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TESTING REGIONAL IMPACT ANALYSES IN NOVA SCOTIA

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Introduction

This paper uses the recently completed Nova Scotia input-output system in an attempt to answer two questions regarding regional impact analysis. First, are results significantly influenced by detailed knowledge of trade patterns for the activities subject to analysis? And second, is the level of aggregation of the input-output model important to its conclusions?

We proceed as follows: The following section briefly describes the input-output system; the next section considers the analytic questions in more detail, along with alternative approaches to their resolution; the fourth section outlines our procedures; and the final section presents the results of our tests.

The Nova Scotia Input-Output System

The Nova Scotia input-output system for 1974 [2] is of the commodity-by-industry format used in the 1965 study [1] and in the Canadian input-output tables [3]. In worksheet form, it traces flows of 594 commodities and 8 primary inputs into 191 industries and indentifies the industry origins of each of these commodities. These flow and origin matrices have been aggregated to 64- and 32-sector levels with equal numbers of industries and commodities, in general accordance with the aggregation pattern used in the 1965 models.

The system yields a fixed-production-coefficient, fixed-market-share model of the economy, with a solution in industry terms commonly specified as

$$X = (I - D(I - \hat{M})B)^{-1}DY$$

where X is a vector of industry gross outputs, D is a matrix of market-share coefficients (showing commodity outputs as proportions of industry outputs), $\hat{M}$ is a diagonal matrix of commodity import coefficients, B is a matrix of production coefficients, and Y is a summary vector of exogenous demands for commodities. The inverted term corresponds to the $(I - R)^{-1}$ of traditional Leontief-type models, where R is a matrix of regional production coefficients.

With the model expressed as above, and with $R = D(I - \hat{M})B$, a solution for a particular industry final-demand vector ($F = DY'$) can also be obtained by iteration as

$$X' = IF + RF + R^2F + R^3F + \ldots + R^nF$$

Since our experiments include impact analyses based on the 191-industry

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interindustry flows and involve manipulation of the first and second rounds of spending, we use this iterative approach here. Rounds of spending are identified by their position on the right side of this equation, and 13 rounds are calculated (n = 12).

What Difference Does Detailed Knowldege Make?

Impact analyses based on aggregated tables (at, say, the 32-industry level) may frequently interpret "noise" in the aggregated industries (or a lack of homogeneity in input and output patterns among the establishments composing the industry) as actual impacts for a particular firm or detailed industry. For example, the impact of a new vegetable-canning plant with export sales of one million dollars annually might be traced through the 32-industry model as that of a one-million-dollar export by the food industry. Obviously, the food industry in general purchases a wider range of commodities than does a specific vegetable-canning plant, which may have no need for the beef, flour, pop bottles, and other purchases important in producing the many outputs of the food industry in general. As a result, and even though the overall impact through a standard multiplier analysis may be correct, the distribution of the impact to the various supplying industries may be substantially in error.

How can we minimize this effect of establishment-input heterogeneity within industries? How can the noise level be reduced? There are several ways.

Continuing with our example, we might use the 32-industry table as our base but, through reaggregation, add a 33rd industry, vegetable canning, before constructing the inverse matrix from which multipliers are derived. Substantially reducing input heterogeneity by narrowing the industry's definition, this procedure lowers the first-round noise with the minimum expenditure of effort on the part of the analyst. Since the first-round expenditures have the greatest impact in determining the directions of interindustry flows, this procedure may be adequate for most purposes.

A second procedure would be to introduce a row and a column representing the specific vegetable-canning plant which we wish to consider. This eliminates the noise involved in representing the plant with the general vegetable-canning industry and permits the use of specific import coefficients in determining provincial flows. It requires much more effort than the first alternative, and we still face the problem of eliminating the general noise in the system, if that proves to be significant.

A third alternative would be through an iterative solution involving the worksheet tables. Here, working with the 191-industry interindustry tables, we could trace the impact of the new plant through the detailed industry which represents it in the system (in our example, this would be the vegetable-canning industry). Second-round purchases would still retain noise to the extent of the difference between the specific plant and the industry. And since calculations are at the most detailed level permitted by the data, third and later rounds would show the least possible noise. Continuing these iterations through twelve or so rounds would approximate the results which would be obtained from inverting the 191-industry system (a task which might prove difficult under present computing arrangements). This procedure would eliminate a substantial amount of the aggregation noise associated with multipliers derived from the 32-industry system.

This latter iterative alternative represents the best answer to the impact question that the unaided input-output system can produce. Two new questions can be asked. First, is it necessary to go to all

this trouble? That is, could the aggregated inverse provide an adequate answer for most purposes or should one of the more complex alternatives be pursued? And second, is even this "best" answer related to reality as perceived in a detailed establishment-by-establishment tracing of impacts?

The first question can be answered by comparing the impacts of several specific industries traced through the three levels of aggregation of the input-output system. The results of this testing would be important in formulating our approach to impact analysis and the design of a general computing program for such analysis.

The answer to the second question can be approached by attempting to trace the impact of a specific establishment's purchases through actual field surveys. The effort associated with such a task is substantial and the probability of success is small. Success would depend on the willingness of a string of establishments to cooperate in naming their suppliers. Firms are understandably reluctant to gather and provide such detail. That the effort involved is great can be seen by guessing the number of establishments involved, which increases in an irregular but almost geometric progression, dependent on the number of different suppliers at each round of spending. If the first firm purchased from 10 suppliers and each of these and succeeding suppliers in turn purchased from 10 suppliers, tracing even 3 rounds of spending would involve contacting 10 cubed, or 1,000, establishments. If 5 suppliers were involved, only 125 interviews would be needed, still a very substantial number both to complete and to analyze. Given these difficulties, a complete tracing of effects is out of the question.

An alternative to this field testing of impact analysis would involve confirmation of import coefficients. Following the procedures used in the 1965 model, imports ($\hat{M}$) have been estimated in the 1974 Nova Scotia input-output system as residuals, the differences between domestic supply and total demand. These imports, estimated at the 594-commodity worksheet level, are used to reduce total commodity flows to approximate provincial flows, or commodity purchases from local industries only ($(I - \hat{M})B$). Even here, confirmation of a few import coefficients would be a substantial chore. This is because commodity import coefficients represent the average propensity to import commodities by all industries. And even if a set of commodity import coefficients were established for a detailed industry, they would still represent the average behaviour of the set of establishments composing that industry, so virtually any investigation of the behaviour of a specific establishment would show substantial deviation from this average. An input-output analyst assumes these deviations balance out over extended rounds of spending to approach the results derived from averages.

Perhaps the best procedure to follow, given the difficulty of tracing actual experiences as case studies which prove or disprove the wisdom of using impact analyses based on the input-output tables, would be to subject a set of example impact estimates to review in the second round of spending. That is, we should interview the managements of example firms to determine the local content of their purchases. This second round is most important, since it is the largest and since it sets the pattern of flows into the economy.

Procedures and Data Collection

To test the effectiveness of our impact analysis programs in simulating results to be expected in actual situations, we developed a special procedure which would permit us to specify transactions which might occur in rounds one, two, and three of an impact analysis. This routine simply interrupts an iterative solution to an impact calculation. For round one, the initial change is specified as usual; for round two, a new column of regional production coefficients is inserted for the study industry; and for round three, new columns of regional production coefficients for all industries supplying inputs to round two are added. As it turned out, the round-three routine was simply a programming exercise, since we could not collect sufficient data to use it.

Next, we identified three manufacturing industries of interest to the Nova Scotia Department of Development, and then selected a firm in each of these industries. With the help of the Department of Development, interviews were arranged with these firms and a vector of expenditures by each was developed. Subject to the usual rules regarding disclosure of data collected in confidence, the vector was defined to include purchases from the 191 worksheet industries plus wages and salaries. With this detail, the impact of aggregation could be examined at the same time that the effect of knowledge of round two transactions was being tested.

The interview data are in a confidential file at the Nova Scotia Department of Development. In general, we can say that the import coefficients for these firms are higher than those used in the Nova Scotia system overall. As discussed above, this is inherent in the system and is due to the method of estimating average import coefficients which has become accepted for use with the Canadian-style rectangular input-output system.

For each of the three cases, four impact analyses were undertaken for three levels of aggregation. The four analyses were: (1) Model 1, round 1 only; (2) Model 1, rounds 1 and 2; (3) Model 2, round 1 only; and (4) Model 2, rounds 1 and 2.

Results of Impact Tests

The Data

The test cases were selected from three industries of interest to the Nova Scotia Department of Development: (1) the carpet, mat and rug industry; (2) paper box and bag manufactures; and (3) the railway rolling stock industry. While case two is a specialized manufacturer of bags, the others appear to be representative of their industries; each is of substantial relative size. Since a Census of Manufactures questionnaire had been filed by each firm and each had given permission for the Department of Development to use the returns for research purposes, we were able to conduct our interviews with some foreknowledge and thus concentrate on trade coefficients. We had simply to ask where purchases originated.

Are Trade Patterns Important?

Since impact analyses using detailed tables would best eliminate problems due to aggregation and allow us to concentrate on trade-pattern problems, we have based this section on analyses using the 191- and 64-industry tables.

A summary of the results based on the 191-sector tables is presented in Table 1. When we assume that import coefficients are the averages represented by the input-output data, the total change in output associated with an initial change of $1000 is greater by an average of 16.1 per cent in Model 1 and 26.1 per cent in Model 2. If case two is eliminated because of the possibly high departure of the establishment from industry norms, these averages are 13.6 and 23.0 per cent, respectively.

Table 1

CHANGES IN OUTPUT (PER $1000 INITIAL CHANGE) IN NOVA SCOTIA FOR THREE CASE STUDIES WITH AND WITHOUT KNOWLEDGE OF ESTABLISHMENT TRADE PATTERNS, TRACED THROUGH THE 191-INDUSTRY INPUT-OUTPUT TABLE, 1974

Case	Total change in output under knowledge of: Round one only (1)	Rounds one and two (2)	Difference Absolute (3=1-2)	Per cent (4=3/2)
		Model 1		
1. Carpet, mat and rug industry	1239.3	1087.2	152.1	14.0
2. Paper bag and box manufactures	1270.8	1050.2	220.6	21.0
3. Railway rolling stock industry	1197.7	1056.7	141.0	13.3
Mean	1235.9	1064.7	171.2	16.1
		Model 2		
1. Carpet, mat and rug industry	1922.3	1569.1	353.2	22.5
2. Paper bag and box manufactures	1968.0	1483.9	484.1	32.6
3. Railway rolling stock industry	1843.3	1496.5	351.8	23.5
Mean	1912.9	1516.5	396.4	26.1

As shown in Table 2, the results are similar for the 64-industry table. Without knowledge of the trade patterns for our case-study establishments, we overestimated the impacts on total output associated with initial changes of $1000 by an average of 18.6 per cent in Model 1 and 30.0 per cent in Model 2. Note, however, that the overestimate due to lack of knowledge is substantially higher in case two than it was in the detailed analysis in Table 1. This reflects an effect of aggregation, which we will discuss later. If the other two cases above are considered, the overestimates average 12.7 per cent for Model 1 and 22.3 per cent for Model 2 in the 64-industry test. These results are very close to those obtained above for cases one and three.

Table 2

CHANGES IN OUTPUT (PER $1000 INITIAL CHANGE) IN NOVA SOCTIA FOR THREE CASE STUDIES WITH AND WITHOUT KNOWLEDGE OF ESTABLISHMENT TRADE PATTERNS, TRACED THROUGH THE 64-INDUSTRY INPUT-OUTPUT TABLE, 1974

Case	Total change in output under knowledge of: Round one only (1)	Rounds one and two (2)	Difference Absolute (3=1-2)	Difference Per cent (4=3/2)
	Model 1			
1. Carpet, mat and rug industry	1234.7	1098.2	136.5	12.4
2. Paper bag and box manufactures	1377.8	1054.3	323.5	30.7
3. Railway rolling stock industry	1192.0	1055.9	136.1	12.9
Mean	1268.2	1069.5	198.7	18.6
	Model 2			
1. Carpet, mat and rug industry	1935.4	1602.1	333.3	20.8
2. Paper bag and box manufactures	2177.1	1490.1	687.0	46.1
3. Railway rolling stock industry	1849.5	1495.4	354.1	23.7
Mean	1987.3	1529.2	458.1	30.0

Since aggregation to the 64-industry level does not significantly alter the results with respect to output in cases one and three, we can examine the income effects at the 64-industry level using tables produced by our simple impact-analysis program. These income effects are shown in Table 3. In both cases, and as expected, the income and employment effects of a $1000 change traced through the model without qualification is greater than when it is traced starting with the specific trade pattern of an establishment. Employment is overestimated by 9 and 16 per cent in Model 1 and by 13 and 22 per cent in Model 2. The overestimates for household income are 16 and 14 per cent in Model 1 and 21 per cent for both cases in Model 2.

Table 3

INCOME AND EMPLOYMENT EFFECTS ASSOCIATED WITH $1000 INITIAL CHANGE IN NOVA SCOTIA FOR TWO CASE STUDIES WITH AND WITHOUT KNOWLEDGE OF ESTABLISHMENT TRADE PATTERNS, TRACED THROUGH THE 64-INDUSTRY INPUT-OUTPUT TABLE, 1974

Case and Effect	Round one only (1)	Rounds one and two (2)	Difference Absolute (3=1-2)	Difference Per cent (4=3/2)
	Model 1			
1. Carpet, mat and rug industry				
employment	52.8	48.3	4.5	9.3
household income	344.0	296.7	47.3	15.9
3. Railway rolling stock industry				
employment	32.6	28.1	4.5	16.0
household income	322.3	281.5	40.8	14.5
	Model 2			
1. Carpet, mat and rug industry				
employment	63.4	55.9	7.5	13.4
household income	449.5	372.0	77.5	20.8
3. Railway rolling stock industry				
employment	42.6	34.8	7.8	22.4
household income	421.1	347.0	74.1	21.4

Does Aggregation Make a Difference?

An important point to be settled is the level of aggregation at which impact analyses should be performed. As noted earlier, it is obvious that the least noise due to aggregation will be introduced when the analysis is based on the most detailed tables. But detailed initial expenditure vectors may be difficult to obtain, and computing time is much longer than for less detailed tables. If analyses based on the smaller tables yield similar results, then they can be used without major problems.

Table 4 records the effects of aggregation on our three case studies. Case one and three seem relatively invariant with respect to aggregation. Both establishments are significant parts of their industries and play major roles in shaping industry coefficients. However, case two differs significantly from this pattern. This establishment, a member of the detailed paper box and bag industry, differs in many ways from the typical manufacturer described by this classification. At the 64-industry level, the establishment is part of the paper products industry, and the change in output associated with an initial change of $1000 differs by only 8 to 11 per cent. But at the 32-industry level, the change differs by 28 to 30 per cent. This dramatic increase is due primarily to the inclusion of pulp and paper mills in the aggregated industry. These mills purchase a large amount of their raw materials (pulpwood) locally and thus make the local trade proportion much higher in the aggregated industry than in the detailed industry.

Table 4

CHANGES IN OUTPUT (PER $1000 INITIAL CHANGE) IN NOVA SCOTIA FOR THREE CASE INDUSTRIES, TRACED THROUGH THE 191-, 64-, AND 32-INDUSTRY INPUT-OUTPUT TABLES 1974

	Level of aggregation			Per cent of 191-industry change	
	191	64	32	64	32
			Model 1		
1. Carpet, mat, and rug industry	1239.3	1234.4	1212.8	99.6	97.9
2. Paper bag and box manufactures	1270.8	1377.8	1629.4	108.4	128.2
3. Railway rolling stock industry	1197.7	1192.0	1217.6	99.5	101.7
			Model 2		
1. Carpet, mat, and rug industry	1922.3	1935.4	1978.0	100.7	102.9
2. Paper bag and box manufactures	1968.0	2177.1	2555.5	110.6	129.9
3. Railway rolling stock industry	1848.3	1849.5	1993.6	100.1	107.9

Conclusion

The tests based on our three cases indicate that specific knowledge is important in impact analyses. At the detailed 191-industry level a simple impact analysis, in which only knowledge of the initial impact is assumed, overestimates the total output change calculated with knowledge of the geographic spending pattern of the test firm by an average of 16 per cent in Model 1 and 26 per cent in Model 2. At the 64-industry level of aggregation, output increases based on initial changes alone overestimated those made with knowledge by 19 and 30 per cent for Models 1 and 2; the overestimates for new employment averaged 12 and 17 per cent and, for household income, 15 and 21 per cent.

Our tests of the effects of aggregation indicate that aggregation patterns could seriously influence the results of an impact analysis when a heterogeneous industry is the subject of the test. In the two cases in which the establishment studied was a significant part of its industry at the 32-industry level, the variation in impact due to aggregation was insignificant, ranging from minus 2.1 per cent to 7.9 per cent of the 191-industry estimate. But in the case of a specialized member of the paper box and bag industry, the effect of aggregation was to increase the total impact estimate by over 28 per cent.

In general, two conclusions can be drawn from our analysis. One is that aggregation is not a major problem. In Nova Scotia, the 64-industry tables seem to be adequate for use in avoiding serious aggregation error. If the firm under analysis (hypothetical or otherwise) is typical of existing firms in its industry, the 32-industry aggregation is also adequate.

The second conclusion is that there is a significant difference between analyses of the impact of change for an industry and change for an establishment. Input-output models are industry models and conclusions regarding the impact of change are based on an assumption that the change affects the industry as a whole. When such conclusions are compared with the results of analyses of the impact of change for a specific establishment, the possibilities for variation in technology and trade patterns are so great as to make the industry impacts only rough estimates.

References

1. Levitt, Kari. Input-Output Study of the Atlantic Provinces, 1965. Ottawa: Information Canada, 1975.

2. Schaffer, William A. "Constructing the Nova Scotia Input-Output System", Canadian Journal of Regional Science, I, 1 (Spring 1978), 1-11.

3. Statistics Canada. The Input-Output Structure of The Canadian Economy, 1961-66. Ottawa: Information Canada, 1976.