. G., Narin, F., and Deeds, D. 2000 An analysis of the critical role of public science in innovation: the case of biotechnology. *Research Policy* 29:1-8.

Milken Institute. 2004. *America's biotech and life science clusters*. http://www.deloitte.com/dtt/cda/doc/content/us_lifesciences_milkenreport_0604 percent283 percent29.pdf (Last retrieved on Oct 15, 2007)

Munroe, T., Gary, C. W., and Hutton, D. 2002 A critical analysis of local biotechnology industry clusters in Alameda, Contra Costa, & Solano Counties. http://www.baybio.org/biotechnologyreport.pdf

Myrdal, G. 1957 *Economic Theory and Underdeveloped Regions*. Harper and Row, New York

Neis, J. 2007. Impact on Small Venture-backed Companies. House Small Business Committee Hearing March 29, 2007 Patent Reform. http://www.piausa.org/patent_reform/congressional_testimony/john_neis_03_29_2007

O'hUallachain, B. 1984 The identification of industrial complexes. *Annals of the Association of American Geographers* 74 (3):420-436.

Oliver, A. L. 2004 Biotechnology entrepreneurial scientists and their collaborations. *Research Policy* 33:583-597.

Pinch, S., Henry, N., Jenkins, M. and Tallman, S. 2003 From 'industrial districts' to 'knowledge clusters': a model of knowledge dissemination and competitive advantage in industrial agglomerations. *Journal of Economic Geography* 3 (4):373-388.

Porter, M. 1990 *The competitive advantage of nations*. London: MacMillan.

Porter, M. 1998 *Competitive strategy: techniques for analyzing industries and competitors*: Free Press.

Powell, W. W., Koput, K. W., Bowie, J. I. and Smith-Doerr, L. 2002 The spatial clustering of science and capital: accounting for biotech firms - venture capital relationships. *Regional Studies* 36 (3):291-305.

PricewaterhouseCoopers 2007 MoneyTree Report. https://www.pwcmoneytree.com/MTPublic/ns/index.jsp (Last retrieved on Oct 15, 2007)

Rind, K. W. 1981 The role of venture capital in corporate development. *Strategic Management Journal* 2 (2):169-180.

Rosenfeld, S. A. 1997 Bringing business clusters into the mainstream of economic development. *European Planning Studies* 5 (1):3-23.

Sainsbury, L. 1999 Biotechnology clusters: Department of Trade and Industry, United Kingdom. http://www.dti.gov.uk/biotechnologyclusters/chapt04.pdf

Saxenian, A. 1994 *Regional advantage: culture and competition in Silicon Valley and Route 128* Boston: Harvard University Press.

Schumpeter, J. A. 1942 *Capitalism, socialism and democracy*. New York Harper.

Schweitzer, S. O., Connell, J., and Schoenberg, F. P. 2006 Clustering in the biotechnology industry. *International Journal of Healthcare Technology and Management* 7 (6):554-56

Storper, M., and Venables, A. 2004 Buzz: Face-to-Face Contact and the Urban Economy. *Journal of Economic Geography* 4:351-370.

Swann, P., and Prevezer, M. 1996 A comparison of the dynamics of industrial clustering in computing and biotechnology *Research Policy* 25:1139-1157.

Thompson, C. 1989 The geography of venture capital. *Progress in Human Geography* 13(1):62-98

Timmons, J., and Bygrave, W. 1986 Venture capital's role in financing innovation for economic growth. *Journal of Business Venturing* 1:161-176.

United States Department of Commerce 2003 A survey of the use of biotechnology in United States Industry. 2003. http://www.technology.gov/reports/Biotechnology/CD120a_0310.pdf

Vernon, R. 1966 International investment and international trade in the product cycle. *Quarterly Journal of Economics*: 190-207.

Westlund, R. 2000 Skilled, available workers top pharmaceutical site seekers' wish list. http://biotech.about.com/gi/dynamic/offsite.htm?site=http://www.siteselection.com/features/2000/july/pharm/index.htm

Witriol, A. S. 2004 Biotechnology and entrepreneurship. http://entcent.rutgers.edu/MBA%20Reports/Biotech%20Entrepreneurship.pdf

Wonglimpiyarat, J. 2005 The dynamic economic engine at Silicon Valley and US Government programmes in financing innovations. *Technovation* 26(9)1081-1089

Zook, M. A. 2002 Grounded capital: venture financing and the geography of the Internet industry, 1994-2000. *Journal of Economic Geography* 2: 151-177.

Zook, M. A. 2004 The knowledge brokers: venture capitalists, tacit knowledge and regional development. *International Journal of Urban and Regional Research* 28 (3), 621-41.

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The Industrial Geographer (ISSN 1540-1669) publishes articles and research notes that focus on a broad range of economic issues across all economic sectors and explore issues at all scales from the firm to the globe. The journal encourages submissions that are theoretically driven empirical research, papers with an applied and planning thrust, and papers that explore directions for future research. Two issues are published annually, one in the Fall (September-October) and one in the Spring (April-May). Individuals interested in organizing a special issue should contact the editors with a proposal outlining the issue theme and potential contributions.

Review Process

All manuscripts are subject to double-blind peer review. Upon receipt of the manuscript, a paper will be sent out for review to three (3) professionals with expertise in the core area investigated. The three (3) reviewers will be comprised of at least one (1) editorial board member and one (1) non-board member. Ideally, the initial review process will be completed within six (6) to eight (8) weeks from initial submission. No initial review should exceed twelve (12) weeks. Please note that July submissions will not be sent out for review until the first week of August.

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The Industrial Geographer solicits high-quality research in economic geography, encompassing both the traditional, research article format, and shorter research notes and discussions. All submissions to *The Industrial Geographer* must represent the original work of the author(s). It is the responsibility of the author(s) to obtain copyright permissions, if necessary. Simultaneous submissions of works to other journals are not acceptable. A cover letter must be provided along with any submission that certifies that the above conditions have been met, and will be met as long as *The Industrial Geographer*'s review process is ongoing.

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3. Presentations

Graves, W. 1997 Mapping the new economy: Estimating intellectual capital distributions from balance sheet data, Presented at the Southeast Division of the American Association of Geographers (SEDAAG).

4. Books

Illeris, S. 1996 *The Service Economy: A Geographical Approach*. New York: Wiley.

5. Working Papers or Other Resources

Atchison, S. 1993 Care and feeding of lone eagles. *Business Week,* November 15, p. 58.

DeVol, R. 1999 America's High-Tech Economy: Growth, Development, and Risks for Metropolitan Areas. Milken Institute, Santa Monica, CA.

Rickman, P. 2001 Official, United Auto Workers Local 12, Toledo, OH, telephone interview August 15.

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