The Importance of Local and Global Externalities for the Urban Industrial Development.
A Dynamic Factor Analysis

di
Stephane Ghio*
Barbara Pistoresi**

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* Università degli Studi di Modena e Reggio Emilia
University of Toulon France
CRERI

** Università degli Studi di Modena e Reggio Emilia
Dipartimento di Economia Politica
Viale Berengario, 51
41100 Modena (Italia)
e-mail: pistoresi@unimo.i
The importance of local and global externalities for the urban industrial development. A dynamic factor analysis.

Stephane Ghio
University of Modena, Italy
and CRERI, University of Toulon, France

Barbara Pistoresi
University of Modena, Italy

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Abstract

This paper proposes new measures of the degree of specialization (diversification) and equalization (integration) of the U.S manufacturing industry. For this purpose, we use a dynamic factor model and a modified version of the estimation procedure recently proposed by Forni and Reichlin (2001). These measures are used to derive indirect evidence on the role of local and global externalities. Our findings suggest that there is not a single type of externalities predominates in the explanation of the urban industrial development.

JEL: C53, L60, R11
Keywords: Sectoral Growth, U.S Metropolitan Areas, Externalities, Dynamic Factor Analysis

Correspondence: Barbara Pistoresi, Dipartimento di Economia Politica, Universita' di Modena, Viale Berengario 51, 41100 Modena, Italy.
Fax: +390592056947, E-mail: pistoresi@unimo.it
1 Introduction

Specialization of the industrial structure is an indicator of the presence of MAR (Marshall-Arrow-Romer) externalities, while diversification of economic activities of the relevance of Jacobs externalities. Intra-industry or MAR externalities lead to localization of the same activities in the same metropolitan area (or city), while inter-industry or Jacobs externalities lead to agglomeration of firms of different industries in the same city, in other words they induce a local "variety" of economic activities. Firms of the same industry located in different cities may also be linked by global (i.e inter-city) MAR externalities. If these externalities are important, similar economic activities also tend to be concentrated geographically (equalization). Finally, if inter-industry and inter-city relationships are strong and global Jacobs externalities important, economic activities spread over the economy, i.e. they are localized in diversified cities (integration).

This paper studies the degree of specialization (diversification) and equalization (integration) of the U.S manufacturing industry by analyzing the features of the sectoral income growth of 20 manufacturing sectors in 61 metropolitan areas (cities). For this aim, we use a dynamic factor model and a simple estimation procedure build on Forni and Reichlin (2001). As also these authors stress, the main advantage of this estimation procedure with respect to alternative econometric strategies is that it is adequate to study the features of data set characterized by high cross-sectional disaggregation and by dynamic complexity while retaining both sophisticated dynamic modelling and parameter heterogeneity. The difference between our model with respect to the Forni and Reichlin's one is that we have four dynamic factors instead of three dynamic factors and hence we also have to adapt the estimation procedure to this complexity.

Our statistical representation isolates the following four dynamic factors: (i) the income dynamics common to all sectors in all cities (aggregate component), (ii) the income dynamics which is common to all sectors in a city but orthogonal to the other cities (city-specific or urban component), (iii) the income dynamics which is common to each sector of all the cities but orthogonal to the other cities (sector-specific or sectoral component), (iv) the income dynamics completely idiosyncratic both to cities and sectors (idiosyncratic component). The aggregate component is used as a measure of economic integration, the urban component of diversification, the sectoral component of equalization, while the idiosyncratic component is regarded as a measure for specialization of the economic activities. The decomposition of income growth in these dynamic components allows us to

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1 In general factor analysis concerns static models. Appendix B in Pistoresi and Strozzi (2001) discusses static and dynamic factor models. See also note 38 of that paper for the references concerning static factor models.
have indirect evidence of the role of local and global MAR (Jacobs) externalities inducing these different industrial structures.

Why the dynamic structure of our statistical model is so relevant? More properly, why is it important to take into account the heterogeneity in the dynamics of the common (national or common across sectors or cities) components of the models? It is because it can takes into account phenomena like different propagation mechanisms of the technological innovation (e.g., Lippi and Reichlin, 1994) or of the location-specific information (e.g., Jaffe et al., 1993) across cities and sectors. For example, the dynamic specification of the aggregate component may allow us to consider the possibility that a common (national/international) productivity shock may generate a certain kind of response in one sector at a specific moment and in a particular city (or area) and a response of the same or different sign and magnitude in a different sector and/or city at a certain time.

Related empirical studies consider the role played by MAR and Jacobs externalities (e.g., Glaeser et al. 1992, Henderson et al., 1995, Feldmann and Audretsch, 1999, Forni and Paba, 2001). However, this literature focuses only on the local dimension of this type of externalities. At the same time, recent theoretical papers on the new economic geography show that global MAR and Jacobs externalities may play an important part in urban growth (Englemann and Walz, 1995, Walz, 1996, Martin and Ottaviano, 1999). In our paper, hence, we consider all these types of externalities simultaneously in a unique econometric model in particular by taking also into account the impact of global spillovers on the urban growth.

Our empirical investigation suggests that there is not a single type of externality that predominate in the explanation of the U.S. urban industrial development, in other words local/global MAR and local/global Jacobs externalities are equally represented.

The remainder of the paper is organized as follows. Section 2 introduces the concepts of specialization (diversification) and equalization (integration) based on the role of local MAR (local Jacobs) and global MAR (global Jacobs) externalities. Section 3 describes the statistical model and the estimation procedure. Section 4 presents the dataset and discusses the results. Section 5 concludes.

2 Local and global dimensions of urban growth

In this section we present the patterns of aggregate and local development of the industrial growth. Moreover, we show that these patterns of development generate common or idiosyncratic income dynamics with respect to cities and sectors. Table 1 summarizes the local versus global and sectoral versus intersectoral dimensions of urban growth as follows

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2Jaffe et al. (1993) found that location-specific information spreads out slowly, making geographic access to that knowledge important to firms. The dynamics in our model takes into account both the possibility of a slow and heterogeneous process of diffusion of the information across firms or industries.
Table 1 Patterns of aggregate and local development

<table>
<thead>
<tr>
<th></th>
<th>Sectoral</th>
<th>Inter-Sectoral</th>
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<tr>
<td>City</td>
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<td>Diversification</td>
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<td>LOCAL MAR</td>
<td>LOCAL JACOBS</td>
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<tr>
<td>Inter-city</td>
<td>Equalization</td>
<td>Integration</td>
</tr>
<tr>
<td></td>
<td>GLOBAL MAR</td>
<td>GLOBAL JACOBS</td>
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</table>

1. Specialization

Specialization of the industrial structure may be due to the fact that spatial proximity of firms with the same activities creates local external economies or localization economies. These MAR externalities (Glaeser et al., 1992, Henderson et al., 1995) are created for example by a learning-by-doing process in which local firms of a same sector have an advantage to compose knowledge by a repetitive communication. This process leads to a urban sectoral concentration (Premer and Walz, 1994) and may favor local competition. This local competition may stimulate innovation at the urban level (Bairoch, 1985, Porter, 1990). The specialization of the industrial structure at the city-level generates an income dynamics idiosyncratic both to cities and sectors. This may be considered the idiosyncratic component of the national income growth.

2. Diversification

The diversification of the industrial structure, that is the agglomeration of firms of different sectors in the same urban area, may be the consequence of urbanization economies expressed by an improvement of factors productivity. These Jacobs’ type externalities (Jacobs, 1969, Glaeser and al., 1992) come from the construction of a technological potential which is build on knowledge diversity. Performance of a sector in a urban area may be influenced by the performance of firms in other sectors. The diversification of the industrial structure generates an income dynamics which is common to all sectors in a city but orthogonal to the other cities. This may be considered as the urban component of the national income growth.

3. Equalization

Equalization of the industrial structure, that is the interactions of firms of a same sector located in different urban area, may be linked by global (i.e. inter-urban) MAR externalities (Englmann and Walz, 1995, Walz, 1996). For example, a good transport network may explain this kind of inter-urban externalities (Kubo, 1995). The equalization of the industrial structure generates an income dynamics which is common to each sector.
of all the cities but orthogonal to the other cities. This is the sectoral component of the national income growth.

4. Economic integration

Inter-sectoral and inter-urban relations can be developed if an economic tendency exists which weaken local markets and if the national territory has a sufficient structure to permit a high level of economic integration. From a theoretical point of view, this configuration appears, for example, when transport costs are low and may lead to complete urban/regional specialization, in association with an important inter-urban/regional trade (Walz, 1996, Martin and Ottaviano, 1999). The economic integration induces the income dynamics to be common to all sectors in all cities.

3 Dynamic factor analysis

Now we present the statistical model used to measure the degree of specialization (diversification) and equalization (integration) of the U.S manufacturing industry. The analysis is performed through the estimation of a dynamic factor model as in Forni and Reichlin (2001). The income growth, $y_{it}^{ij}$, for the j-th sector of city i at time t is modeled as follows:

$$y_{it}^{ij} = a_{ij}^{ij}(L)n_t + b_{ij}^{ij}(L)s_t^i + c_{ij}^{ij}(L)t_t^i + d_{ij}^{ij}(L)e_t^{ij}$$

for $i = 1, ..., I$ and $j = 1, ..., J$. $a_{ij}^{ij}(L), b_{ij}^{ij}(L), c_{ij}^{ij}(L), d_{ij}^{ij}(L)$ are rational functions in the lag operator $L$; $n_t, s_t^i, t_t^i, e_t^{ij}$ are unobserved white noises mutually uncorrelated at all leads and lags. In particular, $n_t$ is an aggregate shock (national or international) common to all cities and sectors; $s_t^i$ is a sector-specific (sectoral) shock common across cities but orthogonal to the other sectors; $t_t^i$ is a city-specific shock common across sectors belonging to the same city but orthogonal to the other cities; $e_t^{ij}$ is an idiosyncratic shock. These shocks define the following components: $a_{ij}^{ij}(L)n_t = \text{the aggregate component}$, it captures the income dynamics which is common to all sectors in all cities; $b_{ij}^{ij}(L)s_t^i = \text{the sector-specific or sectoral component}$, it describes the income dynamics which is common to each sector of all the cities but orthogonal to the other sectors; $c_{ij}^{ij}(L)t_t^i = \text{the city-specific or urban component}$, it reflects the income dynamics which is common to all sectors in a city but orthogonal to the other cities; $d_{ij}^{ij}(L)e_t^{ij} = \text{idiosyncratic component}$ it describes the income dynamics completely idiosyncratic both to cities and sectors. Note that there is a correspondence between the patterns of regional development showed in Table 1 and the common

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3 We take the first differences of the variables (in logs), because the hypothesis they are I(1) processes is not rejected. The results on the degree of integration are available on request. Note that the series are washed out by the drift. In other words, we use zero-mean first differences.
and idiosyncratic components isolated using our dynamic factor model. Table 2 describes this correspondence.

**Table 2 Measuring the patterns of development by using a dynamic factor model**

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<tr>
<th>City</th>
<th>Sectoral</th>
<th>Inter-Sectoral</th>
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<tr>
<td></td>
<td>Specialization</td>
<td>Diversification</td>
</tr>
<tr>
<td></td>
<td>Idiosyncratic component</td>
<td>Urban component</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Inter-city</th>
<th>Equilalization</th>
<th>Integration</th>
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<tbody>
<tr>
<td></td>
<td>Sectoral component</td>
<td>Aggregate component</td>
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</table>

The dynamic specification of the propagation mechanism in (1) is related to two sources of heterogeneity: (i) an heterogeneity due to different responses of the variables to common shocks, \( n_t, s_t^i, l_t^i \) and (ii) an heterogeneity due to different responses to idiosyncratic shocks \( \varepsilon_t^i \). In the first case, the response functions are described by \( a^{ij}(L)n_t, b^{ij}(L)s_t^i, c^{ij}(L)l_t^i \), while in the second case by \( d^{ij}(L)\varepsilon_t^i \). Heterogeneity of type (i) implies that, for example, the responses of each sector of each city to an aggregate shock can be characterized by completely heterogeneous sectoral impulse response functions: the sectoral-urban responses to an aggregate shock can be different in magnitude, in sign, and also in timing. In the long run, the common components cannot diverge in a permanent way because they are driven by a unique shock: they are cointegrated and strictly comove. On the contrary, the heterogeneity of type (ii) implies that the sectoral-urban responses to idiosyncratic shocks are by definition always different both in the short and long run because these shocks are mutually orthogonal. Finally, note that \( n_t, s_t^i, l_t^i, \varepsilon_t^i \) can be transitory or permanent shocks.

The model can be estimated by OLS equation by equation following a five steps procedure. The unobservable shocks \( n_t, s_t^i, l_t^i, \varepsilon_t^i \) are proxied by weighted averages of the variables calculated for different dimensions: aggregate, sectoral and urban level. The importance of the idiosyncratic shock \( \varepsilon_t^i \) is represented by the OLS residuals. This is a modified version of the estimation procedure proposed by Forni and Reichlin (2001) and presented in the next section.

**3.1 The estimation procedure**

In the following, we present a modified version of the estimation procedure proposed by Forni and Reichlin (2001). Their procedure is adapted to estimate four dynamic factors as in model (1). It is a five steps procedure based on the implications of the Law of Large Numbers\(^4\).

\(^4\)On this point see Granger (1987) and Forni and Lippi (1997) Chapter 1.
Step 1. We perform an OLS estimation of the growth rate of income in each sector-city $y_{it}^{ij}$ on the simple aggregate average: $y_t = \frac{1}{IJ} \sum_{i=1}^{I} \sum_{j=1}^{J} y_{it}^{ij}$

$$y_{it}^{ij} = \alpha^{ij}(L)y_t + e_{it}^{ij}, \quad (2)$$

for each $i = 1, \ldots, I$ and $j = 1, \ldots, J$. $\alpha^{ij}(L)$ is specified as a second order polynomial$^5$. The var-covar matrix of the residuals is used to construct the matrix of weights $\omega^{ij}$ useful to compute the new (weighted) aggregate average$^6$:

$$\overline{y}_t = \sum_{i=1}^{I} \sum_{j=1}^{J} \omega^{ij} y_{it}^{ij}.$$ This average is almost-collinear to the aggregate component $a(L)n_t$ because of the aggregation process (Law of Large Numbers)$^7$, that is

$$\overline{y}_t \approx \overline{a}(L)n_t, \quad (3)$$

where $\overline{a}(L) = \sum_{i=1}^{I} \sum_{j=1}^{J} \omega^{ij} a^{ij}(L)$. In other words, the unobservable factor $a(L)n_t$ in model (1) can be proxied by using the observable $\overline{y}_t$.

Step 2. Now we regress OLS equation by equation $y_{it}^{ij}$ on $\overline{y}_t$ obtained above and on the simple average of each city: $y_i^t = \frac{1}{J} \sum_{j=1}^{J} y_{it}^{ij}$.

$$y_i^t = \overline{a}^{ij}(L)\overline{y}_t + \gamma^{ij}(L)y_i^t + h_{it}^{ij}. \quad (4)$$

As in Step 1, the var-covar matrix of the OLS residuals $h_{it}^{ij}$ can be used to obtain the weights to construct new urban averages (relative to each city): $\overline{y}_i^t = \sum_{j=1}^{J} \omega^{ij} y_{it}^{ij}$. Also in this case we use a second order specification for $\overline{a}^{ij}(L)$ and $\gamma^{ij}(L)$. As in the case of the weighted aggregate average, the weighted average of the city is almost collinear to the aggregate and local components that is

$$\overline{y}_i^t \approx \overline{a}^{i}(L)n_t + \overline{c}^{i}(L)l_t^i, \quad (5)$$

where $\overline{c}^{i}(L) = \sum_{j=1}^{J} \omega^{ij} c^{ij}(L)$ and $\overline{a}^{i}(L) = \sum_{j=1}^{J} \omega^{ij} a^{ij}(L)$.

We tried different specifications for $\alpha^{ij}(L)$, including leads and lags of $\overline{y}_t$. We found that on average a two lags specification could not be rejected by the F-test.

$^6$ For the optimal weighting procedure see Forni and Reichlin (2001).

$^7$ When $I$ and $J$ are relatively large, the orthogonality of the sectoral, urban and idiosyncratic shocks implies that the variances of the sectoral, local and idiosyncratic components are small compared to the total one.
Step 3 Similarly to Step 2, we regress OLS equation by equation $y_{ti}^{ij}$ on the weighted aggregate average $\bar{y}_i$ and on the simple average of each sector:

$$y_{ti}^{ij} = \frac{1}{J} \sum_{i=1}^{J} y_{ti}^{ij}, \text{ i.e.}$$

$$y_{ti}^{ij} = \bar{a}^{ij}(L)\bar{y}_t + \beta^{ij}(L)y_t^i + \kappa_t^{ij}. \quad (6)$$

We use a second order specification for $\bar{a}^{ij}(L)$ and $\beta^{ij}(L)$. The var-covar matrix of the residuals, $\kappa_t^{ij}$, can be used to obtain the weights to construct a new sectoral averages: $\bar{y}_t^{ij} = \sum_{j=1}^{J} w^j y_{ti}^{ij}$. It is almost collinear to the aggregate and sectoral components:

$$\bar{y}_t^{ij} \approx \bar{a}^{ij}(L)\bar{y}_t + \bar{b}^{ij}(L)s_t^i, \quad (7)$$

where $\bar{b}^{ij}(L) = \sum_{i=1}^{J} w^i b^{ij}(L)$ and $\bar{a}^{ij}(L) = \sum_{i=1}^{J} w^i a^{ij}(L)$.

Step 4 Now we can obtain the sectoral and local components. In particular, the local component of each $i$ is the OLS residual of a regression of the weighted urban average and weighted aggregate average obtained in Step 1 and 2:

$$\bar{y}_t^i = \alpha^i(L)\bar{y}_t + \xi_t^i, \quad (8)$$

where $\xi_t^i = \bar{v}^i(L)t_i$.

The sectoral component is obtained in a similar way by using the weighted aggregate average and weighted sectoral average obtained in Step 1 and 3:

$$\bar{y}_t^i = \alpha^i(L)\bar{y}_t + z_t^i, \quad (9)$$

where $z_t^i = \bar{b}^{ij}(L)s_t^i$.

Step 5. The final step allows us to derive the idiosyncratic components. First, we regress $y_{ti}^{ij}$ on the weighted aggregate averages:

$$y_{ti}^{ij} = A^{ij}(L)\bar{y}_t + x_t^{ij} \quad (10)$$

Then, the OLS residuals $x_t^{ij}$ are regressed on the residuals $\xi_t^i$ and $z_t^i$ representing respectively the local and sectoral components. Hence,

$$x_t^{ij} = B^{ij}(L)z_t^i + C^{ij}(L)\xi_t^i + x_t^{ij} \quad (11)$$

where $A^{ij}(L)\bar{u}(L) = \alpha^{ij}(L), B^{ij}(L)\bar{b}^{ij}(L) = \beta^{ij}(L), C^{ij}(L)\bar{c}^i(L) = \kappa^{ij}(L)$. 

8
4 Data and results

The dataset we use is REIS (Regional Economic Information System). It stems from the U.S Department of Commerce, Economic and Statistic Administration, Bureau of Economic Analysis. We consider the growth rate of earnings of 20 manufacturing sectors (2-digit) belonging to 61 US Metropolitan Statistical Areas (MSAs). The span of the analysis is 1969-1993. In Appendix we report the complete list of sectors and metropolitan areas used. The series are deflated by the national consumer price index. From now on we will refer indifferently to earnings or income and to metropolitan areas or cities.

Table 3 shows the variance decomposition derived by model (1). It focuses on the relative weight of common, urban, sectoral and idiosyncratic components. It suggests that there is no evidence that a particular type of externalities prevail to explain the urban industrial development.

Local factors explain 53% of the total variance of income growth, in particular the urban component explains 26.23% while the idiosyncratic component the remaining 26.87%. This outcome suggests that local factors and local MAR and Jacobs externalities are important to explain the industrial development.

Aggregate factors also play an important role to explain the urban industrial structure (46.9%). For example, an expansive monetary policy or a technological shock that hit the whole industrial system, or a particular national policy act to help a particular industry equally represented in all the cities and global MAR and Jacobs externalities represent factors that contribute to explain the common and sectoral variance of income growth.

If we focus on the sectoral vs. inter-sectoral dimensions of urban growth, both at the local and the global levels, we find that the sectoral dimension represents 54.13% of the variance of urban growth while the inter-sectoral dimension represents only 45.87% of this variance. In other words, the sectoral dimension of urban growth plays a slightly more important role than the inter-sectoral one in the explanation of US SMA growth between 1969 and 1993.

Table 3 Percentage of variance explained by the common, urban, sectoral and idiosyncratic components

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<tr>
<th></th>
<th>Sectoral</th>
<th>Inter-Sectoral</th>
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<tbody>
<tr>
<td>City</td>
<td>Idiosyncratic = 26.87%</td>
<td>Urban = 26.23%</td>
</tr>
<tr>
<td>Inter-City</td>
<td>Sectoral = 27.26%</td>
<td>Common = 19.64%</td>
</tr>
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</table>
5 Conclusions

This paper contributes to the empirics of externalities. In particular, it proposes new measures of the degree of specialization (diversification) and equalization (integration) of 20 U.S manufacturing sectors belonging to 61 U.S metropolitan areas (MSAs). These measures are used to derive indirect evidence of the presence of local MAR (Jacobs) and global MAR (Jacobs) externalities. For this aim, we use a dynamic factor model and a modified version of the estimation procedure proposed by Forni and Reichlin (2001).

Our empirical investigation suggests that no one type of externality predominates in the explanation of the U.S (urban) industrial development, i.e. local/global MAR and local/global Jacobs externalities are equally represented. With respect to the existing empirical literature on this topic, we analyze local or global externalities in a unique model, i.e. they are modeled simultaneously.

Our methodology can be extended in a number of directions. For example, it is possible to replicate the analysis focusing on the distinction between high-tech and low tech sectors to check if MAR externalities are important for both groups whereas Jacobs externalities are important only for high-tech sectors (Henderson et al., 1995). Moreover, it is possible to derive a more precise indication of the role of innovation spillovers distinguishing between long run and short run features of the data and their variance decomposition.

References


APPENDIX

In the following we list the metropolitan areas and manufacturing sectors used in the empirical analysis.

Metropolitan Areas

1) Akron (OH)
2) Bakersfield (CA)
3) Bangor (ME)
4) Benton Harbor (MI)
5) Bergen-Passaic (NJ)
6) Buffalo-Niagara Falls (NY)
7) Chicago (IL)
8) Cleveland-Lorain Elyria (OH)
9) Colorado Springs (CO)
10) Dallas (TX)
11) Detroit (MI)
12) El Paso (TX)
13) Elkhart - Goshen (IN)
14) Erie (PA)
15) Eugene - Springfield (OR)
16) Flint (MI)
17) Fort Lauderdale (FL)
18) Fort Myers-Cape Coral (FL)
19) Fresno (CA)
20) Hamilton - Middletown (OH)
21) Jackson (MI)
22) Jersey City (MI)
23) Lakeland-Winter Haven (FL)
24) Lancaster (PA)
25) Los Angeles - Long Beach (CA)
26) Lubbock (TX)
27) Madison (WI)
28) Melbourne - Titusville - Palm Bay (FL)
29) Miami (FL)
30) Milwaukee - Waukesha (WI)
31) Modesto (CA)
32) Massau - Suffolk (NY)
33) New York (NY)
34) Oakland (CA)
35) Orange County (CA)
36) Phoenix - Mesa (AZ)
37) Portland (ME)
38) Provo-Oren (UT)
39) Racine (WI)
40) Reading (PA)
41) Reno (NV)
42) Riverside-San Bernardino (CA)
43) Salinas (CA)
44) San Diego (CA)
45) San Francisco (CA)
46) San Jose (CA)
47) S. Barbara-S.Maria - Lompoc (CA)
48) Santa Rosa (CA)
49) Seattle-Bellevue-Everett (WA)
50) South Bend (IN)
51) Spokane (WA)
52) Springfield (MA)
53) Stockton-Lodi (CA)
54) Tacoma (WA)
55) Trenton (NJ)
56) Tucson (AZ)
57) Ventura (CA)
58) Waco (TX)
59) West Palm Beach - Bocaraton (FL)
60) Williamsport (PA)
61) York (PA)

Manufacturing sectors (2-digit)

1) Food and kindred products
2) Textile mill products
3) Apparel and other textile products
4) Paper and allied products
5) Printing and publishing
6) Chemicals and allied products
7) Petroleum and coal products
8) Rubber and miscellaneous products
9) Leather and leather products
10) Lumber and wood products
11) Furniture and fixtures
12) Primary metal industries
13) Fabricated metal products
14) Machinery and computer equipment
15) Electric equipment, exclude computer equipment
16) Transport equipment exclude motor vehicles
17) Motor vehicles and equipment
18) Stone, clay and glass products
19) Instruments and related products
20) Miscellaneous manufacturing industries
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55. Paolo Silvestri [1990] "Sull'autonomia finanziaria dell'università", pp. 11
83. Mario Forni
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E' capacità concorrenziale nell'industria della Pricate Vices Pubblis
Michele Grillo e Michele Sebastiano Brusco e soluzioni di Gian Gian
Enrico Giovannetti distretto ottimo come soluzione di riqualificazione dell'approccio distretto industriale;
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