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INDUSTRIAL DEVELOPMENT IN CITIES

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ABSTRACT

Using extensive data on 1970 and 1987 urban characteristics, the paper analyzes changes in employment in specific manufacturing industries in cities between 1970 and 1987. Two sets of questions are the focus. First, what present or past characteristics of a city's economic environment are critical in determining current employment levels in different industries? How much persistence in employment patterns is there over time and what is the source of that persistence? The second set of questions explores what inferences can be made from the data and results concerning the nature of externalities in urban markets, involving diversity of suppliers to firms, information spillovers concerning current market conditions and information spillovers involving the spread of technology.

While the literature assumes employment levels in individual industries in individual cities show strong mean reversion ("convergence"), in fact that is not the case in the 1970-87 time period. The raw data show strong persistence. The major source of that persistence appears to be persistence in local demand conditions (i.e., persistence in regional comparative advantage), as opposed to other measured <u>or</u> unmeasured urban characteristics. Retention of employment is also strongly helped by the historical degree of local specialization in the industry, perhaps indicating a form of dynamic externality. Other historical conditions are not important.

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In the past twenty years, the industrial structure of America has changed dramatically. Nationally, most traditional manufacturing sectors have stagnated or shrunk, sometimes by enormous percentages. There have also been dramatic regional shifts in economic activity. Cities have responded in very different ways. While mostly retaining their populations, many cities have experienced vast reductions in manufacturing employment to become almost completely service oriented. However, some have retained or others have greatly enhanced their manufacturing base. In addition, some new high-tech sectors have grown nationally, presenting an opportunity for some traditional manufacturing urban centers to adjust the composition of their economic base and an opportunity for formerly non-manufacturing centers to attract high tech industries.

These dramatic changes in the industrial structure of America provide an unusual opportunity to analyze the determinants of industrial locational across cities. Using extensive data on 1970 and 1987 urban characteristics, we analyze employment in specific manufacturing industries in cities in 1987, given the 1970 baseline. In analyzing this data we focus on two sets of questions. First, what present or past characteristics of a city's economic environment are critical in determining current employment levels in different industries? The estimations which examine this first set of questions are based on a framework which allows us to predict the impact of shocks to the economy on where industries locate (e.g., the impact of a Mexico-USA free trade agreement, as in Henderson 1992). The second set of questions explores how much persistence in employment patterns there is over time and what is the source of that persistence. Is persistence related to measured or unmeasured city characteristics or to immobility of plant and equipment; or can one infer the presence of dynamic externalities from persistence? With available USA data, we don't believe it is possible to completely isolate and identify dynamic externalities as distinct from other forces (such as persistence of static externalities). However, the paper uncovers critical issues and derives new empirical findings, which are very suggestive.

MODELLING INDUSTRIAL EMPLOYMENT

Models of industrial location are based on several facts and concepts which we discuss in this introductory section of the paper. First of all cities produce very different product mixes. At a one and two-digit level of industry detail, metro areas tend to specialize relatively, while at a two and three-digit level of detail specialization may be absolute. Then location comprises both discrete (is the industry there or not) and continuous (if there, what is the scale of operation) events. Specialization is predicted by theoretical modelling of systems of cities (Henderson 1974 and 1988 and Abdel-Rahman and Fujita 1991), and is strongly supported by our data, as well as documented in the literature (Bergsman *et al.* 1975 and Henderson, 1988 and 1992). In 1987 even the most common two-digit industries registered employment (over 250 workers) in only 60-90% of metro areas. Most 3-digit industries and some two-digit ones registered employment in under 40% of metro areas. Moreover, many metro areas exhibited a very high degree of specialization with a significant fraction (8-15%) of the local labor force in just one industry. It is true that employment levels for individual industries are strongly correlated across cities (e.g., in 1987 machinery has correlation coefficients of .87 and .56 with fabricated metals and primary metals respectively), but local employment *shares* of different industries typically are very weakly correlated (.08 and -.02 for the industries just named).

This specialization involving heavy concentration of individual industries in a relatively few locations implies that there are magnetic forces which draw firms in the same industry into clusters. While the focus of this paper is not on explaining spatial concentration of industries at a point in time, but rather on explaining persistence in locational choices over time, the forces involved are similar, so we review them. In terms of clustering of firms at a point in time, the literature distinguishes at least four items. First are static externalities, related to information spillovers. Given uncertainty about demand conditions, uncertainty about supply conditions, and uncertainty about the quality of purchased inputs in a search context, there are information spillovers where firms benefit from those around them from whom they can obtain information. The most obvious sources of information are local firms in the same industry, who inadvertently or otherwise provide information about market conditions. Second are "forward and backward linkages" – the fact that close spatial proximity reduces the transport costs of trade among interconnected firms. Third in a Dixit-Stiglitz (1977) world adapted to production diversity (Abdel-Rahman (1988), scale and diversity in segments of the local nontraded intermediate goods sector benefit firms in particular export industries. Finally, firms in a particular industry may cluster into a particular location to enjoy particular location specific amenities relatively important to that industry.

The second fact that models of industrial location generally rely on is that firms and industries are highly mobile within and across metro areas. Cities can radically and rapidly change what they produce. We could cite the post World War II almost immediate exodus of remaining textiles from New England, or earlier textile departures (Kane, 1988). However, our own sample provides a good example, with a nationally rapidly growing industry, electronic components. We will see later that about half of our sample of 224 cities had significant employment in components in 1987. While between 1970 and 1987, there were 34 "entrants" or localities newly producing components, there were also 15 "exiters." Fifteen metro areas with significant employment in 1970 of a rapidly growing industry nationally actually stopped producing electronic components. These metro areas simply shifted their focus to other commodities.

This notion of mobility is strengthened by the fact that there is tremendous fluidity of firms within industries, which suggests that, for example, the immobility of machines and equipment may only be a short-run impediment to movement of firms. The work of Dunne, Roberts and Samuelson (1989, 1990) tells us that plant births and deaths are rapid. For example, 50% of manufacturing plants in existence in 1977 did not exist just five years later in 1982 and 52% of 1982 plants did not exist in 1977. Work on job shifts by Davis and Haltiwanger (1991) tells us correspondingly that between 1972 and 1986, the annual rates of gross job creation and destruction were 9 and 11% respectively. Most of these reflect permanent changes at the plant level (i.e., not layoffs and rehires), reflecting exogenous plant-specific shocks rather than sectoral shocks, inducing a shift in employment opportunities across sites. Moreover, specifically with respect to capital immobility, the 10-15% estimated annual rates of depreciation on industrial capital suggests that immobility only impedes firm movement within the short horizon of replacement. In summary, in the 17-year period between 1970 and 1987, in any metro area, almost all plants and employees could have turned over "naturally,"providing an opportunity to make completely new location choices.

These facts suggest that employment in different industries in a city may be continually shifting in response to changes in current economic conditions (wages, fuel prices, demand bases) and, hence the city's current comparative advantage. A city may lose a particular mainstay industry or even lose its entire manufacturing base and still thrive with a new, say, service-oriented base. Some researchers (e.g., Glaeser et al. 1991) have gone so far as to presume that there is generally tremendous turnover in what cities do. This leads to an assertion of strong reversion to the mean in employment levels ("convergence") or an assertion that past specialization in an activity detracts from growth of that activity. In either case, metro areas with historically high levels of employment in an activity will tend to experience significantly lower growth rates of that activity, than areas with historically low levels of employment.

However, we must ask the question of whether in fact there is this consistent pattern of extensive turnover in what cities do. In particular, is there strong reversion to the mean in different economic sectors and characteristics of cities? To answer this question, we estimate basic convergence type equations relevant to our data. These have the form

$$log(y_{87,j}/y_{70,j}) = X_j\gamma - \delta log y_{70,j} + \epsilon_j \qquad (1)$$

$$\delta \equiv (1 - e^{-\beta T})$$

where y is the magnitude of interest in assessing convergence. β is the annual rate convergence, and T is the time period, 17 years for most measures. The arguments of X are a constant term, three regional dummies, and two variables relating to 1970 educational composition of the population in city j (% adults with high school or more and % with college or more). These last two are noncritical to the results. The data are fully described in a later section. In Figure 1 we give some scatter plots and in Table 1 we report the estimated $\delta's$ and the implied $\beta's$ for different magnitudes. We also report 1970 and 1987 standard deviations for $log\ y$.

A δ of zero in this growth formulation is the same as a coefficient of one for $log\ y_{70}$ when the dependent variable is simply $log\ y_{87}$. That is, for $\delta = 0$, controlling for regional shifts, 1987 employment is 1970 employment, apart from stochastic influences on individual city employments. A δ of one implies 1970 and 1987 employment are unrelated. A δ between zero and one implies reversion to the mean – large initial local industries grow more slowly than small ones.

Consistent with results for regions (Barro and Sala-I-Martin 1991), wage convergence in either the sense of $\sigma-$ convergence (reduced variances) or $\beta-$ convergence (reversion to the mean) is strong. In fact, using cities as the unit of observation, wage convergence is much faster than for states. However, for quantity variables such as population, total manufacturing employment or per capita manufacturing employment, convergence is essentially non-existent. While the δ coefficients are significant for population and total manufacturing employment, they imply very small $\beta's$. Scatter plots in Figure 1 and regression results suggest that regional shifts and outliers dominate the process. Moreover, per capita manufacturing employment has a δ insignificantly different from zero. This persistence in quantity measures where growth rates are independent of differences in initial levels is not inconsistent with some regional results (Blanchard and Katz 1992 and Barro and Sala-I-Martin 1991).

For individual industries the empirical formulation is plagued by problems of sample

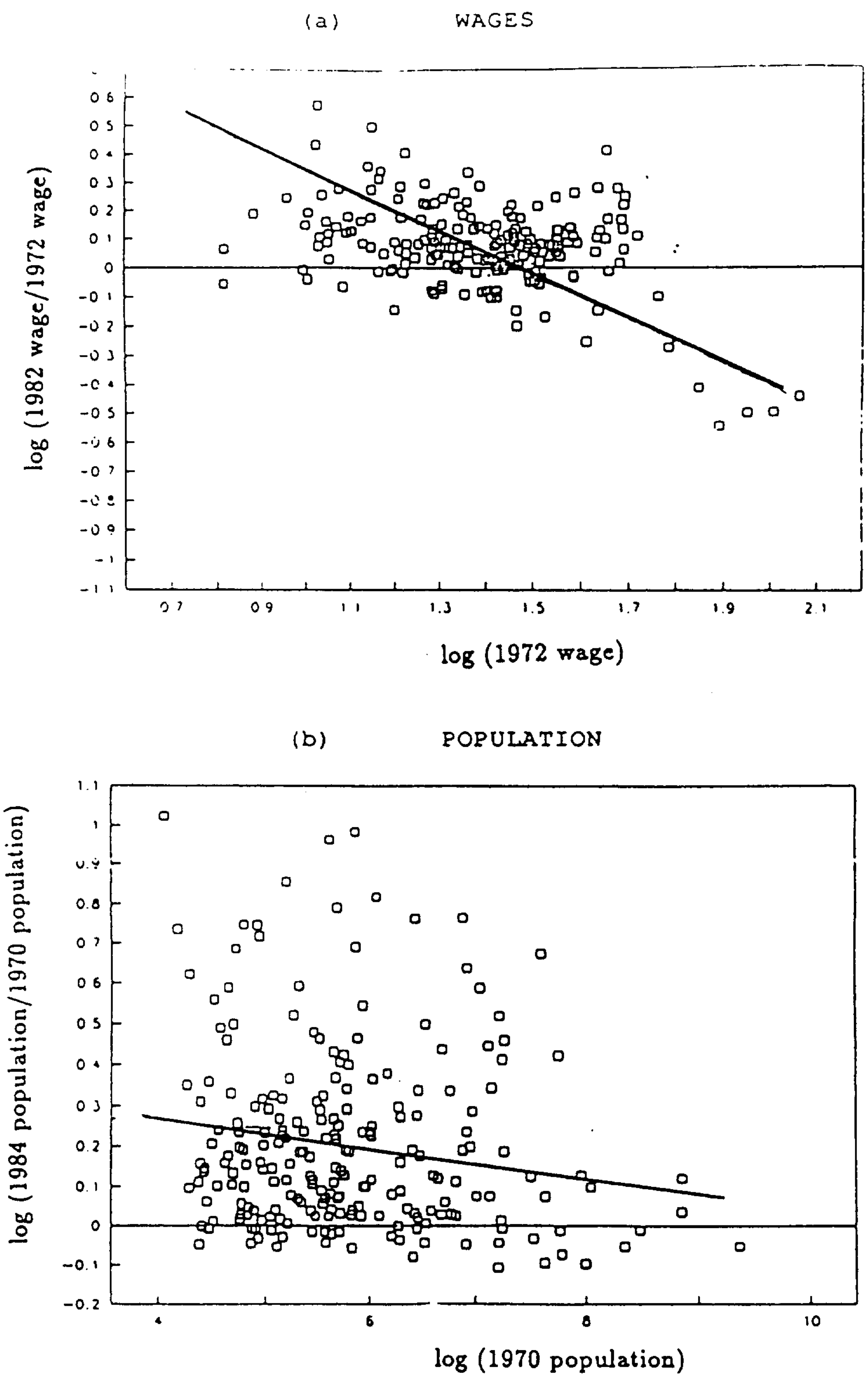

Figure 1. Scatter Plots

(c) RATIO: MANUFACTURING TO TOTAL LOCAL EMPLOYMENT

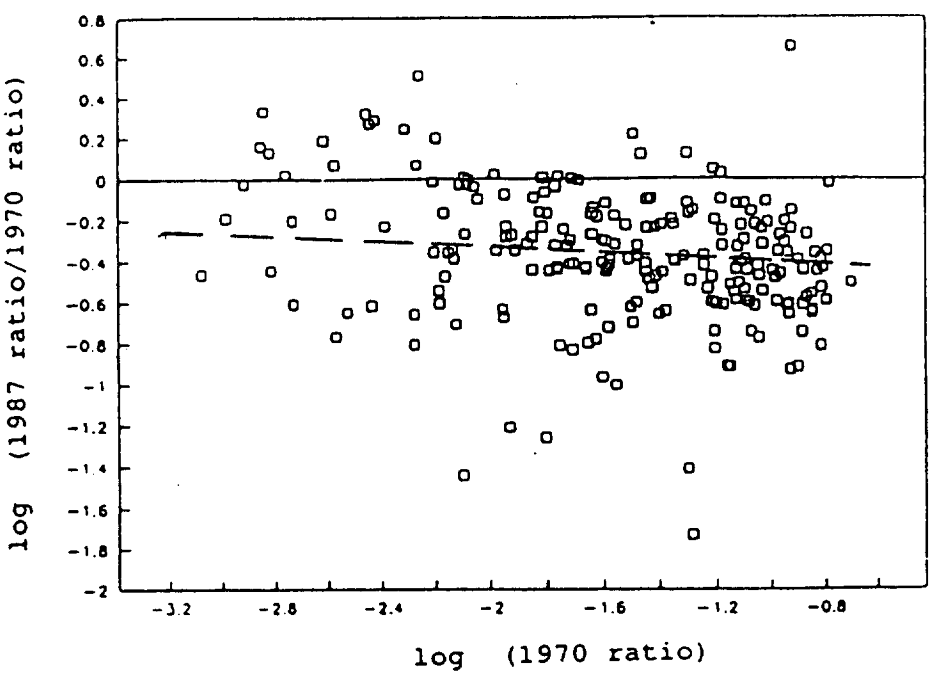

Figure 1 (continued)

Table 1: (Non-) Convergence Across Metro Areas

(standard errors in parentheses)

y	δ	Implied β (*100%) (annual rate of convergence)**	R^2	N	σ_{1970}	σ_{1987}
wage rate	.743* (.038)	13.59%	.67	207	.31	.20
population	.037* (.014)	0.27%	.32	224	1.01	1.00
total manu. employ.	.058* (.020)	0.35%	.38	224	1.28	1.21
per capita manu. employ.	.061 (.054)	0.37%	.16	224	.54	.56
machinery*** employ.	.035*	0.21%	n.a.	205	n.a.	n.a.
electrical *** machinery employ.	.145*	0.92%	n.a.	205	n.a.	n.a.
primary*** metals employ.	.040*	0.24%	n.a.	205	n.a.	n.a.

*t-statistic is equal to or greater than 1.96.

**T is 10 years for wages, 14 for population and 17 for all other variables.

***For individual industries in 1987 only, cities where employment is less than 250 are censored. This makes estimates of σ_{1987} to compare with σ_{1970} impossible. Second, we estimate an equation of the form $log y_{87,j} = X_j\gamma + (1-\delta) log y_{70,j} + E_j$ by Tobit. To capture scale (i.e., our concern is with urban composition, or per capita employments) in X_j we control for urban population, as well as (just) regional dummies. For the three industries the coefficients and standard errors of $(1-\delta)$ were .965 (.064), .855 (.054), and .960 (.089).

choice given censoring of 1987 data (see later). Results are very sensitive to choice of sample. Our preferred results based on Tobit regressions in Table 1 on the full sample for machinery and electrical machinery, and primary metals imply significant coefficients of 0.035 to 0.145.

These results suggest that there is some glue which holds industries in the same place, not just at a point in time, but over time as well. Any empirical formulation needs to explicitly examine why there is this persistence. In this paper we suggest that both dynamic externalities and persistence in comparative advantage in regions are at work. Based on two-stage least squares work to factor out time invariant unmeasured city specific effects, we estimate that the role of time invariant amenities in explaining persistence is small. Second, we hypothesize that linkage forces are not the explanation. Current firms don't benefit in linkage terms from what firms were there historically – you can't buy from or sell to the past. The role of comparative advantage in explaining persistence will be explored by examining the impact of regional natural resources and amenities differentials on industrial location. The role of dynamic externalities will be inferred by focusing on the impact of historical concentrations of an industry in a location on current employment. To understand the inference we will make, we need to comment on the nature of dynamic externalities.

Dynamic externalities typically involve information spillovers concerning the spread of technology to producers and the productivity of the research sector itself (Romer 1986, 1990). Work on patent citations by Jaffe *et al.* (1992) suggests information spillovers are both very localized, diffuse slowly, and overwhelmingly occur within the same industry. In a world in which there is location specific knowledge, or in which knowledge diffuses slowly over space, access to that knowledge could bind firms to the same location over time. Moreover, there is a notion of maturity of "lines of communication" facilitating the spillover of information among firms. A social network facilitating communications does not develop overnight among stranger firms. Rather it reflects interpersonal contacts and mechanisms for such contacts developed over the years that is not readily movable. Such a network developed in a dynamic context enhances information flows about both current market conditions, linkage conditions, and technology enhancement.

Before proceeding, with statements of the estimating equations and data description, we note one other commonly cited externality influencing location, which we will test for. This concerns diversity of the local economic environment, currently or historically. Diversity may be important in enhancing knowledge spillovers of the Jane Jacobs type, where diversity in a city is postulated to create an environment ripe for change and learning. More central to current thinking, diversity in the local production environment has Dixit-Stiglitz impacts on the productivity of exporting firms. If after controlling for levels of economic activity, diversity matters per se, then that is an externality, above and beyond, say, any linkage effects.

Diversity may also matter in an entirely different way for newly evolving industries. Certain urban industrial environments may be more fertile to evolving industries, which are necessarily dependent upon excellent information flows. Thus the personal computer industry may have been more likely to sprout in an environment with a high degree of diversity in the electronics industry, with high employment concentrations in the education, R & D, and health industries, or with a more educated population. Whether these sprouts survive to maturity will depend on the richness of the initial or historical environment, as well as on current local economic conditions.

In this paper we estimate a model of industrial location for three major two-digit industries — machinery, electrical machinery and steel. In the last section we also look at the locational determinants of two "new" or rapidly evolving high-tech industries — computers and electronic components. We test for the role of city specific unmeasured effects, the role of diversity of the local environment, the sources of persistence and the role of regional comparative advantage. In the next section we specify a location model, deriving the reduced form equations estimated in this paper. Then we describe the data and present results for our three two-digit industries. Following that we present results on the two high-tech industries and then conclude.

AN ECONOMETRIC MODEL OF LOCATION

In this section we specify the models to be estimated and discuss the key econometric issues involved. The econometric specification is a reduced-form version (Henderson 1992) of a detailed structural form model of industrial location derived and estimated in Henderson (1991), and is related closely to work by Carlton (1983), Lee (1989) and others. Firms in a city j in a particular industry have a profit function $\Pi_j = \Pi(Y_j, s_j, u_j)$ where Y_j is a vector of arguments such as input prices, the scale of operations of any related industries, and historical conditions, such as employment in the same and related industries 17 years ago. Local scale of this industry, s_j, represents the positive effects of own industry economies of scale and the negative effects of trying to sell more and more of the product in a limited regional market area, which may negatively impact the (unobserved) output price. Finally, u_j is an error term. That error component may be decomposed into a time invariant component and a current stochastic component.

The local supply of entrepreneurs to the industry is a function of a vector of arguments, Z_j, which could include local population, costs of living, the scale of related industries which might supply competent entrepreneurs, and historical conditions such as industry scale in the past. Thus, we have the supply function $\Pi = \tilde{\Pi}(Z_j, s_j, d_j)$ where, as local scale, s_j, rises, per firm profits must rise to attract more entrepreneurs.

The scale of local operations is determined by the intersection of the $\Pi(\cdot)$ and $\tilde{\Pi}(\cdot)$ functions. Equating and solving for s_j we get a reduced-form equation of the form

$$s_j = s(Y_j, Z_j, e_j). \tag{2}$$

Equation (2) forms the basic estimating equation. e_j combines influences of u_j and d_j. The procedure for two-digit industries will be to estimate equation (2) for 1987 employment as a function of 1987 variables plus relevant 1970 variables.

Equation (2) describes local scale for cities with the industry. Some industries are not ubiquitous and then there is a discrete choice problem of whether a city has an industry or not. This choice depends on whether at some minimal scale, $\bar{s}_j$, the profits the industry can provide $\Pi(Y_j, \bar{s}_j)$ are sufficient (i.e., exceed $\tilde{\Pi}(Z_j, \bar{s}_j)$). There are several ways to model minimum scale, $\bar{s}_j$ (Henderson, 1991); but regardless a discrete choice criterion emerges where the probability that a city has the industry is the

$$\text{Prob } (\Pi(Y_j, \bar{s}_j, u_j) > \tilde{\Pi}(Z_j, \bar{s}_j, d_j)) = \text{Prob } (m(A_j, Z_j) > \tilde{e}_j). \tag{3}$$

Again $m(\cdot)$ is a reduced-form function with a different shape than $s(\cdot)$ in (3). $\tilde{e}_j$ may or may not correspond to e_j in equation (2), depending on the precise formulation (Henderson, 1991).

The derivation of equation (3) here abstracts from some of the dynamic elements of whether an industry is located in a city or not. Equation (3) can easily be interpreted to allow historical conditions to influence current location decisions. However, there may be an asymmetry in entry versus exit. One can think of a process where an industry enters a city if (3) has ever been satisfied in the recent past. Once established, exit for an industry may be a much less certain process. The determinants of the probability of exit conditional on initial location in a city may differ from the determinants of the probability of not having the industry conditional on no initial location. We will investigate this issue for high tech industries.

These proposed estimations raise a variety of econometric issues. First is simultaneity. Recall, for example, that the error terms, u_j, d_j and e_j may contain time invariant components. In that case for an industry, measures of historical employment in the own industry will be a right-hand side endogenous variables. For major two-digit industries such as machinery in which cities may have large employment concentrations it may also be questionable to treat local wage rates or measures of overall city scale as exogenous. We have a long list of instrumental variables (weather, natural resource endowments, historical characteristics) to try to correct for simultaneity.

For non-ubiquitous industries, equations (2) and (3) must be estimated jointly accounting for the correlation between e_j and $\tilde{e}_j$. We do MLE in this case. There is also a selectivity issue in terms of cities which we examine. While no 1970 metro areas have been removed from the sample (although some have been combined), new metro areas have arisen (81 by our definition). These new metro areas are much less likely to have durable manufacturing industries and more likely to have relatively low manufacturing employment levels. For any industry, estimating for a sample of 224 1970 metro areas, raises a selectivity issue from excluding 81 1987 MSA's.

DATA

The data are for 1970 and 1987. We examine employment in the machinery, electrical machinery, primary metals, computer and electronic components industries. We focus on the 224 Standard Metro Statistical Areas (SMSA's) in 1970 that can be related to 1987 Metropolitan Statistical Areas (MSA's) or Primary Metropolitan Statistical Areas (PMSA's). To match up metro areas requires combining some 1987 PMSA's to match with 1970 SMSA's and vice versa. These combinations reduce the initial 243 1970 SMSA's to 224 metropolitan areas. We also retain 1987 information on 81 new metro areas in 1987 that did not exist in 1970, to deal with certain issues of selectivity bias.

For 1970, while we have the 1972 Census of Manufacturers tape of 2-, 3-, and 4-digit industries in SMSA's, those data are censored so that (1) any industry in a metro area with less than a small fixed number of employees in the industry is not reported and (2) any industry in a city whose economic data are censored for disclosure reasons is also not reported (unlike 1987). To deal with this problem, instead of Manufacturing Census data, we use employment data from the Sixth Count of the 1970 Population Census which divides SMSA employment into 229 different industries (roughly a 3-digit scheme). For electronic components, to get data on finer industrial classifications and more modern industrial definitions we also use employee and firm data from the 1970 County Business Patterns, where counties are aggregated to the 1970 SMSA definitions. All these 1970-72 industrial data are combined with corresponding data on urban area characteristics from the 1972 City and County Data Book and the 1972 Census of Manufacturers (for wages). There are also data on access to 29 Rand-McNally national business centers and state and regional endowments of iron ore and oil.

For 1987 data we start with the 1987 Census of Manufacturers. Industries in a city whose economic data are censored for disclosure reasons give employment figures in intervals. Because the upper open-ended interval starts at just 2500, these employment data are supplemented with 1987 data from County Business Patterns. CBP employment data are less likely to be censored and have a much more extensive set of intervals for censored data, with the upper open-ended interval only starting at 100,000 employees (which, in fact, never applies in our sample). These 1987 data are supplemented with mid-1980's data on urban area characteristics from the 1986 State and Metropolitan Area Data Book, as well as data on utility costs by state and on access to the 30 current Rand-McNally national business centers.

It should be obvious that the data on hand represent an unusual opportunity to analyze industrial location patterns and their impact on the environment. The 1970-72 data give the most comprehensive set of urban area characteristics that exists, allowing us to infer the extent to which "history" affects the present. Variable definitions and means and standard deviations are given in the Appendix.

EMPIRICAL RESULTS FOR TWO-DIGIT INDUSTRIES

For the three major two-digit industries, we estimate equation (2) by a Tobit formulation. While many cities have reported zero employments, such a recording either is a true zero or is 1-249 workers. By using a Tobit we are presuming that either all cities have some minimal employment in the industry but the numbers are censored below 250; or, if some cities have zero employment, the $m(\cdot)$ function in the discrete choice equation (3) has the same shape as the $s(\cdot)$ function in equation (2) and the error terms coincide. Row 1 of Table 2 helps substantiate the first alternative, indicating all cities except one have employment in all these industries.

Table 2 warrants some other comments. Except for electrical machinery, all 1970 numbers in Table 2 are from the Population Census and all 1987 numbers are from the Census of Manufacturers. For electrical machinery we also have some 1970 numbers from County Business Patterns. Table 2 reveals that different censuses record different levels of specific types of economic activity. The Population Census tends to be broader based because it incorporates home production, while the C.B.P. and Census of Manufacturers deal with the formal sector. (How would the activities of Steven Jobs and Stephen Wozniak have been classified in 1976?). Of course, differences in the industrial classification schemes and errors in self-reporting also create differences in the numbers. Table 2 reflects the facts that nationally, electrical machinery and machinery have declined modestly and primary metals have melted away. While some sub-sectors (nonferrous) of primary metals have done relatively better than others, no major sub-sectors have flourished. In contrast both machinery and electrical machinery have had sub-sectors experiencing substantial growth (e.g., computers and electronic components).

In Table 3 we present a basic set of results for equation (2). Equation (2) is specified in double log form except for RHS variables which measure proportions, indices, or shifts in the constant term. In Table 3, we are estimating the determinants of 1987 industry scale, as measured by the log of 1987 employment in the industry. The sample size is 207, rather than 224, because of missing observations on wage rates. While we represent some city economic conditions such as wages and labor force quality as current measures (1987) in fact, they are for 1982 and 1980 respectively. While we start by discussing the ordinary Tobit results. The explanatory power of the model is very high, in terms of R^2's (for OLS

Table 2
Industry Employment Patterns Across 224 Metro Areas

	Machinery	Electrical Machinery	Primary Metals
1970 number of cities w/zero employment	0	0 (Pop. Census) 33 (C.B.P.)	1
1970 number of cities w/over 249 employees	196	176 (Pop. Census) 158 (C.B.P.)	152
1987 number of cities w/over 249 employees	206	175	146
1970 mean employment over all cities	6,667	6,504	4,211
1970 mean employ. in cities w/over 249 employees	7,598	8,251	6,133
1987 mean employment in cities w/over 249 employees	6,948	6,801	3,706

estimates). The results on coefficients in Table 3 are divided into blocks. Generally, we will focus on the last two blocks, representing measures of the urban industrial environment that stimulate or repress employment in particular industries. However, for this first table we will comment on the entire set of results. In interpreting coefficients, it is important to remember that the estimating equation controls for 1970 employment.

Locational and Labor Force Variables

In the first block are the constant term and locational variables. Relative to the West (the constant term), controlling for 1970 employment, machinery and electrical machinery have declined in the Northeast and Midwest. These reflect an absolute shift of manufacturing South and West, induced by regional populations shifting South and West, and perhaps by economic climate variables not represented in Table 3, such as state regulations governing strikes and unemployment insurance and workman's compensation. These shifts, however, are all relative to 1970. The Northeast and Midwest remain the U.S. centers for traditional manufacturing. Removing 1970 employment from the equation reverses the signs of the regional dummies for machinery and electrical machinery. While relative to 1970, machinery and electrical machinery have "shifted" through deaths in old locations, relocations, and most critically firm births in new locations, primary metals have not. The asymmetry may be explained by the fact that in a rapidly declining industry, births and relocations occur at a lower rate so that regional shifts are small. The last variable in the first block measures distance from a MSA to the nearest of the 30 Rand-McNally national business centers. Other things being equal, distance to markets matters, repressing the demand of an industry to locate in less accessible MSA's.

The second block of variables represent current local labor market conditions. For machinery and electrical machinery, higher wages reduce demand substantially, with a 1% rise in wages reducing labor employment by 1% or more. Correspondingly, controlling for wages and 1970 employment, improvements in labor force quality as measured by increases

Table 3: Determinants of log (1987 Industry Employment)
(standard errors in parentheses)

	Machinery		Electrical Machinery		Primary Metals	
	Tobit	2-Stage Coefficients**	Tobit	2-Stage Coefficients**	Tobit	2-Stage Coefficients**
constant	-1.944* (.806)	-1.474	.590* (1.151)	3.191	-4.968* (1.803)	-4.882
region northeast	-.442* (.153)	-.336	-0.603* (.209)	-.490	.026 (.322)	.122
region midwest	-.363* (.137)	-.354	-.446* (.177)	-.333	.096 (.291)	.457
region south	-.020 (.144)	-.016	-.020 (.205)	.006	.294 (.309)	.516
distance to nat'l. bus. ctr.	-.040* (.014)	-.065	-.044* (.021)	-.058	-.023 (.039)	-.103
% adults w/ high school or some college	1.680 (1.001)	2.096	.352 (1.417)	1.197	1.313 (2.248)	4.044
% adults /w college degree	2.854* (1.224)	2.752	5.517* (1.775)	4.985	-6.102* (2.911)	-3.600
log (1982 manu. wage)	-.961* (.031)	-1.100	-1.729* (.346)	-2.704	.158 (.518)	-.236
log (1987 all other manu. employ.)	.348* (.076)	.407	.319* (.083)	.554	.532* (.150)	.528

Table 3 – (Continued)
Determinants of log (1987 Industry Employment)
(standard errors in parentheses)

	Machinery		Electrical Machinery		Primary Metals	
	Tobit	2-Stage Coefficients	Tobit	2-Stage Coefficients	Tobit	2-Stage Coefficients
index: lack of manu. diversity	-.112 (.190)		.361 (.539)		.360 (.378)	
ratio: durable manu. to all manu.	.512* (.221)	.495	.109 (.291)	1.255	-.459 (.515)	-4.494
log (1970 own ind. employ.)	.533* (.069)	.404	.555* (.065)	.308	.468* (.119)	.598
specializ. past: ratio 1970 own ind. employ to total local employ.	8.265* (2.252)	13.026	7.066* (2.265)	10.088	15.888* (2.179)	22.043
N	207		207		207	
R^2 (OLS)	.873		.825		.657	

* t-statistic is greater than or equal to 1.960.

** These estimates include a (completely inconsequential) measure of 1984 local population (see text) and are based on a sample size of 205.

in educational attainment of the adult population increase the demand by an industry to locate in a city. Again, the declining primary metals industry provides a contrast. While it is true that declining industries could respond to better or worse labor market conditions in terms of which cities lose relative to others, other firm specific factors determining the rate of individual firm phase-out may dominate.

The Current Industrial Environment

The third block of variables in Table 3 measures general aspects of the current industrial environment in cities, over and above labor market conditions. Specific aspects of the environment concerning specific other industries will be discussed later. The general level and composition of all other manufacturing activity in a city may affect employment in any specific industry. Major portions of the output of the three industries in Table 3 are inputs for other manufacturing industries. As a result, we might expect that an increase in the scale of other local manufacturing activity stimulates employment in all our industries, which it does. The use of this variable, log (1987 all other manufacturing employment) is discussed extensively in the next section. For machinery, it appears that if the composition of manufacturing activity is more towards durable goods, that further stimulates machinery. For electrical machinery and primary metals this durable composition effect does not appear. An externality interpretation for these effects is also possible. Scale of other manufacturing could enhance productivity through enhanced information flows and stimulation of a more diversified economic environment for any particular industry. Enhanced local productivity will stimulate local employment (demand for the industry to locate in that city). Estimation of the determinants of value-added would be required to properly sort this out, although we return to the issue later in this paper.

In this third block of coefficients in Table 3, we have a measure of the lack of diversity in the local manufacturing environment. The measure is based on the Hirschman-Herfindahl index and is the sum of squared shares of all other two-digit manufacturing industries in all other manufacturing. An increase in the index reflects less diversity in the environment. If employment in the 19 other two-digit industries is evenly distributed, the index has a value of 0.053; while if it is concentrated all in one other two-digit industry, it has a value of 1. For the three industries in Table 3, this index does not have a consistent significant impact on employment. Diversity of the local manufacturing environment (as opposed to scale) doesn't matter for these industries.

Later we will discuss other measures of the scale and diversity of the local environment. These include measures of the scale and diversity of the wholesaling, business services, professional services and manufacturing environment, historically. They also include measures of the scale and local concentration of specific other manufacturing industries that interact with each of the industries studied in this paper.

We also note other measures of current economic conditions such as urban population, state fuel and electrical prices, median residential rents, coastal location, and contiguity of other PMSA's were insignificant and inconsistent in their impact and had no consistent nor strong impacts on other variables.

History

The last block of variables is the most critical and interesting. It deals with the role of history. For the moment history is described by two measures relating to just own industry employment in 1970. Variables relating to other conditions historically will be discussed later. Besides log (1970 own industry employment), to control for the level of historical activity, as in Glaeser *et al.* (1991), we include a measure of the concentration of historical activity, or the extent to which the city was specialized in own industry activity. "Specialization" is 1970 own industry employment divided by 1970 total local employment.

There are three reasons for including this variable. First, empirically it is important. Second, although the two measures are correlated (for machinery the simple correlation coefficient is 0.60), the inclusion of specialization past has essentially no impact on the coefficient of log (1970 own industry employment), generally moving that coefficient by less than 10%. That is, past specialization is an add-on effect over and above any impact of past levels.

The third reason is conceptual. Absent unmeasured time invariant location specific attributes, the glue holding industries in the same place may be the development of an economic climate facilitating information flows, broadly construed. We hypothesize that *level* measures of past employment may capture both the role of historically based economic climate and persistence of unmeasured location specific attributes, if such exist. In the next section we will try to separate these two effects. However, specialization may measure something different. Specialization itself would appear to facilitate information flows among relevant firms and the development of location specific knowledge, relative to an environment with diffuse economic activity. The influence of a productive concentrated environment may persist over time, because it represents the development of a communications network. To move and recreate the environment elsewhere requires (a) en masse movement of the industry and (b) reestablishment of lines of communication. Communication efficiency will depend on the length of time of contacts, as well as the concentration. Locations with established concentrations in an industry have a long-term advantage over their competitors.

The coefficients on log (1970 own industry employment) in Table 3 are about 0.5. Based on the simple Tobits, in Table 1, for the three industries, the coefficients on log (1970 own industry employment) lie between 0.965 and 0.855, suggesting very modest reversion to the mean. However, once we control for other economic conditions in Table 3, a coefficient of 0.5 implies significant reversion to the mean (convergence at the rate of 4% a year). This implies that measured local economic conditions accounted for in Table 3 explain a lot of the persistence in employment patterns. In the next section we explore exactly which measured conditions account for persistence.

The degree of past specialization also significantly impacts current employment. The coefficients are positive, large, and significant indicating strong positive impacts of historical concentration of own industry creating a positive economic environment. For example, for machinery, a one standard deviation (.036) increase in the share of machinery in overall local employment in 1970 from a mean of .026, holding 1970 machinery employment fixed, increases 1987 machinery employment by 27%. Other things being equal for both 1970 and 1987, if we compare a city with 20,000 machinery workers in 1970 who comprise 2% of the work force, with a city with 10,000 machinery workers who comprise 8% of the work force in 1970, in 1987, the second city would have a larger work force in machinery.

Issues Concerning Basic Results, Specification, and Persistence

Before proceeding to examining other historical aspects of the local economic environment, we need to comment on four primarily econometric issues, the first two of which were mentioned in the previous section. These two are critical to explaining persistence of individual industry employments.

Endogeneity

The first issue, generally stated, is that many of the RHS variables listed in Table 3 are potentially endogenous. Specification tests for endogeneity provided some evidence that is a problem.[1] In particular, we focus on wages and all variables in blocks three and four of Table 3. Conceptually since, say, machinery is such an important manufacturing sector, error drawings affecting the local machinery sector may impact the local manufacturing wage rate. As another example referred to above, if the error term contains a site specific, time invariant component that will be reflected in the RHS log (1970 own industry employment).

In Table 3 we present two-stage estimates of the coefficients treating wages and all

[1] To test for endogeneity with a censored LHS variable, we add on residuals for RHS variables which are estimated from first stage regressions of these potentially endogenous variables on a list of exogenous variables (Smith and Blundell, 1986). For machinery, we could accept the hypothesis of all exogenous right-hand side variables. For electrical machinery and primary metals, wages tested as endogenous, and some others contained fairly large, but insignificant movements in coefficients.

variables in blocks three and four as endogenous.[2] Standard errors are not reported, because if RHS variables are endogenous, standard Tobit calculations of the errors are incorrect.[3] The two-stage estimates differ from the regular ones consistently in three ways. The wage elasticity for employment becomes more negative, the coefficient on all other (current) manufacturing rises, and the coefficient on past own industry specialization increases.

For the variable of interest in explaining persistence, log (1970 own industry employment), for machinery and electrical machinery there is a 20-40% drop in the coefficient, indicating that lagged employment may be partially picking up the impacts of time invariant error components. But that drop in coefficient for particular cities would be offset by the rise in the past specialization coefficient. Nevertheless, we see the persistence in employment levels per se dropping further, with a decomposition connected with unmeasured time invariant site specific attributes.

Persistence

The second issue concerns which of the current measured economic conditions are responsible for the drop in the coefficient of log (1970 own industry employment) from, 0.97 to 0.85 in estimations of equation (1) to 0.5 in Table 3. Experimentation revealed that log (1987 all other manufacturing employment), rather than, say, past specialization, is solely responsible for the drop in the log (1970 own industry employment). It is also

[2]These variables include region dummies, 1987 access to national business center, state industrial fuel price, % urban 1970, % 18 years or older 1970, % 65 years or older 1970, % adults with 4 years high school or some college 1970, % adults with college or more 1970, % female headed families 1970, % housed in single family homes 1970, % housed in pre-1950 housing in 1970, mean January temperature, annual rainfall, 1970 distance and driving time to national business centers, railway dummy, 1970 cost of electric power by state, state population 1970, % manufacturing workers with no high school 1970, % manufacturing workers with college 1970, multiple name SMSA 1970, state land area, regional iron resources 1970, regional oil reserves 1970, % high school or more 1980, % college or more 1980, and ratio black to total population 1980.

[3]With so many endogenous variables, MLE attempts to estimate the model and correct standard errors were fruitless. Ordinary 2SLS results where censored observations were given midpoint employment values of 125 yielded almost identical results as in Table 3. Coefficients which were significant in the ordinary table estimations in Table 3 were significant under these 2SLS estimations.

responsible for a rise in the coefficient of past specialization for machinery and electrical machinery.[4] We need to consider several things about this variable.

First, concerns whether log (1987 all other manufacturing employment) is a "legitimate" variable. From our perspective it represents a critical aspect of the local economic environment – the derived demand for the products represented in Table 3. Machinery is primarily an input into other manufacturing and the same to a large extent is true for primary metals and even electrical machinery. These producers also rely on inputs from other durable goods manufacturing sectors. These producers are to some extent found in cities where there is an industrial demand and supply for their product. While total manufacturing employment has a large variability over time, it also has a high degree of persistence both from Table 1, and from noting that the simple correlation coefficients for 1970 and 1987 all other manufacturing employment for our different industries are all over 0.9. Thus persistence in machinery employment may be partly explained by derived demand conditions and their persistence.

A second concern is that the use of log (1987 all other manufacturing), in the equation may imply an overrepresentation of certain magnitudes. In particular, we have log (1970 own industry employment), 1970 own industry employment/1970 total local employment, and log (1987 all other manufacturing employment). While these variables in themselves are not inordinately correlated,[5] 1987 and 1970 all other manufacturing employment are very highly correlated. Thus we would be in trouble if total local employment and total (or all other) manufacturing employment move together or form a constant ratio. In fact, manufacturing to total employment in cities is highly variable, as should be apparent in

[4]With the addition of log (1987 all other manufacturing) the the coefficients on past specialization rise from 1.90 to 8.27 and 2.18 to 7.07 for machinery and electrical machinery respectively. The impact for primary metals is negligible. Note that 1970 total local employment forms the denominator of past specialization and that 1970 total local employment and log (1987 all other manufacturing) are positively correlated (ρ is about 0.6).

[5]The ρ's for log (1987 all other manufacturing) and past specialization, for log (1987 all other manufacturing) and log (1970 own industry) and for log (1970 own industry) and past specialization are respectively 0.14, 0.80 and 0.60.

Figure 1. For example, the ratio in 1970 for our sample of 224 cities of manufacturing to total local employment has a one standard deviation interval of 0.13 to 0.35 about the mean.

Omitting log (1987 all other manufacturing), a key derived demand variable constituting a critical part of the local economic environment for certain manufacturing industries, would lead to an overstatement of inherent persistence of own industry employment. If log (1987 all other manufacturing) explains a significant part of the persistence of machinery or electrical machinery employment, what then explains the persistence of overall manufacturing as represented in Table 1? We can't resolve that question here; it is beyond the scope of the paper. However, we did some preliminary work which suggests that regional comparative advantage is at work.

First, we explored the determinants of the log (1987 ratio of total local manufacturing to overall local employment). With determinants of regional dummies, coast line dummy, state iron ore resources, SMSA rail dummy, SMSA heating degree days, log (1970 state electricity price), and state agricultural workers, we get an equation with plausible signs to coefficients and an R^2 of 0.31. Adding in the log (1970 ratio) in two-stage least squares work raises the R^2 to 0.63, weakens some of the other original set of explanatory variables and yields a coefficient of 0.57 on the log (1970 ratio). Since in OLS work the coefficient is 0.78 and in Figure 1 is essentially 1.0, given the drop to 0.57, part of the persistence in total manufacturing can be explained by measured regional attributes (iron ore resources, electrical prices), as well as unmeasured ones. However, some of the persistence must also lie with externality forces applied to total manufacturing.

Second, we experimented with ordinary 2SLS work for machinery. With a base set of variables (constant, regional dummies, wage rate, labor force quality) the coefficient on log (1970 own industry employment) is 0.87. Just as in Table 3 after we add in the full set of explanatory variables (including log (1987 all other manufacturing), the coefficient falls to 0.41. However, if we replace log (1987 all other manufacturing) by its exogenous regional determinants (see previous paragraph) the coefficient of log (1970 own industry employment) does fall also, from 0.87 to 0.58. Thus persistence may be part explained by persistence in comparative regional advantage.

Other Issues

A third issue concerns why our results on past specialization differ from those in Glaeser *et al.* (1991). We consistently get a positive impact (whether we use current or 1970 economic conditions (wages, education, etc.) and whether or not an all other manufacturing variable is included); they get a negative one. In our work if log (1970-own-industry-employment) is entered in linear form (i.e., as 1970-own-industry-employment) as in Glaeser *et al.* (1991), then the sign of past specialization reverses. Based upon private communication with Ed Glaeser, it appears this reversal does not occur in their work. However, the samples (and time periods) are very different. First, they do not use the census definitions of the geographic area of metropolitan areas. Second, in drawing their sample, Glaeser *et al.* (1991) only include machinery, for example, if it is one of the six major two-digit industries in a city in 1956 including retailing, wholesaling and services. So the representation of manufacturing sectors in their sample is fairly limited (about 1/4 to 1/3 of the observations).

The final issue is quite different. It concerns selectivity in choosing the sample of cities. Since 1970, 81 new MSA's or PMSA's have arisen which are excluded from our sample for lack of information about 1970. To test for selectivity bias, we conducted one Heckman type test. A Probit analysis of whether a city was an SMSA in 1970, based on locational variables, and educational, racial, and industrial composition variables, gave a prediction accuracy of 91%. The inverse Mill's ratio variable calculated from the Probit when inserted in an OLS regression of machinery employment levels on variables in Table 3 produced a very small and insignificant coefficient. Although this is strictly a test of selectivity bias when selection is based on observability of the LHS variable (when, in fact, the problem concerns observability of a RHS 1970 variable), it indicates any general problems with basing results on a selected subsample.

Other Historical Measures and the Economic Climate

So far our measures of history relate just to own industry employment and concentration of such. We have given these an externality interpretation – history matters in a high turnover situation because it represents the development of location specific knowledge and the development of a local communications network, both external to firms. For any sector, do other sectors than the own sector contribute to this critical economic environment. Likely candidates include closely interconnected industries. From input-output tables we evaluated what sectors particular industries interact with most intensively, either as purchasers or suppliers. We also know what industries tend to cluster together spatially, from an analysis of correlation of locational patterns (Henderson, 1988).

We conducted extensive investigations for machinery, electrical machinery, computers and electronic components. Our strategy was to see first what 1970 activities influenced either 1970 employment or 1987 employment, before accounting for the general type of 1987 characteristics of cities given by the variables in Table 3. In Table 4 we list the types of activities investigated. For these activities we constructed measures of level of employment, diversity within the activity (Hirschman-Herfindahl index) and concentration of the activity within the city (ratio of employment in the activity to total city employment).

There are a number of examples of 1970 other industry activities influencing 1970 own industry employment levels, a smaller set of examples where 1970 activities persist in their influence in 1987 before we account for 1987 current conditions, and (almost) no examples where 1970 activities persist in their influence after we account for 1987 conditions. Let's look at machinery, in particular. The level and diversity of business or professional services, as listed in Table 5 have no impact in 1970 or 1987. The level of 1970 wholesale activity affects 1970 employment even after two-stage analysis to deal with simultaneity issues but

Table 4
Diversity and Levels of Other Economic Activities
(a) Possible Activities

Wholesale Trade (1970)	Business Services (1970)
motor vehicles and equipment	advertising
electrical goods	commercial R and D
machinery equipment and supplies	business management and consulting
hardware, metal products, scrap	computer programming
trucking and warehousing	auto services and repair
	electrical and business repair
Professional Services (1970)	**Manufacturing**
health services	1970: 50 "3-digit" industries
college and universities	
libraries and other educational services	1987: 20 "2-digit" industries
engineering and architectural services	
accounting, auditing, bookkeeping services	relevant input and purchaser industries for 1987 and 1970
miscellaneous professional services	

(b) Relevant Activities Beyond Those Listed in Table 2

Machinery	Electrical Machinery	Primary Metals
1970 all other manufacturing	1987 plastics employ	1970 all other manufacturing
	1987 computer employ	1987 fabricated metals
	1987 instruments employ	

does not consistently affect 1987 employment, even before we account for 1987 conditions. Fabricated metals employment in 1970 affects 1970 machinery employment, but not after we account for simultaneity; and the influence does not persist in 1987. For electrical machinery, 1970 employment levels in specific industries such as plastics, computers and instruments, as well as wholesale activity, impact 1970 employment and 1987 employment levels, but only before accounting for 1987 characteristics. For all these industries general measures such as listed in Table 3 as calculated for 1970 may impact 1970 employment and may persist to 1987 before accounting for 1987 characteristics. All this gets us into tedious industry specific detail. However, there is one generic result.

Apart from own industry employment levels and concentration in 1970, with one possible exception, no measures of levels or diversity of other past general or specific economic activity persist in significant influence in 1987, after 1987 characteristics are accounted for. The one possible exception is past all-other-manufacturing activity, controlling for current all-other-manufacturing employment (but noting the two are very highly correlated). For machinery and electrical machinery, the impact of past all other manufacturing activity is negative although the coefficient is only significant for machinery. Taking current and past all-other-manufacturing activity together, this suggests that an industry benefits today from current all-other-manufacturing activity but that exact same activity may hurt the industry in the future.

In Table 4, we also report specific 1987 economic activities which impact our three two-digit industries, apart from the general measures reported in Table 3. For machinery no specific other current manufacturing activities appear to significantly, consistently impact employment once diversity, overall level, and durable vs. nondurable composition of other manufacturing activity was accounted for. Specific major input or output activities examined include primary metals, fabricated metals and transportation manufacturing. As a capital good, machinery is purchased extensively by all other manufacturing industries and appears to orient location to purchasers rather than input suppliers. Primary metals appears to respond just to one of its primary purchasers, fabricated metals. In contrast, electrical machinery seems to be strongly interconnected with different purchasers and suppliers such as plastics, instrument, or transportation equipment. Sorting out whether these are linkage or externality effects is really not possible here.

NEW HIGH-TECH INDUSTRIES

In this section we look in detail at two high-tech industries – computers and electronic components. We estimated Tobit specifications for these industries, getting results somewhat similar to their two-digit counterparts in Table 3. However, there were differences in the role of both historical influences and past concentrations. For that reason, and for two others, we choose to examine the whole problem from a different perspective. The two other reasons are:

(1) While two-digit major industries such as machinery and electrical machinery appear to have positive employment levels everywhere, computers and electronic components do not. For example for 1970, County Business Patterns data indicate that the electronic components industry has zero employment in 1970 in 92 of the 224 MSA's. For computers, from the Sixth Count of the 1970 Population Census 20 MSA's have people reporting no employment in computers ... an industrial census might well have found about 100 MSA's with no computer employment in 1970. Regardless, for detailed three-digit industries, a Tobit formulation will be inappropriate if the $m(\cdot)$ function in equation (3) differs from the $s(\cdot)$ function in equation (2), or the disturbance terms differ. A discrete-continuous choice analysis will then be appropriate.

(2) Computers and electronic components are arguably "new" industries. Major portions of their products for 1987 either didn't exist in 1970 or were not in commercial use. The then existing industries produced products of a very different form. Thus, we could take the view that we are analyzing a new phenomenon. As such, we are not just trying to sort out the determinants of employment levels today, but the determinants of

what cities actually have these high-tech industries. What historical factors determined the winners in the race to attract and retain significant employment in high-tech industries? Was a historical presence of the predecessor industries critical or were other factors critical? If a city did or didn't have significant employment in the prodecessor industries in 1970, do the determinants of the probability of having significant employment in the industry in 1987 differ (conditional upon the 1970 event)?

To answer these questions we first analyze the determinants of the joint event, does a city have the industry or not and, if so, what is the employment level. Error terms are joint normal. For electronic components the results are from MLE. For computers they are based on the Heckman two-stage procedure to correct for selectivity bias in the continuous relationship. For the discrete choice part we examine the determinants of where high-tech industries are found in 1987, based just on 1970 MSA characteristics. For the continuous choice part, the determinants of 1987 employment levels are based upon both 1987 and 1970 characteristics. For 1970 electronic component employment figures are based on County Business Patterns data since the Population Census lumped electronic components in with other three-digit industries.

Where High-Tech Industries Are Found

In Table 5, we present the discrete choice results on where an industry is found. We start by looking at columns (1) and (2) in Table 5. The employment equations (which are similar to Table 3 results) are presented in Appendix B. In Table 5, for the discrete choice, given censoring, we are analyzing in what cities employment is greater than or equal to 250. We define that as a "significant presence." First, we note that the model predicts remarkably well, achieving overall rates of over 85% accuracy (where, for example, a "correct" prediction is a predicted probability exceeding 0.5 for a city having the industry). The accuracy rates in predicting whether a city has an industry or not are almost the same for cities with the industry as for those without. For both industries, the patterns

Table 5

Probability of a City Having Significant Employment in New High-Tech Industries, Based on Past Environment

	(1) Computers	(2) Electronic Components	(3) Electronic Components
constant	-14.056*	-3.483	
	(3.874)	(2.699)	
region northeast	.070	-1.327*	
	(.513)	(.562)	
region midwest	-.760	-1.472*	
	(.425)	(.433)	
region south	.343	-.998	
	(.549)	(.504)	
distance to national business center	–	-.186	
		(.134)	
1970 % adults with at least high school	6.873	-2.638	
	(3.819)	(2.732)	
1970 % adults with college degree	7.045	15.504*	
	(6.082)	(4.863)	
log (1972 manu. wage)	-.521	-.867	
	(.480)	(.810)	
log (1970 all other manufacturing)	.727*	.484*	
	(.276)	(.246)	

Table 5 – (Continued)

Probability of a City Having Significant Employment in New High-Tech Industries, Based on Past Environment

	(1)	(2)	(3)
log (1970 own ind. employ.)	.124 (.176)	.223* (.052)	
specialization past: (own ind.total employ.)	281.852* (136.13)	–	–
% 1970 labor force in higher education or misc. professionals	92.882* (37.179)	–	–
% 1970 labor force in air trans. manu.	7.216* (3.513)	–	–
log (1970 computer employ.)		.092 (.116)	
index: 1970 lack of diversity		-2.278 (2.447)	-8.836 (4.540)
index, conditional on 1970 employ.	–	–	10.196* (5.115)
N	224	224	
% predicted correctly	87	86	

for coefficients in Table 5 are similar and are consistent with employment level results in Appendix B. Access, regional location, wages, and education generally all matter (or don't matter) in the expected fashion. The new results deal with the impact of the 1970 industrial environment.

There are two sets of results concerning 1970 environments. First for electronic components, past concentration of the predecessor industry is unimportant for both the discrete and continuous choice part of the equation. Second for computers, while past concentration is very important for having a significant presence in 1987, its impact on employment levels (Appendix B) is rather weak. Third, log (1970 own industry employment) has much smaller coefficients in Appendix B than Table 3 results for traditional industries. Its coefficient is insignificant for computers for the discrete choice although it is significant and important for electronics. A one standard deviation increase from the mean of log (1970 own industry employment) for an "average" city in the West raises the probability of having electronics from .86 to .97; for an average city in the Northeast, the probability goes from .41 to .71. In summary, between past specialization (for computers) and past employment levels (for electronic components), history of the predecessor industry is important in determining whether a city in 1987 has these high-tech industries or not. But persistence in terms of employment levels is very low for both industries. Given the dramatic change in product characteristics this is not surprising.

The second set of results concerning the location of these high-tech industries is that other aspects of the historical environment are critical in influencing location. Controlling for region, both industries seem oriented to locating in cities with prior high manufacturing employment. The computer industry favors cities with prior employment concentrations in related high-tech or R & D activities, such as aircraft (including missiles), and higher education and related miscellaneous professionals. A one standard deviation increase from 1.9% of the work force in higher education to 2.3% raises the probability for an average city in the West of having 1987 computers from .85 to .92; and, for the Northeast the

Table 6

Location of High-Tech Industries: Numbers of Cities

	1970 Employ* ≥ 250	1987 Employ ≥ 250	"Entry:" 1970 Employ < 250 1987 Employ ≥ 250	"Exit" 1970 Employ ≥ 250 1987 Employ < 250
computers	48	70	27	5
electronic components	90	109	34	15

*The 1970 Population Census indicates 20 of 224 MSA's had zero computer employment, while the 1970 County Business Patterns indicates 94 MSA's had zero employment.

rise is from .36 to .51. These are startling impacts. For electronic components, even prior computing employment does not seem to impact location. However, lack of diversity has a strong but insignificant negative impact. We explore that next, in the context of conditional probabilities.

Not all 1970 cities with significant high-tech employment have significant high-tech employment in 1987. As Table 6 reveals, while there has been entry, there has also been exit. While the numbers of exiters for computers are too small to be useful for estimation, for electronic components we can estimate the probabilities of significant 1987 employment, conditional on having significant employment in 1970.

The conditional probabilities are estimated by allowing the slope and constant term coefficients to vary with significant 1970 employment or not. The differential constant term as well as most differential slope coefficients were insignificant. One result concerning diversity of all other manufacturing emerges and is reported in column 3 of Table 5. Relative to cities not having the industry in 1970, diversity was much less important for cities having the industry. The coefficient goes from an almost significant (t-statistic = 1.95) - 8.84 for those without the industry, to a net of 1.36 for those with. In fact, we go from increased diversity (i.e., decreased index) positively impacting cities not having the industry to increased concentration (decreased diversity) positively impacting those already established with electronic components. This suggests increased diversity is important in attracting an industry but more concentration is important in retaining it.

In Appendix B, we present the complete results for the 1987 employment level equations. Results on past employment have already been noted. Three comments are noteworthy. The computer equation given limited sample size is weak. Second, the discrete (Table 6) and continuous choice results are similar in signs and magnitudes for both industries. Third, lack of diversity appears to hurt electronic component employment. Electronic components appears to be an industry where diversity matters.

CONCLUSIONS

For any industry the nature of a city's industrial-economic environment is critical in determining whether the industry locates there and what its scale of operation is. Current market conditions such as local wages, levels and concentrations of other industries and labor force quality are critical. But the past also matters. For established industries, prior concentrations of own industry employment appear to foster an environment which stimulates productivity and future employment levels. We infer that such environments promote the development of a network encouraging the vital exchange of information and knowledge among firms. Such networks are enhanced by long-term existence, solidifying lines of communication and perhaps reflecting a locational immobility to economic environments.

Surprisingly though, apart from concentrations of own industry employment, no other measures describing prior levels or diversity of various types of services and other manufacturing activity appear to significantly impact the present for established industries. Own past employment appears to be a sufficient number to summarize the impact of the past on current activity.

For newer industries, in particular the high-tech ones examined in this paper, the past has a profound impact on where the industry is found. Prior concentration or employment of the originating form of the industry, prior aspects of the labor force, and prior concentrations of other related industries all impact where newer industries locate. This suggests the prior environment of a city is critical to attracting an industry, again fostering a context for the efficient exchange of information. It also appears that greater industrial diversity may be important in attracting an industry to a new location, but not in retaining it. However, once a city has established an industry, current actual employment levels appear to depend most on current market conditions, as for established industries.

Appendix A

Data Sources and Definitions

"1987" Variables

Sources: Employment data are from the 1987 Census of Manufactures supplemented by 1987 County Business Patterns Data. Socioeconomic data are from the 1986 State and Metropolitan Area Data Book (Bureau of the Census). Access data are based on Rand McNally's 30 national business centers in 1990. National business centers are market centers defined by volume of transactions.

Manu. wage ($1000) - avg. income of production workers in 1982 (mean 17.4; s.d. 3.6)

% adults with at least high school - for 1980 population over 25 (mean 0.68; s.d. 0.08)

% adults with at least college - for 1980 population over 25 (mean 0.16; s.d. 0.05)

distance to national business center - straight line distance (mean 1.71; s.d. 3.29)

total manu. employ. (1000's) - for 1987 (mean 58.4 s.d. 100.8)

ratio durable to all manu. - for 1987 (mean 0.44 s.d. 0.21 (excludes machinery))

diversity index - for 1987 (mean 0.17 s.d. 0.24 (excludes machinery))

Regions northeast, midwest and south dummy variables have means of .18, .29, and .35 respectively.

"1970" Variables

Sources: Employment data are from 1970 Population Census Sixth Count Table 1270 on employment by SMSA. Socioeconomic data are from the 1972 City and County Data Book and the 1972 Census of Manufacturers.

manu. wage - average hourly wage of production and nonproduction workers for 1972 (mean 4.6; s.d. 3.6)

specialization past machinery - for 1970 (mean .026; s.d. .030) specialization past electrical machinery - for 1970 (mean .024; s.d. .033)

specialization past primary metals - for 1970 (mean .023; s.d. .041)

specialization past electronic components - for 1970 County Business Patterns (mean .011; s.d. .026 for 207 metro areas)

specialization past computers - for 1970 (mean .002; s.d. .006 for 207 metro areas)

total manu. employ. (1000's) - for 1970 (mean 58.8; s.d. 110.8)

% labor force in higher education and misc. prof. - for 1970 (mean .019; s.d. .004)

% manu. employ. in aircraft industry - for 1970 (mean .032; s.d. .066)

total employ. (1000's) - for 1970 (mean 219.1; s.d. 368.3)

% adults with at least high school - for 1970 pop. over 25 (mean .55; s.d. .08)

% adults with at least college - for 1970 pop. over 25 (mean .11; s.d. .04)

diversity index - for 1970 for 50 manu. ind. (mean .12; s.d. .08 (excludes electronic components))

Appendix B

High-Tech Employment Levels

	Computers	Electronic Components
constant	-8.045*	2.706
	(2.853)	(1.991)
region northeast	-.456	-.794*
	(.412)	(.318)
region midwest	-1.006*	-1.192*
	(.372)	(.288)
region south	.298	-.990*
	(.440)	(.346)
distance to nat'l. business center	–	.022
		(.070)
1980 % adults w/ at least high school	8.444*	1.284
	(3.560)	(2.523)
1980 % adults w/4 or more years college	2.064	2.748
	(3.854)	(3.183)
log (manu. wage)	.379	-1.955*
	(.259)	(.567)
log (all other manu. activity)	.380	.362*
	(.220)	(.127)
index: lack of manu. diversity		-1.446*
		(.629)

Appendix B – (Continued)

High-Tech Employment Levels

	Computers	Electronic Components
ratio: durable to total manu.	-1.690 (.940)	–
log (past own industry employ.)	.298 (.161)	.332* (.094)
specialization past	27.538 (22.884)	
inverse Mill's ratio	.743* (.330)	n.a.
ρ (maximum likelihood version)	n.a.	.557 (.312)
R^2 (2nd stage OLS)	.484	(.635)
N	70	101/207

References

Abdel-Rahman, H. M. (1988), "Product Differentiation, Monopolistic Competition, and City Size," *Regional Science and Urban Economics,* 18, 69-86.

———.and M. Fujita (1991), "Specialization and Diversification in a System of Cities," University of Pennsylvania, mimeo.

Barro and Sala-i-Martin (1991), "Convergence Across States and Regions," *Brookings Papers on Economic Activity,* 1.

Beeson, P. and R. Eberts (1989), "Identifying Productivity and Amenity Effects in Interurban Wage Differentials," *Review of Economics and Statistics,* 1989, 443-452.

Bergsman, J., P. Greenston, and R. Healy (1975), "A Classification of Economic Activities Based on Location Patterns," *Journal of Urban Economics,* 2, 1-28.

Blanchard, O. and L. Katz (1992), "Regional Evolutions," MIT, mimeo.

Carlton, D. (1983), "The Location and Employment of New Firms," *Review of Economics and Statistics,* 65, 440-449.

Davis, S. J. and J. Haltiwanger (1991), "Gross Job Creation, Gross Job Destruction, and Employment Reallocation," Federal Reserve Bank of Chicago, WP 91-5.

Dixit, A. and J. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity," *American Economic Review,* 67, 297-308.

Dunne, T., M. J. Roberts and L. Samuelson (1989), "Plant Turnover and Gross Employment Flows in U.S. Manufacturing," *Journal of Labor Economics,* 7, 48-71.

———.(1990), "The Growth and Failure of U.S. Manufacturing Plants," *Quarterly Journal of Economics.*

Glaeser, E., H. Kallal, J. Scheinkman, and A. Shleifer (1991), "Growth in Cities," NBER Working Paper No. 3787.

Hansen, E. R. (1987), "Industrial Location Choice," *Regional Science and Urban Economics,* 17, 89-109.

Romer, P. M. (1986), "Increasing Returns and Long-Run Growth," *Journal of Political Economy,* 94, 1002-37.

——.(1990), "Endogenous Technological Change," *Journal of Political Economy,* 98, 71-101.

Smith, R. J. and R. W. Blundell (1986), "An Exogeneity Test for a Simultaneous Equation Tobit Model," *Econometrica,* 54, 679-685.