The Export-Occupation Interface: The Chicago Experience

Philip R. Israilevich
Regional Economics Applications Laboratory,
Federal Reserve Bank of Chicago

Graham R. Schindler
Regional Economics Applications Laboratory,
University of Illinois at Urbana-Champaign

Geoffrey J. D. Hewings
Regional Economics Applications Laboratory,
University of Illinois at Urbana-Champaign

This paper is one of a series associated with the September 18, 1996, workshop "Global Linkages tot he Midwest Economy." Linda M. Aguilar, Jack L. Hervey, and Thomas H. Klier served as workshop conveners . The workshop was the sixth of a series held at the Federal Reserve Bank of Chicago as part of the 1996-97 project "Assessing the Midwest Economy." Inquiries should be directed to the Public Information Center, Federal Reserve Bank of Chicago, P.O. Box 834, Chicago, Illinois 60690-0834, or telephone (312) 322-5111. The Federal Reserve Bank of Chicago's Web site can be accessed at http://www.frbchi.org.

Abstract

The effect of exports on occupational demand is estimated. The notions of absorption and dissipating industries are introduced. Absorption industries form economic clusters that provide a mechanism to help explain the nature of regional changes as a result of the changes in exports.

Introduction

There is a long tradition in regional economic analysis that addresses the role of exports in the promotion of regional economic growth and development. Attention has been directed to the types of exports and their composition, the impacts of exports on the structural composition of the region, and, more recently, on the role of international exports as a generator of economic stimuli. While supply-side issues have not been ignored, they have often been handled implicitly rather than explicitly. This paper estimates the effect of manufacturing exports on the occupational structure of a region. The estimated relationships between export activity and occupational demand would allow regional institutions (such as those involved in labor training and retraining) to prepare a work force to meet labor demands from the exporting sectors of the economy. We use regional model simulations to determine the impact of exports on the labor market disaggregated into detailed industry-specific occupational components. An important distinction is made in the internal workings of the regional economy between absorption industries and dissipating industries; and the concept of occupational capital is introduced as an important attribute of the competitiveness of a region's economy.

In the next section of the paper, the major issues are addressed; following this discussion, attention is focused on the operational aspects of exports and their links to occupational structure. In the fourth section, the dynamics of regional intradependencies are described; the transmission of exports into labor demand occupies section 5. The empirical analysis, focusing on Chicago, will be dealt with in section 6 and some concluding remarks complete the paper.

The Issues

In order to derive the export-occupational interface we have to "walk" through the chain of relationships between export and other economic variables. First, to meet increased demand, the exporter would require an extra supply of primary factors (labor and capital) and intermediate factors (goods and services) necessary for the production of a given export. Then, the suppliers of intermediate goods have to increase their output to satisfy the exporter's demand. The increased employment in the export sector and its suppliers will generate extra income, which will be respent in the region, creating additional demand for regional amenities, goods and services, and labor.

This long chain of relationships is beneficial for regional growth; a companion piece of work (see [3]) has explored the role of changes in the degree of intermediation in a region's economy. In essence, the approach adopted here is based on the role of interdependence as one of the most important mechanisms in explaining the changing competitive position of a region's economy through time. However, the degree of intermediation or chain of relationships can be shortened if the region does not have an adequate supply of the necessary factors. This would create "leakage" of the potential regional expansion. Due to limitations in the region's supplies, imports from other regions will fill in the missing links in the exchanges of goods and services. Moreover, the absence of labor supply or other primary factors may not be substitutable by import (migration). In this case, exports may not be produced in the region

and production will be relocated to the regions with a more adequate supply of the necessary factors. Of course, the transfer of one part of the commodity chain of relationships may serve to unravel other parts as suppliers find that they no longer have a large-enough market to serve within the region or purchasers find their sources of supply have disappeared.

The unsatisfied demand for region's primary factors will reduce regional competitiveness for the export of goods and services. Modeling this chain of relationships enables an estimation of the structure of the primary factors necessary to meet the demand originated by exports. In this paper, we will pay attention to labor as one of the primary factors. We will identify the detailed occupational structure of labor as a necessary base for export market expansion. In this sense, our analysis explicitly considers supply-side factors as an important economic engine that may enhance or retard future regional growth prospects.

Operational Theory

We consider export activity as an exogenous shock promoting regional growth. As a result of the shock, two distinct categories of industries are formed. Exports prompt one group of industries to increase its role in the regional economy, while another group of industries would diminish its role in the region. We call the first group of industries *absorbing* and the other *dissipating*. Both of these notions are defined and measurements of absorption and dissipation are provided. In the traditional input-output literature these two groups would be defined by the technological linkages between sectors ([7]; [8]). However, in this paper, we determine *economic linkages*. For example, the Cleveland metro area was specializing in processing ferrous metals. This process is highly toxic and workers frequently contracted lung disease. As a result, the Cleveland Clinic specialized in lung ailments and became a national medical center. In this example, metal processing is economically linked to the medical sector.

Many economic linkages would be hard to observe in reality because, *ceteris paribus*, certain requirements are necessary to detect the reaction of many economic variables to a change in the export of a single good. The difficulties are due to the fact that other changes in the economy are taking place along with the changes in export of a specific good or service. By concentrating on the absorption group of industries that are linked to a selected group of exporting goods, we can determine the detailed requirements of the labor force. In this context, we analyze the demand for the variety of occupational categories that form *occupational capital* requirements, which is a disaggregation of human capital. Local authorities armed with information of occupational capital requirements can promote or undermine the future of the selected export niche depending upon their reaction to the changes that have been forecast to occur.

One of the innovative features of this paper is the definition of economic cluster, which is different from the traditional technological clusters that economists use for the identification of economic linkages. Industries inside the economic cluster are absorbing industries and the rest are dissipating industries. A second feature is the way in which the impacts from a persistent shock to the region in the form of a change in exports are handled. First, export of good *i* prompts the growth of industry *i* and

associated absorption industries growth. This would be handled through the traditional multiplier approach. However, in addition to this impact, a second effect can be identified; the persistence, in time, of a change in the export of good *i* can generate changes in the economic structure of purchases and sales within the region—in other words, changes in the nature and strength of intermediation. This is captured by dynamic changes in the input-output matrices; the Chicago Regional Econometric Input-Output Model (CREIM) successfully captures these effects (see [9]) and estimates both multiplier effects on an annual basis and the effects from the changes in the structure prompted by the export of good *i*. The export-occupational interface is estimated for the Chicago SMSA based on 1994 foreign export data.[1] Estimations are derived from the simulations derived from CREIM.

Dynamics of regional intradependencies

The development of the regional economy depends on external and internal factors. External or exogenous factors, such as exports and imports, migration, financial flows, and the like, are assumed to be formed outside the region. Internal factors, such as labor force, transport or communication infrastructure, and the like, originate in the region. Both of these types of factors are linked in the regional economy through the sale and purchase of goods and services. These linkages can be viewed as a system of interactions between different elements of the region. These interactions predetermine the demand for local resources as a result of external-factor changes. In this paper, we consider only one external factor—the demand for regional export. In addition, external factors may influence the internal structure of the region. With this, the effect on the demand for local resources would come from two sources:

- Exogenous factors entering the regional system determining demand for inputs
- Exogenous factors modifying the structure of the regional system

The first source of exogenous factors, would be handled typically by a static model, such as input-output, or static econometric models. CREIM accounts for both sources of exogenous factors by allowing the regional structure to be modified through the persistent effects of the changes in the exogenous variables.

Interactions between producers and purchasers form the basic characteristics of a region's economic structure. Using this structure, we can predict changes in different components of the regional economy as a reaction to exogenous changes (shocks to the regional economy). Here we analyze the effect of foreign exports from Chicago on occupational demand. This question is of special concern because the lack of skills may represent a bottleneck for future export growth.

At present, very few analysts can identify labor demand generated by export; it is even more difficult to relate export to a specific set of occupations. Yet this information is necessary for educators to both supply the market with appropriate labor skills and give students accurate predictions about the anticipated demand for their chosen occupation. Failure in these regards may hamper the regional economy and will frustrate students who graduate from local institutions with diminished expectations for the prospect of future employment.

Transmission of demand for export of goods and services into a demand for labor

An increase in the export of good *i* implies output growth in industry *i* and industries that form the suppliers' network. But how does it affect output shares s_i, i=1,...,n ? As a result of the growth of export in industry *i*, one set of shares will increase and the rest of the shares will decline. Changes in output shares will predetermine changes in employment shares. We will show the transformation from output to employment shares. Industries with increasing employment shares are defined as *absorbing* industries relative to export *i*. Industries with declining employment shares relative to export *i* are *dissipating* industries. If the share of export *i* will continue to increase, then the absorbing industry's shares will continuously increase, while the dissipating industry's shares will continuously decline with growth of export *i*. Since shares of employment will change, the output shares will change as well, which in turn will change input-output coefficients as a result of the growth of export *i*. CREIM accounts for these types of effects (see [9]). To conclude this paradigm, persistent export increases will raise the prominence of the absorption industries through direct effects and through the changes in structure of the economy in the form of changes of the input-output coefficients.

The Nature of the Absorption and Dissipation Industries

The difference between absorption and dissipation industries is defined by shares of employment changes:

$$\frac{s_i^s - s_i^b}{s_i^b} = \frac{(\Delta_i + n_i)/(\Delta + N)}{n_i / N} - 1 = \frac{(\Delta_i + n_i)\cdot N}{(\Delta + N)\cdot n_i} - 1 = \frac{\Delta_i N + n_i N}{\Delta n_i + N n_i} - 1 =$$

(1)

$$\frac{\Delta_i N + n_i N - \Delta n_i - N n_i}{\Delta n_i + N n_i} = \frac{\Delta_i N - \Delta n_i}{\Delta n_i + N n_i} = \frac{(\Delta_i N / \Delta n_i) - 1}{(N n_i / \Delta n_i) + 1} = \frac{\left(\frac{\Delta_i}{n_i}\cdot\frac{N}{\Delta}\right) - 1}{\left(\frac{N}{\Delta}\right)}$$

where superscripts *s* and *b* identify the value of the employment shares before the shock and after the shock, n_i and N are sectoral employment in *i* and total employment before the shock, and Δ_i and Δ are the changes in employment in sector *i* and in total employment after the shock. If the share changes for industry *i* (equation 1) are positive, then *i* is the absorption industry; otherwise *i* is a dissipation industry. To determine positive or negative share changes, we should examine only the numerator sign of (1). Therefore, we only have to examine this ratio:

(2)
$$\frac{\Delta_i}{n_i}\cdot\frac{N}{\Delta}$$

relative to unity. This ratio can be rewritten as $\left(\frac{n_i}{N}\right)^{-1} \cdot \left(\frac{\Delta_i}{\Delta}\right)$, the product of the employment share prior to the shock and the *shock-induced* employment share. If the shock-induced employment share maintains the same ratio as the share prior to the shock, then $\left(\frac{s_i^s - s_i^b}{s_i^b}\right)$ will not change. In this case, the structure of the economy will not be altered by the shock. If, however, the shock-induced employment share will exceed that of the base case $\left[\frac{\Delta_i}{\Delta} > \left(\frac{n_i}{N}\right)^{-1}\right]$, then the economic structure will shift toward the shock aided absorption industries $(s_i^s > s_i^b)$. Therefore, the shock will affect the distribution of the employment shares, and this effect can be absorption or dissipation aiding. As a result of the employment distribution change, the structure of the economy will change. Structural change can be described in the form of changes in employment distribution, as it was done above, or it can be described in the form of output changes.

In the following exposition, we will try to relate shock-induced structural change to output measures. As noted earlier, the shock affects output values first, then the changes in output prompt changes in demand for employment.

Transmission Mechanism

A growing share of exports will increase the shares of absorption industries measured in the form of output. Persistently growing shares of export will continuously increase the share of absorption industries and decrease the share of dissipating industries. How are employment shares affected if changes are measured in the form of output? If productivity does not change over time in respect to a shock (export change), then employment will change in direct proportion to output. In this case, the output analysis would be easily related to employment changes. However, employment productivity changes over time and in relation to the shock. In the 1980s, manufacturing productivity increased rapidly while the service sector did not exhibit any productivity gains in Chicago (see [5]).

Output is measured as revenue reported by companies in the region, aggregated to an industry level; productivity, as a ratio of output to labor, may change as a multifactor function. Productivity would increase if the import of intermediate goods increases, because more revenue can be produced while using less of a region's resources, including primary resources. In addition, increases in capital intensity would normally increase productivity. In addition, reduction of X-inefficiency (management inefficiency) may increase employment productivity. Change in technology may change productivity as well. All these factors are incorporated in the dynamics of change in CREIM.

If the shock to the whole economy were to be equally distributed over all outputs, then service employment would grow faster than the manufacturing employment because manufacturing productivity is growing over time in Chicago. In other

words, the output shock would be transmitted into employment growth, increasing service employment share at the expense of the declining share of manufacturing employment. To capture this transmission mechanism, we want to determine productivity change prior to the shock and after the shock:

$$\frac{x_i}{n_i} \sim \frac{x_i + \Delta_x}{n_i + \Delta_n} \tag{3}$$

where x and n are output and employment, and Δ with the corresponding subscript indicates a shock-induced change in output or employment. The change can be evaluated over time assuming all other variables are fixed, and hence this change is simulated with the shock. This relationship can be rewritten as

$$\frac{n_i + \Delta_n}{n_i} \sim \frac{x_i + \Delta_x}{x_i} \tag{4}$$

and denoting $\frac{x_i + \Delta_x}{x_i} = \Delta x_i$ as the output percentage change and Δn_i as the employment percentage change, we can define the elasticity of employment change, over output change for sector i:

$$E_i = \frac{\Delta n_i}{\Delta x_i} \tag{5}$$

If $E_i = 1$, then changes in output would bring about the same percentage change in employment; if $E_i > 1$, then the change in output will create greater changes in employment, and similarly if $E_i < 1$, a change in output will result in a smaller percentage change in employment. In order to establish the relative gain or loss of sector i's employment in relation to the whole economy, we have to compare output changes to employment changes:

$$\frac{\Delta x_i}{\Delta X} \sim \frac{\Delta n_i}{\Delta N} \tag{6}$$

where X and N denote the overall regional output and employment. All variables are changed due to the same shock in any single sector or set of subsectors. Next, in similar fashion to sectoral elasticity, we can determine the overall regional elasticity E. By dividing relative output change by the relative employment change (all resulted from the same shock), we will determine relative elasticity:

$$\frac{\Delta n_i / \Delta N}{\Delta x_i / \Delta X} = \frac{\Delta n_i / \Delta x_i}{\Delta N / \Delta X} = \frac{E_i}{E} = \varepsilon_i \tag{7}$$

The shock-induced output (Δx_i) will affect all sectors of the economy. Since industries vary in terms of labor intensities, the effect on employment can be consider-

ably different from that on the output. Therefore, small changes in the output share can be translated to a great change in employment share. For example, if a steel processor utilizes capital-intensive technology while its economic cluster is labor intensive, then its ε_i can be considerably smaller than unity. As a result, a change in output of this sector may not affect the output distribution in the economy but it will instead affect the employment distribution. The effect will be an increased share of employment in all other sectors, or decrease of $\left(\frac{\Delta n_i}{\Delta N}\right)$, steel sector's share of employment. In this example the steel sector will "transmit" demand for its product into employment in other sectors. If $\varepsilon_i < 1$, then the relative change in employment *i* exceeds that of output. Therefore, the shock aides sector *i*'s employment by a greater percentage than the overall employment relative to output changes.

Another way of interpreting ε_i is to consider changes in employment productivities; if productivity (as a result of the shock) in *i* declines relative to the productivity change in the overall economy, then $\varepsilon_i < 1$. Transmission elasticity ε_i measures labor intensity changes in one sector relative to the whole economy.

We have estimated that the service sector in Chicago has an $\varepsilon_i > 1$ which increases over time while the manufacturing sector decreases over time and $\varepsilon_i < 1$ (see [2]). This means that the shock to the manufacturing sector would increase employment in the overall economy by a greater percentage than the shock effect on output, while the service sector would have the opposite effect. In other words, in the case of an equal change in manufacturing and service outputs, the service sector employment will benefit by more than twice the amount relative to manufacturing employment.

Now we can express employment share changes $\left(\frac{s_i^s - s_i^b}{s_i^b}\right)$ through output changes. Changing the notation in equation 1 as $\Delta_i \equiv \Delta_{n_i}$ and $\Delta \equiv \Delta_N$, then utilizing the transmission elasticities notion, we can rewrite equation 2 as:

$$\frac{\Delta_{n_i}}{n_i} \cdot \frac{N}{\Delta_N} = \varepsilon_\iota \left[\frac{\Delta x_i}{\Delta X} \cdot \left(\frac{n_i}{N}\right)^{-1} \right] \tag{8}$$

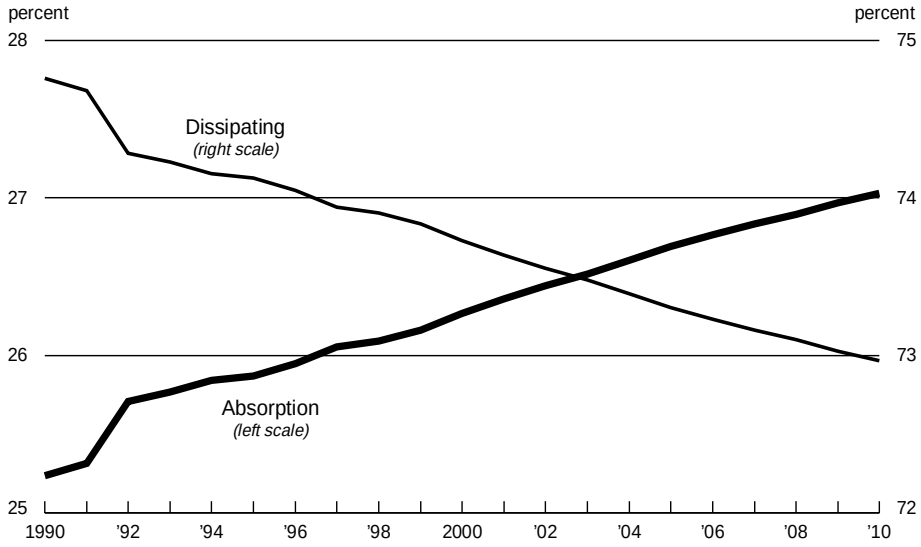
In this case, the shock-induced output change in *i* is related to the base labor ratio, $\left(\frac{n_i}{N}\right)$. If the shock-induced output share of *i* exceeds the corresponding employment share, then the economic structure will shift toward the absorption industries if we assume $\varepsilon_i = 1$. The transmission elasticity will amplify the structural shift if $\varepsilon_i > 1$, or dampen and possibly reverse the structural shift if $\varepsilon_i < 1$.

Chicago experience

To illustrate the approach presented above, we first consider the impact of exports from a single industry—food and kindred products. Afterwards, the impact of all manufactured goods exported from the Chicago SMSA is estimated.

In 1994 foreign exports from Illinois in the food and kindred products sector, SIC 20, amounted to 2.8% of total revenues. Assuming that this figure holds roughly for Chicago, the food and kindred products sector was continuously shocked during the years 1990 to 2010 with an export demand of 2.8% of producers' annual revenue. With the shock, manufacturing and nonmanufacturing industries formed a total of 10 absorption sectors out of a possible 53 sectors in the entire Chicago economy. Interestingly, 9.7% of the shock-induced revenue of the absorption sectors could be attributed to nonmanufacturing industries, the remaining effect occurring in manufacturing sectors. In terms of employment though, the difference between manufacturing and non-manufacturing sectors is even more drastic: 60.3% of employment of the absorption sectors were manufacturing while 39.7% were in nonmanufacturing sectors. The employment share gains in all of the absorption industries are presented in figure 1. In 1994 the overall employment gain in food and kindred products was 2,030 workers; the indirect effect on the rest of the absorption sectors was 2,270 jobs. Dissipating industries exhibited an employment share decline due to the shock as

Figure 1 SIC 20 Impact: Employment Share Change



shown on the same graph, although the required employment amounted to 3,260 workers. In order to support the expansion of the food and kindred products sector in the form of 2,033 workers, the absorption sectors should be ready to find an additional 2,270 employees. This translates to an additional demand of occupations. The occupational distributions are presented in table 1. Notice that although the industrial mix between the absorption and dissipation sectors is quite different, the occupational distribution for the two appears to be quite similar. This similarity might be due to aggregation bias. If they are similar, then this would imply that to support an expansion of food and kindred product exports in terms of occupational capital would be an easy task due to the small occupational disparity between absorption and dissipation groups.

Overall, we estimate that foreign manufacturing exports from the Chicago region in 1994 consisted of $10.8 billion in constant 1992 prices. The entire vector of manufacturing exports was used to shock the model, which then formed a set of absorption and dissipation industries. Although all the direct shocks were allocated to the manufacturing sectors, many of the absorption industries are nonmanufacturing. With nonmanufacturing absorption industries present, proper industrial policy for the manufacturing sector should extend to nonmanufacturing sectors. That is, nonmanufacturing growth is in fact a precondition for manufacturing export growth, assuming nonmanufacturing imports are too costly.

Table 1 SIC 20 Impact: Occupation Allocation—1994

	Thousands			Percent		
Occupation	**Absorp.**	**Dissip.**	**Total**	**Absorp.**	**Dissip.**	**Total**
Professional speciality	0.44	0.35	0.79	10.3	10.7	10.5
Executive, administrative, and managerial	0.51	0.36	0.87	11.8	11.2	11.6
Technical, sales, service, and administrative/clerical	2.09	1.79	3.88	48.6	55.0	51.3
Precision production, craft, and repair	0.36	0.35	0.71	8.4	10.6	9.4
Operators, fabricators, and laborers	0.84	0.38	1.22	19.6	11.6	16.2
Agriculture, forestry, and fishing	0.05	0.03	0.08	1.2	0.9	1.1
Totals	4.30	3.26	7.56	100	100	100

Table 2 Total Manufacturing Export Impact: Occupational Allocation

	1994			2010			Change		
Occupations	**Absorp.**	**Dissip.**	**Total**	**Absorp.**	**Dissip.**	**Total**	**Absorp.**	**Dissip.**	**Total**
Professional speciality	10.89	16.13	27.02	8.01	15.87	23.87	–2.89	–0.26	–3.15
Executive, administrative, and managerial	13.00	16.87	29.88	9.40	15.03	24.43	–3.60	–1.84	–5.45
Technical, sales, service, and administrative/clerical	50.68	82.22	132.89	37.91	71.45	109.35	–12.77	–10.77	–23.54
Precision production, craft, and repair	22.06	11.89	33.95	16.97	9.76	26.74	–5.09	–2.12	–7.21
Operators, fabricators, and laborers	41.76	12.80	54.56	29.11	10.36	39.48	–12.65	–2.43	–15.08
Agriculture, forestry, and fishing	0.79	1.61	2.40	0.57	1.55	2.12	–0.22	–0.07	–0.29
Totals	139.19	141.51	280.70	101.98	124.02	225.99	–37.22	–17.50	–54.71

	Percent			Percent		
Shares	**Absorp.**	**Dissip.**	**Total**	**Absorp.**	**Dissip.**	**Total**
Professional speciality	7.8	11.4	9.6	7.9	12.8	10.6
Executive, administrative, and managerial	9.3	11.9	10.6	9.2	12.1	10.8
Technical, sales, service, and administrative/clerical	36.4	58.1	47.3	37.2	57.6	48.4
Precision production, craft, and repair	15.9	8.4	12.1	16.6	7.9	11.8
Operators, fabricators, and laborers	30.0	9.0	19.4	28.5	8.4	17.5
Agriculture, forestry, and fishing	0.6	1.1	0.9	0.6	1.2	0.9

In 1994 the estimated employment required to support manufactured foreign exports from Chicago amounted to 6.3% of total employment; by 2010 this figure falls to 4.1% of total employment. This employment share decline, in spite of a projected revenue increase, results largely from forecasted productivity gains. Of interest, though, during this time period, four industries switched from the dissipation to the absorption group, one of which was a nonmanufacturing industry. This shows that absorption and dissipation groups are quite stable over time. With these and other structural changes, such as Chicago's dramatic shift away from a manufacturing-based economy (see [2]), come necessary changes in the region's portfolio of occupational capital. Table 2 shows the occupational distribution in 1994 and 2010 for absorption and dissipation industries. The 2010 industry groupings have been adjusted for the four sectors that switched classifications. As previously mentioned, the occupations are ordered roughly by their required level of formal education, from most to least. In 1994 dissipating industries represented a more skilled labor force with over 81% of employment in occupations generally requiring some postsecondary school training. Conversely, absorption industries had over 46% of employment in occupations requiring either employer-provided training or no formal training.

Conclusion

We started this paper with a discussion of the impact of exports on the occupational capital of a region; then we presented the framework within which this impact was estimated. The export-induced impact was estimated for the Chicago region, and we found that only 6.3% of Chicago's occupational capital is related to foreign manufacturing exports. As a matter of fact, nonmanufacturing sectors experienced a larger employment impact than manufacturing sectors. This leads us to an important conclusion that in the efforts to make regions more competitive so that producers of export would continue to expand their facilities, a region should develop a set of support facilities in the sense of the industries that are not technologically related to the exporting industries. However, this is not a development of the variant of "build them and they will come" but a recognition of the importance of regional interdependence as an important component of a region's comparative advantage.

Preparation of occupational capital is one of the primary factors that enhances regional competitiveness. The fact that a larger portion of education is funded by the public and education is a long-term process may result in discrepancies between the supply of occupations and demand by private and public sectors. In many instances, educational institutions have to align educational plans with the future regional demand for occupations. Since exports are exogenous factors for the regional economy, one has to use knowledge of the structure of interactions to prepare the region for anticipated changes in export. The process of adaptation is an ongoing one as occupational demands are likely to shift many times over the course of 15 to 20 years. A forecasting capability becomes essential because adjustments cannot be made instantaneously.

Footnotes

[1] Foreign export data were obtained from the MISER. These data were developed by the Massachusetts Institute for Social and Economic Research. For the detailed description, see Hayward and Erickson, 1995 ([1]).

References

[1] Hayward, J.D., and R.A. Erickson. 1995. The North American Trade of U.S. States: A Comparative Analysis of Industrial Shipments, 183-91. *International Regional Science Review* 18: 1-31.

[2] Schindler, G., Israilevich, P., and G. Hewings. 1995. Chicago's economic transformation: Past and future. *Economic Perspectives*, Federal Reserve Bank of Chicago, 19, No. 5, 2-9.

[3] Sonis, M., Hewings, G.J.D., Guo, J., Israilevich, P.R., and G.R. Schindler. 1997. The hollowing-out process in the Chicago economy, 1975-2015, *Assessing the Midwest Economy Working Paper Series*, No. GL-7, Federal Rerserve Bank of Chicago.

[4] Israilevich, P.R., and R. Mahidhara. 1990. Chicago's Economy: Twenty years of structural change. *Economic Perspectives*, Federal Reserve Bank of Chicago, 14, No. 2, 15-23.

[5] Israilevich, P.R., and R. Mahidhara. 1991. Hog butchers no longer: 20 years of employment change in metropolitan Chicago. *Economic Perspectives*, Federal Reserve Bank of Chicago, 15, No. 2, 2-13.

[6] Richardson D. J., and P.J. Smith. 1995. Sectoral Growth Across U.S. States: Factor Content, Linkages, and Trade. *NBER Working Papers*. No. 5094.

[7] Simpson, D., and J. Tsukui. 1965. The fundamental structure of input-output tables: an international comparison. *Review of Economics and Statistics*. 47. 434-46.

[8] Hewings, G.J.D., Israilevich, P.R., Sonis, M., and Schindler, G.R. (1997) Structural Change in a Metropolitan Economy: The Chicago Region 1975-2011, in C.S. Bertuglia, S. Lombardo, P. Nijkamp (eds.) *Innovative Behavior in Space and Time*, Springer-Verlag, Berlin.

[9] Israilevich, P.R., Hewings, G.J.D., Sonis, M., and Schindler, G.R. 1997. Forecasting Structural Change with a Regional Econometric Input-Output Model, *Journal of Regional Science*, Issue 4, Dec., Vol. 37, pg. 565-590.