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# MINIMIZING EMPLOYMENT INSTABILITY: A MODEL OF INDUSTRIAL EXPANSION WITH INPUT-OUTPUT CONSIDERATIONS

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## Introduction

The potential for pronounced economic prosperity and decline exists for regional economies that rely on a dominant industry or industries. Connecticut, for example, is a state that has experienced economic prosperity from reliance on a dominant industry. Its dependence on the defense industry has been documented and discussed frequently in academic, political, and business arenas (Bean, 1988; Browne, 1990; Henderson, 1990; Wundt, 1991). Not only have the two major defense-related industries (aircraft and aircraft parts and ship and boat building) benefited directly in terms of employment from this reliance, but many production-related industries have experienced relative employment stability during times of increased federal expenditures on defense. With the post-Cold War era a reality, Connecticut's policy makers are faced with the question of which industries they should encourage to expand in order to assist the state in its transition from a defense-dependent economy to one that is more diversified in its production of goods and services. Their primary concern is to seek the expansion of industries that are not only compatible with the existing economic structure of the state, but those that will continue to promote economic stability.

Encouraging the expansion of cyclically stable industries is one of many objectives that state policy makers may have. Others include financial assistance to communities and individuals that are dependent on defense contracts and labor retraining.[1] Expanding the employment base by creating a more favorable climate for the manufacturing sector is an often-cited objective, however, especially during times of eco-

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[1] While interesting and important, a discussion of multiple objectives and the related political issues is beyond the immediate scope of this paper.

nomic recession.[2] The model developed here will provide policy makers more focus in their efforts to encourage economic growth.

## Purpose

The purposes of this paper are twofold. The first is to develop a model that will help identify industries that may be encouraged to expand in order to promote growth and stability in state employment. The second is to examine the relationship between the proposed industries and their general industry characteristics, such as historical growth and variance in employment.

## The Model

*Minimizing Cyclical Instability*

It is assumed that state policy makers are interested in encouraging the expansion of industries that will promote cyclical stability. Therefore, the objective of the model is to minimize the cyclical variation in overall state employment. The variance of industry employment is assumed to be the appropriate measure of instability to minimize.

The model is structured similar to a portfolio optimization model found in the financial literature. An advantage of employing this approach is its ability to account explicitly for interindustry variations. Measuring instability by recognizing both individual industry variability and interindustry covariation has been shown to be an empirically significant gauge of overall instability (Conroy, 1975). The basic model can be written as:

(1) $\min \sigma_p^2 = X(V)X'$

subject to

(2) $TE = \sum_{i=1}^{n} X_i$

where:

| | | |
|---|---|---|
| X | = | A row vector (1 × n) of industry employment; |
| V | = | The variance/covariance matrix (n × n); |
| X' | = | The column vector (n × 1) of industry employment; and |
| TE | = | Total employment. |

[2] This theme was stressed at a recent conference sponsored by the Connecticut Business and Industry Association and in articles appearing in the *Hartford Courant*, October 11 through October 15, 1992.

The elements of the matrix (V) are the interindustry variance/covariance terms of detrended employment. Because trend is viewed as predicted movements in each employment series (and not as a source of instability for policy makers to minimize), a log-linear model is used to detrend each industry's employment.[3] Equation (2) is equivalent to the fully invested constraint in a portfolio context, ensuring the region's industrial employment (TE) is expended fully. The model will determine the levels of employment in each industry that will minimize overall cyclical instability in the state.

**Input-Output Considerations**

While a detailed analysis of interindustry fluctuations may provide further understanding of overall instability, this approach alone cannot provide a solution to the problem of reducing economic fluctuations of regions. The process of reducing instability in a regional context involves the expansion or reduction in physical resources of industries within the region. While a certain degree of resource mobility and divisibility must be assumed (to be discussed below), practical considerations of input acquisition, production, and the sale of output also must be considered if this process is to provide feasible results. These considerations require additional interindustry information, such as that provided by the input-output (I-O) relationships among industries. Incorporating interindustry production/consumption linkages in the model will help address the question of feasibility of proposed model solutions by enabling us to evaluate the impact of specific industry increments or general industry expansion on the existing regional economy.

For the present application, the I-O table is incorporated into the model as an additional constraint in the following manner. Expressed in the usual I-O format, a region's industrial structure can be represented by the following relationship:[4]

(3) $(I - A)B = F$

where:

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[3] It is of the form: $\ln Y = a + b(t)$, where $\ln Y$ is the natural log of industry employment, t is a time variable from 1964 to 1983, and a and b are parameters to be estimated. A cyclical series for each industry is calculated as actual employment minus estimated employment, both in natural logs.

[4] The development of the state I-O table and its incorporation into the model follow the methods developed by Cho and Schuermann (1980) and Latham and Montgomery (1979).

$I$ = An identity matrix;
$A$ = A matrix (n × n) of direct requirements;
$a_{ij}$ = The amount of input required from industry i to produce one unit of output of industry j;
$B$ = A column vector (n × 1) of each industry's base period total output; and
$F$ = A column vector (n × 1) of base period final demand.

Because the units in this analysis are expressed in employment, the interpretation of coefficient $a_{ij}$ is the employment requirement in the ith industry to sustain one employee in the jth industry. Similarly, F is expressed in employment terms (all consuming sectors other than intermediate demand consisting of personal consumption expenditures, gross private domestic investment, changes in inventory, exports, imports, and government purchases).

Because the optimization model is concerned with assessing the impact of changes in industry magnitudes, a similar relationship based on the new levels of industry employment can be expressed as:

(4) $(I - A)X = \hat{F}$

where:

$\hat{F}$ = A column vector (n × 1) of new final demand; and
$X$ = The vector (n × 1) of new industry output levels.

Because the values in the new final demand vector cannot be projected precisely, constraints representing the technological relationships are incorporated into equation (4) as:

(5) $(I - A)X >= F$

where:

$\hat{f}_i$ is >, =, or < $f_i(1+g_i)^t$; and
$g_i$ = The growth rate for industry i.

The individual industry growth rates can be determined from actual employment growth between the years considered. Based on this rate, an upper and lower bound is placed on each industry's employment that reflects industry growth trends and provides flexibility for the model when determining optimal industry employment levels.

The full model is given as:

$$\min \sigma_p^2 = X(V)X'$$

$$\text{subject to } TE = \sum_{i=1}^{n} X_i \text{ and } (I - A)\, X \geq F.$$

The solution to the optimization problem enables us to measure the impact of various expansions on each industry through exogenous changes in final demand.

## Empirical Analysis

*Simulations*

Several simulations of the model based on alternative assumptions of employment growth in the State of Connecticut are examined, allowing a comparison of the base employment levels (1977) with the solutions under alternative scenarios.[5] The purpose of these simulations is to determine the industry solutions that would provide minimum overall instability given a desired growth in total employment; these solutions are constrained by the production relationships between industries and actual growth rates of final demand. From a policy perspective they may provide state policy makers information on which industries may be encouraged to expand (and firms may be identified by their SIC codes). In that the model can provide some guidelines for policy makers, it reduces some of the risk associated with this activity.

Eighty-one manufacturing sectors at the three digit SIC level are included in the model.[6] Only the manufacturing sector is included because most regional studies have shown that manufacturing industries are typically the source of greatest instability (Borts, 1961; and Conroy, 1974 and 1975). A study of the Connecticut economy indicates that inclusion of the service sector would not offset the cyclical behav-

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[5] The optimization program employed is GINO (general interactive optimizer), by The Scientific Press, Palo Alto, California. The first simulation tests the full model run with the final demand vector values ($f_i$) set equal to their 1977 levels. Thus, the model will determine the objective function value with each industry's actual employment levels (both final demand and total employment specified) for the base period. Additionally, due to the substantial data requirements, this step also serves as a test to ensure the solutions provided by the model equaled the actual solutions. The model's solution for total employment only deviated one-fifth of 1 percent from actual, with the surplus variable in the employment constraint.

[6] Annual manufacturing employment data for Connecticut for the 1964-1983 interval are obtained from *County Business Patterns (CBP)*. To be most useful for this study, the greatest level of detail possible was desirable. Due to disclosure laws, employment information for 81 industries is the most disaggregated level that could be obtained.

ior of the manufacturing industries (Wundt, 1992). Furthermore, while some studies have suggested that producer services can be an important source of increased per capita income (Hansen, 1990), other studies propose caution for public policy initiatives in this area (M. Perry, 1991).

It is necessary to build an I-O table for the state based on the 81 three digit industries listed in Table 1. The base table from which it was built is the 1977 United States table. (While the details of the table's construction are too lengthy to describe here, essentially a state table was built using a modified location quotients method and then converted into employment terms.[7]) Total employment in each industry also is reported in Table 1.

The employment bounds placed on each industry's final demand are based on the actual growth rates that occurred in each industry from 1972 through 1983. The estimated employment value of final demand is determined by adjusting the benchmark year's (1977) value of final demand by the historical growth rate in total employment. The lower and upper bounds on final demand are set equal to the minimum and maximum values of estimated final demand over the period studied.

Due to the many demands imposed by the I-O constraints, the fixed constraint, equation (2), is converted to a soft constraint, allowing for a slight deviation from the strict equality. The equation becomes:

$$(6)\ TE + S = \sum_{i=1}^{n} X_i$$

where:

TE = Total employment for 1977 (TE = 377,969); and
S = An artificial surplus variable.

Three simulations are presented in this section. The first assumes manufacturing employment will grow at approximately 1 percent per year for five years. This would increase total employment to 397,249

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[7] See Wundt (1988, appendix 5) for details of table construction. In addition to the usual I-O assumptions (see Richardson, 1972, for example), converting the table from dollar to employment terms requires the additional assumption that employment is proportional to sales. Also, because the I-O coefficients are based on the 1977 table, structural change is assumed to be unchanged from 1977. The table's inclusion into the model provides some sense of interindustry technological relationships that should be only marginally dependent on cyclical effects (Holland and Cooke, 1992). While an I-O table is not a perfect tool, especially at the regional level, it permits a more feasible solution to the problem of reducing instability.

(397,249 = 377,969 *$[1.01]^5$). A second scenario is more optimistic, assuming a 1 percent increase in total employment for ten years. This results in a level of employment of 417,513 (417,513 = 377,969*$[1.01]^{10}$). The third case assumes a reduction in total employment from its 1977 level. There had been a slightly negative growth trend in actual manufacturing employment from 1964 to 1983 (-0.45 percent per year). The reduction in total employment in the negative growth case is slightly less than 3 percent. Despite the decline in manufacturing employment relative to total employment, the model still provides useful information to state policy makers.

In addition to the assumptions of resource redistribution and divisibility stated earlier, a net change in resources is required to fulfill the proposed solutions. Divisibility assumes it is possible to change industry employment in increments that enable optimization to be achieved. This is strict, and it may not be desirable if multiple objectives are considered. Homogeneity implies that labor (and other resources) can change between industries as prescribed. These assumptions are not too prohibitive, however, to prevent the model from yielding results worthy of consideration. Economic theory predicts that there will be a transfer of labor among industries. Depending on the degree of fungibility of skills, firms provide retraining of labor, as does the state. While certain incremental changes in resource use may not be possible, the solutions still provide policy makers a candidate list of industries that may be encouraged to grow, approximating the direction of the proposed solutions. Furthermore, because the proposed growth solutions do not imply an immediate realignment of resources, optimal solutions may be approached over time.

The solutions appear in Table 2. The table is presented according to the percent changes in employment relative to the 1977 base levels. The 5 percent growth model (column 2) provides a reference in that industries are ranked according to their percent change over their base levels. For example, the largest percentage increase in employment would come from SIC 273 (books) and the next largest from SIC 2499 (other wood products), and so on. The remaining columns present the solutions of the 10 percent growth and the negative growth scenarios in relation to the order of SIC categories of the 5 percent solution.

A number of points may be made based on these results. First, the 5 percent growth solutions do not seem to favor an increase or decrease in the (broadly defined) durable goods industries relative to nondurables. Of the first 21 industries proposed to increase, ten are nondurable and 11 are durable. Of the 20 industries with the greatest proposed decrease (the last 20), eight are nondurable, and 12 are durable. This result may arise from the fact that while the durable goods industries have, on average, greater individual cyclical instability (the average detrended variance for durable goods is 1.5 times that of nondurables), the durable goods industries share more zero and negative covariance terms with other industries (the average rank for durables is 1.4 times that of nondurables).[8] The greater the number of zero or negative variance terms an industry has with the remaining industries means that the industry will not pull a significant number of industries in the same direction, even if it possesses a large variance term. This suggests the potential ability of an industry to promote stability within the region despite its durable or nondurable classification.

Second, it is impossible to suggest from the results that there is a pattern of any particular broadly defined group of industries to either increase or decrease. Among the first 20 industries to increase, three belong to the industry group SIC 36 (electronic and electrical equipment—SIC 366, SIC 362, and SIC 361). Among the 20 industries suggested to decrease, three belong to the SIC 36 (SIC 363, SIC 365, and SIC 369). This suggests it may be misleading to generalize about the stability characteristics of three digit industries based on the two digit group to which they belong.

Third, from the overall expansion given in the total employment constraint, the industries solutions are affected by the direct requirement coefficients of the I-O constraints. Each industry's expansion is consistent with the production/consumption linkages between industries required by that expansion. The solutions reveal that there is no linear progression of changes in industry employment among growth scenarios. In some instances, an industry proposed to increase under one alternative becomes one to decrease under another. For example, under the 5 percent growth scenario, employment in the periodicals (SIC 272), weaving mills (SIC 222), and watches and clocks (SIC 387) industries should decrease to improve stability. Under the 10 percent growth scenario, however, the model proposes an increase in employment in these same industries to promote overall stability.

Finally, the results are also sensitive to the bounds placed on the values of final demand. A comparison of solutions between alternative scenarios reveals that proposed changes in industry employment levels are identical. This may be due to a binding final demand constraint; the solutions may differ if, for example, a wider range was defined for the 10 percent growth alternative (or a narrower range defined for the 5 percent growth scenario). The final demand values (and ranges) are selected to represent influences exogenous to the state's economy, however, and cannot be changed arbitrarily without the model losing some of its

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[8] The number of zero and negative covariance terms each industry has with the remaining industries was determined from the variance/covariance matrix of equation (1).

practical merit. The solutions for industry employment under each scenario are determined when the constraints (of which final demand values are a part) are binding. While further simulation assumptions are possible, the present analysis is limited without further knowledge of what ranges final demand values should assume.

The sensitivity of a one unit change in final demand employment on overall instability also is investigated. The marginal impact of each industry change ranges from -0.0027 to +0.00043. A ranking of industries by their marginal impact is associated positively with the ranking of industries according to the number of zero and negative covariance terms an industry has with other industries. The latter ranking measures the industry's ability to offset overall instability. The marginal impact ranking also is correlated negatively to a ranking of industries by individual variances. Therefore, the smaller the individual variance of an industry, the greater is its marginal impact on decreasing overall instability.

As for the impact of these scenarios on the overall stability of the model, there is a slight increase of 0.94 percent in stability (as measured by the portfolio variance) between the base model and the 5 percent scenario and a decrease of 3.0 percent between the base solution and the 10 percent scenario. When a comparison is made to the actual portfolio variances (those calculated with actual industry employment for the final year, 1982), the proposed solutions decrease the overall instability significantly. If the state's economy were represented by the solutions proposed by the 5 percent growth scenario, a net decrease in employment instability of 17.5 percent would have been realized. If we compare the difference between the 10 percent scenario variance and the 1982 actual variance, a net decrease in employment instability of 19.5 percent would have been realized. In either of the growth scenarios, there is a substantial decrease in the region's overall instability. According to the negative growth scenario, there would be a 3.30 percent decrease in instability from the base employment if the state industries assumed the proposed levels.[9] For comparison, between 1977 and 1982, an increase of 20.5 percent in actual employment instability occurred.

As a final note, a word of caution must be sent to policy makers interpreting the results. While the solutions present a menu of candidate industries, there are limits to the benefits implied by them. For example, while SIC 273 is shown to have a stabilizing effect on the state's manu-

[9] Another model simulating a 10 percent decrease in employment in SIC 372 (aircraft and parts) and SIC 3799 (miscellaneous transportation equipment, i.e., ship and boat building) shows that if the state industries assumed the proposed employment levels, there would be a decrease in variance of 2.48 percent over the 1977 level.

facturing economy, this does not imply that ad infinitum increases in this industry will produce proportional increases in stability.

*Industry Solutions and Characteristics*

Given the proposed solutions, two issues related to the study of regional economic stability may be examined. The first is the relationship between overall stability and individual industry stability, and the second is overall stability and the growth rates of industries in the region. Researchers have taken sides on either of these issues (Thompson, 1956; Borts 1961; Richardson, 1969; and Conroy, 1974).

One argument is whether regions can reduce instability by expanding industries that tend to be cyclically stable, particularly those exhibiting stability at the national level. Another is whether rapidly growing industries tend to promote regional instability. While theoretical arguments exist to the contrary, it has been shown that industries that promote stability in one region may be destabilizing in another (Conroy, 1974) and that rapid growth does not necessarily promote instability (Borts, 1961). Because the model provides estimates of industries to expand that promote cyclical stability, a final empirical test is conducted to see the correlation between the proposed solutions and individual industry stability and growth.

Table 3 presents the results of rank correlations that estimate the relationship between rankings of industries based on the objective of minimizing cyclical instability and several industry characteristics.[10] Rankings of industries based on the proposed solutions were correlated with rankings of industries by

- Individual industry variance as a measure of absolute historical employment variations (1977);
- The coefficient of variation as a relative measure;
- Average industry growth rates from 1972 to 1983;
- Average industry size;
- Detrended variance as a measure of cyclical instability; and
- The number of zero and negative covariance terms with the remaining industries (1977).

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[10] The correlation coefficients are estimated using a nonparametric rather than a parametric technique. While coefficients based on the latter provide a better measure of the magnitude of the relationship between two series, this approach was not employed for several reasons. First, the bounds placed on each industry affect the final solutions or employment magnitudes. These solutions would differ if the bounds changed. Thus, correlation coefficients based on magnitudes would vary depending on how the bounds changed. Second, from a policy approach, identifying industries that are candidates for expansion or contraction is the major interest. The model provides guidelines and is not intended to offer a policy whose prescription is to increase an industry by a finite amount. Use of the rank correlation coefficient better satisfies this objective.

Correlation coefficients are based on the proposed solutions for the 10 percent and 5 percent growth models.

It can be seen from the table that a greater correlation exists between the proposed solution rankings and rankings of industries based on coefficient of variation, size, and number of zero and negative covariances than between the solution rankings and rankings of industries by variance, growth rates, and cyclical variance. While inferences based on this analysis must be made with caution, several points may be noted. First, with the exception of size, the magnitude of the coefficients between industry characteristics and the 10 percent solution are larger than their counterparts of the 5 percent solution. One interpretation of this is that over a period of greater growth, as implied by the 10 percent scenario, these characteristics play a more significant role in influencing the stability of the region. Second, industry size is a significant factor in the region's stability. This is because large industries tend to exhibit greater instability in absolute employment than smaller industries. Third, industries with smaller relative employment variations, as measured by the coefficient of variation, tend to promote stability in overall employment. And fourth, the way an industry interacts with the remaining industries may be a more influential factor in overall regional stability than individual industry variance over a longer period of growth. An individual industry may have a large historical variance, but its overall contribution to regional instability may be reduced if its cyclical behavior is offset by the cyclical behavior of many of the remaining industries.

## Summary and Concluding Remarks

This paper has developed an industrial expansion model, the purpose of which is to minimize overall instability in regional employment. Using the State of Connecticut as an example, the model provides regional policy makers a slate of candidate industries to expand that would promote employment stability. Given forthcoming reductions in federal defense expenditures that are likely to have sizable employment effects on the many defense-related industries in Connecticut, the model solutions provide an initial slate of alternative industries for expansion consideration under these conditions. Connecticut's Department of Economic Development, which currently provides financial incentives such as tax breaks, grants, loans, and utility rate reductions to companies, could funnel their efforts into these industries.

The solutions proposed by the alternative growth scenarios are constrained by the technical I-O relationships among industries. While the model is structured in a portfolio variance-minimizing framework, the production/consumption relationships contained in the I-O equations provide a more practical evaluation of industrial expansion within the region. A significant decrease in overall regional instability would have resulted if the proposed industry employment solutions were realized rather than the actual employment in each industry when compared to the base year.

Correlation coefficients based on the proposed solutions and certain specific industry characteristics are estimated. It is found that industry size, relative employment variation, and the number of zero and negative covariance terms tend to be correlated more closely with those industries proposed to increase than absolute variance, individual cyclical variation, and growth rates. These relationships are found to be more significant over a longer period of growth.

Increasing the employment base is the most often-cited goal of state policy makers. The model described in this paper identifies industries that have the potential to expand employment (5 percent and 10 percent growth scenarios) while increasing cyclical stability. Further study on other characteristics of these industries is needed, however. For example, is there a trade-off between expansion of lower wage, less cyclical industries relative to higher wage, more cyclical industries? As the Connecticut work force is characterized as high skilled and well-education and because incomes are related primarily to productivity, the effect of such a trade-off may be small in states such as Connecticut. Additionally, industries that benefit from such a labor force profile are more likely to expand or locate in the state.

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**Table 1—SIC Short Titles and State Manufacturing Employment Levels**

| SIC | Short Titles | Total Employment |
|---|---|---|
| 202 | Dairy Products | 1998 |
| 203 | Preserved Fruits and Vegetables | 262 |
| 205 | Bakery Products | 4335 |
| 208 | Beverages | 1352 |
| 2099 | Other Food and Kindred Products | 2897 |
| 21 | Tobacco Products | 287 |
| 222 | Weaving Mills, Synthetics | 1369 |
| 225 | Knitting Mills | 1636 |
| 228 | Yarn and Thread Mills | 2480 |
| 229 | Miscellaneous Textile Goods | 1684 |
| 2299 | Other Textile Products | 2396 |
| 232 | Men's and Boy's Furnishings | 1573 |
| 233 | Women's and Misses' Outerwear | 5668 |
| 234 | Women's and Children's Undergarments | 994 |
| 238 | Miscellaneous Apparel and Accessories | 1004 |
| 239 | Miscellaneous Fabricated Textile Products | 1850 |
| 2399 | Other Apparel Products | 811 |
| 243 | Millwork, Plywood & Structural Members | 729 |
| 244 | Wood Containers | 317 |
| 249 | Miscellaneous Wood Products | 309 |
| 2499 | Other Wood Products | 318 |
| 251 | Household Furniture | 2615 |
| 259 | Miscellaneous Furniture & Fixtures | 936 |
| 2599 | Other Furniture | 1336 |
| 264 | Converted Paper Products | 1686 |
| 265 | Paperboard Containers and Boxes | 3122 |
| 2699 | Other Paper Products | 2109 |
| 271 | Newspapers | 6338 |
| 272 | Periodicals | 1230 |
| 273 | Books | 716 |
| 275 | Commercial Printing | 7964 |
| 276 | Manifold Business Forms | 670 |
| 278 | Blankbooks and Bookbinding | 1132 |
| 279 | Printing Trade Services | 1422 |
| 2799 | Other Printing & Publishing | 1056 |
| 282 | Plastics Materials and Synthetics | 1080 |
| 284 | Soap, Cleaners, Toilet Goods | 2682 |
| 285 | Paints and Allied Products | 341 |
| 289 | Miscellaneous Chemical Products | 1299 |
| 2899 | Other Chemical Products | 7202 |
| 30 | Rubber & Miscellaneous Plastic Products | 14957 |
| 31 | Leather | 1392 |
| 323 | Products of Purchased Glass | 794 |
| 327 | Concrete, Gypsum, Plaster Products | 1360 |
| 329 | Miscellaneous non-metallic Mineral Products | 2653 |

**Table 1—SIC Short Titles and State Manufacturing Employment Levels (continued)**

| SIC | Short Titles | Total Employment |
|---|---|---|
| 3299 | Other Stone, Clay & Glass | 1701 |
| 331 | Blast Furnace & Basic Steel Products | 4325 |
| 335 | Nonferrous Rolling and Drawing | 10651 |
| 336 | Nonferrous Foundries | 1398 |
| 3399 | Other Primary Metal Industries | 2903 |
| 342 | Cutlery, Hand Tools, and Hardware | 12869 |
| 344 | Fabricated Structural Metal Products | 4695 |
| 345 | Screw Machine Products, Bolts, etc | 6965 |
| 346 | Metal Forgings and Stampings | 6693 |
| 347 | Metal Services | 2788 |
| 348 | Ordnance and Accessories, nec | 7023 |
| 3499 | Other Fabricated Metal Products | 9639 |
| 354 | Metalworking Machinery | 13953 |
| 356 | General Industrial Machinery | 16957 |
| 357 | Office and Computing Machines | 7942 |
| 3599 | Other Machinery Products | 15566 |
| 361 | Electric Distributing Equipment | 4962 |
| 362 | Electrical Industrial Apparatus | 2551 |
| 363 | Household Appliances | 3244 |
| 364 | Electric Lighting and Wiring Equipment | 7823 |
| 365 | Radio and TV Receiving Equipment | 567 |
| 366 | Communication Equipment | 6588 |
| 367 | Electronic Components and Accessories | 8586 |
| 369 | Miscellaneous Electrical Equipment & Supplies | 3508 |
| 372 | Aircraft and Parts | 49972 |
| 3799 | Miscellaneous Transportation Equipment | 27472 |
| 381 | Engineering & Scientific Instruments | 915 |
| 382 | Measuring and Controlling Devices | 6887 |
| 384 | Medical Instruments and Supplies | 6046 |
| 387 | Watches, Clocks, and Watchcases | 5474 |
| 3899 | Other Instruments and Related Products | 3606 |
| 391 | Jewelry, Silverware, and Plated Ware | 2972 |
| 393 | Musical Instruments | 655 |
| 394 | Toys and Sporting Goods | 1171 |
| 396 | Costume Jewelry and Notions | 4321 |
| 3999 | Miscellaneous Manufacturers | 4110 |
| TOTAL | | 377,969 |

**Table 2—Model Solutions for Sector Employment Under Alternative Growth Scenarios (% Changes From 1977)**

| SIC | 5% Growth Increase | 10% Growth Increase | 3% Growth Decrease |
|---|---|---|---|
| 273 | 114.36% | 114.40% | 114.35% |
| 2499 | 101.93 | 102.57 | 101.58 |
| 21 | 98.81 | 98.81 | -40.99 |
| 381 | 94.15 | 94.64 | -0.74 |
| 3299 | 86.78 | 87.28 | 86.10 |
| 229 | 66.48 | 67.89 | 63.49 |
| 362 | 64.68 | 69.35 | -1.56 |
| 327 | 62.73 | 62.79 | 62.64 |
| 366 | 55.84 | 55.84 | 0.69 |
| 234 | 54.58 | 54.58 | 54.58 |
| 244 | 48.94 | 52.03 | 46.74 |
| 289 | 44.46 | 47.61 | -4.64 |
| 394 | 43.52 | 43.55 | 43.52 |
| 2599 | 43.27 | 43.37 | 43.26 |
| 243 | 36.10 | 36.37 | 35.41 |
| 2299 | 35.46 | 39.40 | 34.80 |
| 31 | 32.82 | 33.53 | -0.45 |
| 238 | 32.58 | 32.58 | -16.59 |
| 3599 | 28.93 | 29.68 | -19.21 |
| 361 | 26.44 | 27.15 | 25.02 |
| 278 | 25.03 | 26.75 | 24.15 |
| 228 | 24.98 | 27.47 | 21.27 |
| 396 | 24.83 | 25.73 | 24.75 |
| 348 | 23.75 | 23.75 | 23.75 |
| 2799 | 22.30 | 22.65 | 21.81 |
| 382 | 22.02 | 36.98 | -31.28 |
| 202 | 21.86 | 21.86 | -27.14 |
| 356 | 21.80 | 22.38 | 19.77 |
| 354 | 21.60 | 22.44 | 20.11 |
| 259 | 20.88 | 20.89 | -46.66 |
| 205 | 17.90 | 17.90 | 17.85 |
| 279 | 16.92 | 27.74 | 16.37 |
| 275 | 16.51 | 22.23 | 15.60 |
| 265 | 16.31 | 20.89 | 11.90 |
| 251 | 15.92 | 15.93 | 15.83 |
| 2699 | 13.78 | 24.05 | 11.96 |
| 384 | 13.07 | 13.14 | 12.96 |
| 271 | 12.96 | 12.96 | 12.93 |
| 232 | 12.28 | 12.28 | 12.28 |
| 345 | 11.08 | 12.79 | 8.47 |
| 233 | 10.72 | 10.72 | 10.72 |
| 364 | 9.88 | 10.06 | 8.95 |
| 2899 | 9.53 | 11.77 | -14.00 |
| 329 | 8.97 | 14.20 | 0.41 |
| 367 | 7.96 | 11.11 | -15.90 |

**Table 2—Model Solutions for Sector Employment Under Alternative Growth Scenarios (continued)**

| SIC | 5% Growth Increase | 10% Growth Increase | 3% Growth Decrease |
|---|---|---|---|
| 2099 | 6.92 | 7.17 | 6.37 |
| 344 | 6.73 | 6.91 | 5.13 |
| 3999 | 5.42 | 7.11 | 5.06 |
| 3499 | 5.28 | 7.89 | -32.28 |
| 331 | 4.56 | 6.86 | -0.26 |
| 30 | 2.75 | 6.61 | -1.82 |
| 264 | 1.70 | 17.37 | 0.39 |
| 239 | 0.67 | 1.62 | 0.51 |
| 276 | 0.51 | 90.24 | -0.83 |
| 372 | -0.02 | -0.02 | -0.03 |
| 391 | -0.26 | 7.61 | -25.48 |
| 336 | -0.32 | 3.17 | -8.26 |
| 282 | -0.96 | 2.81 | -2.93 |
| 249 | -1.86 | -0.51 | -2.79 |
| 284 | -2.18 | 33.64 | -2.58 |
| 3899 | -2.39 | -2.20 | -2.61 |
| 3399 | -2.76 | 12.57 | -9.25 |
| 323 | -3.75 | 0.66 | -9.95 |
| 347 | -5.14 | -1.71 | -10.76 |
| 346 | -5.34 | -3.42 | -10.07 |
| 335 | -5.74 | 23.67 | -9.27 |
| 272 | -7.31 | 94.08 | -7.64 |
| 357 | -11.11 | -2.46 | -11.77 |
| 225 | -14.29 | -13.02 | -15.18 |
| 342 | -16.27 | -16.16 | -16.38 |
| 208 | -17.55 | -17.53 | -17.57 |
| 363 | -21.85 | 61.06 | -21.85 |
| 203 | -37.91 | -37.91 | -37.91 |
| 222 | -40.88 | 20.69 | -42.09 |
| 393 | -42.81 | 20.63 | -42.81 |
| 3799 | -43.72 | -43.70 | -44.10 |
| 285 | -44.82 | -44.11 | -45.35 |
| 387 | -53.06 | 5.16 | -53.69 |
| 2399 | -58.76 | 18.32 | -59.02 |
| 369 | -69.06 | -68.83 | -69.02 |
| 365 | -73.96 | -73.96 | -74.15 |
| AVERAGE | 5.25% | 10.62% | -2.65% |

**Table 3—Correlations Based on Ranking of Industries from Growth Solutions and Industry Characteristics**

| 10% Solution Rank and Rank of Industry Based on: | r | t |
|---|---|---|
| Variance | -0.091 | -7.222** |
| Coefficient of Variation | -0.268 | -22.875** |
| Growth | 0.049 | 3.898** |
| Size | -0.204 | -16.782** |
| Cyclical Instability | 0.083 | 6.623** |
| Negative and Zero Covariances | 0.104 | 8.260** |

| 5% Solution Rank and Rank of Industry Based on: | r | t |
|---|---|---|
| Variance | -0.059 | -4.712** |
| Coefficient of Variation | -0.112 | -8.938** |
| Growth | 0.021 | 1.690* |
| Size | -0.113 | -9.017** |
| Cyclical Instability | 0.017 | 1.317 |
| Negative and Zero Covariances | 0.016 | 1.283 |

Note: The rank correlation coefficient formula is $r = 1-[6 \Sigma d^2/n(n^2-1)]$, where n = 81 is the number of paired observations, and d is the difference between paired observations.

** Significant at the 1 percent level
* Significant at the 10 percent level

# PEDAGOGY AND REGIONAL SCIENCE

The editors of *Regional Science Perspectives* have decided to widen our commitment to publishing software reviews (see RSP, 1990, vol. 20, no. 2) of programs designed for classroom use in courses devoted to regional science in order to encompass a wider variety of pedagogic suggestions designed to improve the teaching and learning environment of these courses. We encourage our readers to submit their suggestions/techniques, etc. to be published in this section of the journal. While not undergoing the usual blind review process, the editors and editorial board will try to maintain a level of utility and clarity as well as a lack of redundancy in publishing submissions.