

Correct Partitioning of Regional Growth Rates: Improvements in Shift-Share Theory*

R.H.Lamarche Ph.D.

Department of Geography

University of Ottawa

Associate Researcher

Canadian Institute for Research on Regional Development

Moncton, N.B.

K.P. Srinath Ph.D.

Principal Scientist

Abt Associates Inc.

Washington, D.C.

U.S.A.

D. Michael Ray Ph.D.

Professor of Geography (retired)

25 Old Woods Hill

Torquay Devon, England

Introduction

Shift-share analysis has become one of the most widely-used partitioning techniques in regional development studies since it was introduced by Prof. J. Harry Jones in *The Royal Commission on the Distribution of the Industrial Population* published in 1940. Its appeal is that it provides a very simple method of partitioning regional employment growth into two fundamental components: a partitioning that is crucial to understanding regional growth patterns. The model first measures what it purports to be the contribution to employment growth of the regional industrial structure or "industry-mix". The residual employment growth is then termed the regional share. Unfortunately they are incorrectly measured. Nevertheless, all analysts followed his lead, and his approach became the basis for the

* For their very helpful comments we thank Dr. John Baldwin, Director, Statistics Canada, and Dr. Roger Roberge, Professor, Department of Geography, University of Ottawa.

traditional shift-share model (Dunn 1959; Statistics Canada 1973).

Regional analysts will not abandon a well-established technique without proof of its deficiencies. This paper seeks to provide that proof. It demonstrates that the results produced by the traditional model are incorrect, by identifying the precise mathematical relationship between his model and the Ray-Srinath model. In essence what this paper does is prove that when the regional growth rates are partitioned correctly the process results in the splitting of each of the two traditional components into two finer components which are correct mathematically in the sense that they measure what they say they do.

The problems with the approach used by Jones are, however, conceptual as well as mathematical, and the conceptual limitations cannot be removed without first correcting the mathematical errors. In particular, regional analysts and policy makers no longer accept that regional disparities in employment growth can be understood properly merely in terms of regional industry-mix and regional shifts in industry. An important role is played by other factors, such as regional differences in firm-size distribution and, in an age of increasing globalization, the regional concentrations of foreign multi-national corporations. The Jones model is limited to testing a single assumption: that regional growth rates are largely controlled by industry mix.

The Jones model cannot be extended to analyze these multivariate factors simultaneously. Nor can it be used to examine these regional forces two at a time as they are interwoven and act together simultaneously. Hence in 1990, Ray and Srinath introduced a new multi-factor partitioning model to analyze regional disparities in employment growth (Ray 1990). It was then used to examine the impact on employment growth in Canada of industry-mix, the size-structure of firms, the level of foreign ownership and regional factors, as well as the interactions among them.

The creation of the Ray-Srinath shift-share model is an important theoretical development in shift-share analysis. While traditional shift-share models rely on the comparison of industrial growth rates, the Ray-Srinath is based on a comparison of industrial structures. In traditional shift-share, the question is whether the industries in a region are growing at a faster rate than the overall national rate. In the Ray-Srinath model, the question is by how much does a region's industrial structure differ from the national industrial structure? The discovery of the mathematical links between the two models is also of theoretical importance as it resolves the question of the choice of weights that was of so much concern to Jones.

Not all analysts will want to work through these proofs. However, no analysts will want to try the new methodology without having a convenient

program to do the computations (for more information on one such program refer to rlamarch@cyberus.ca). This paper provides an example to illustrate the dangers of using a defective model. Before proceeding with the mathematics and a discussion of the example, it is important to explain the motivation for a new approach to shift-share analysis and the contributions which the Ray-Srinath model makes.

The Contributions of the Ray-Srinath Model

The Ray-Srinath model was first used in 1990 in a study of the impact of foreign ownership on regional employment growth Canada (Ray 1990), and later in an analysis of the contribution of small firms to regional employment growth (Ray 1996). The model makes a number of contributions to analyzing regional growth patterns.

Ray and Srinath proved that it is not possible to either obtain the correct results or to extend the traditional model because it does not correctly standardize the data with regards to the size of the regions and the size of the industries. The R-S model eliminated the problem of having to deal with disproportionate regional distributions of industries, a serious problem first raised by Rosenfeld in 1959 and again by Cunningham in 1969.

Jones used crude regional rates and crude national industry rates in his model. Jones correctly understood that the mix of industries in a region could affect the employment growth of that region independently of the intrinsic advantages that the region possessed. However, he did not appreciate that the regional distribution of an industry also affects the employment growth of that industry independently of the intrinsic competitiveness of that industry. Using crude rates, as does Jones, fails to correct for what are, statistically, two separate and equally important problems, requiring two standardizations. If the industry growth rates used to calculate the Jones "fair share" rate are not corrected for their regional distribution, then their rates of growth still reflect their regional distribution. Hence his industry-mix effect still includes part of the regional effect. And if the industry-mix effect includes part of the regional effect, then the Jones regional effect is also incorrect. The only way in which to obtain pure region and industry effect rates is to calculate, as does the Ray-Srinath model, standardized region, industry and national growth rates.

The second contribution of the Ray-Srinath model is that it can accommodate any number of factors. The researcher is thus limited only by the data available and not in any way by the model. Thus the Ray-Srinath

model provides a partitioning methodology that is in tune with the current understanding of regional development forces and of contemporary industrial location theory.

Measuring Interaction and Allocation Effects in the Ray-Srinath Model

Two additional refinements are needed in partitioning the effects of the principal factors. These are extracting the interaction and allocation effects. These effects are present in the data and the failure to identify and to extract them results in their being confounded with the main factors. Consider the region effect in the simple two-factor, region and industry-mix analysis in the Jones model for, instance (in the traditional model the region effect is called the regional share effect). One would naturally expect that any one region would have one effect. How else can the analyst speak of a region's effect on employment growth? But, in the Jones model each region has as many region effects as there are industries. That is, in any one region, each industry is also subject to a different region effect. In fact, the Jones model is lumping two separate effects together (neither of which is correctly measured): a region effect and an industry-region interaction effect. Each region does have its general region effect which affects all industries equally. But in addition, there is an interaction between a region and each individual industry in that region, which will in part reflect the industry-specific advantages of the region and in part any exceptional events which have impacted on employment in that industry in that region. These interaction effects generally vary greatly in value from industry to industry. They, in fact, quantify the distinctive location advantages of a given region for each particular industry which apply over and above the common regional effect.

The Ray-Srinath model separates the region effect rate from the region-industry interaction rate, as one can see from equation (11) below. Again it is important to remember that these interaction effects must be correctly extracted, whether or not the researcher is actually concerned with them, in order to ensure that their effect does not confound the main factors.

A final refinement that proved necessary is the calculation of an allocation effect. There is a difference between the national growth rate calculated using the actual distribution and the standardized national growth rate. This difference is termed the "allocation effect". The allocation rate is a national measure. The distribution of industry in a region is uneven

only when compared with the other regions and with the nation as a whole. It is then, by its very nature, a national characteristic.

The main objective of this paper is to demonstrate, algebraically, that the traditional regional share rate combines two components: the true (Ray-Srinath) region effect rate and the region-industry interaction rate as shown in equation (11). It is also demonstrated that the traditional industry-mix rate combines two parts as well: the true (R-S) industry-mix effect and the effect of regional variations in the distribution of industry, the allocation effect as stated in equation (12). This paper illustrates that the improper partitioning of regional growth rates can lead to erroneous conclusions in interpretation and that the Ray-Srinath model does a more effective job of partitioning crude regional growth rates. Because the R-S model reports all region-industry interaction effects it is a more precise and effective planning tool.

The Jones Model 1940

Jones was interested in the difference between the increase in employment in the region (crude regional growth rate) and the increase that would have occurred if the regional employment had grown at the crude national rate.

Let j denote the region and let there be R regions. The crude regional growth rate is the difference in employment at time t and the employment at time 0 (base year) divided by the employment at time 0 .

Let $r_{\bullet j}$ denote the crude regional growth rate. We have

$$r_{\bullet j} = \frac{E_{\bullet j}^t - E_{\bullet j}^0}{E_{\bullet j}^0}$$

Using this definition, we can write the difference in employment between time period t and the base year period as

$$E_{\bullet j}^t - E_{\bullet j}^0 = r_{\bullet j} E_{\bullet j}^0$$

Let $r_{\bullet\bullet}$ denote the crude national growth rate. If employment in the j th region had grown at the crude national rate, then the increase in employment in the j th region would be

$$E_{\bullet j}^0 r_{\bullet\bullet}$$

The difference in the actual increase in employment, in the j th region and the expected increase in employment if the region had grown at the crude national rate, is

$$(E_{\bullet j}^t - E_{\bullet j}^o) - E_{\bullet j}^o r_{\bullet}$$

The total employment in the j th region is the total of employment in all the industries in the region. That is, if we aggregate the employment in each industry in that region, we get the total employment in that region both at the base year period and at period t . Therefore we can write

$$E_{\bullet j}^o = \sum_{i=1}^S E_{ij}^o$$

where i represents industries and there are S industries in each region. Similarly, we can write

$$E_{\bullet j}^t = \sum_{i=1}^S E_{ij}^t$$

Now we can express the difference in the actual growth of employment in the j th region and the expected growth, if the growth had been at the crude national rate, as follows:

$$(E_{\bullet j}^t - E_{\bullet j}^o) - E_{\bullet j}^o r_{\bullet} = \sum_{i=1}^S (E_{ij}^t - E_{ij}^o) - \sum_{i=1}^S E_{ij}^o r_{\bullet} \quad (1)$$

The left-hand side of the equation can be written in a slightly different way by taking out $E_{\bullet j}^o$ as a factor and similarly, the right-hand side of the equation can be written differently by taking out E_{ij}^o as a factor. Then equation (1) can be written as

$$E_{\bullet j}^o \left(\frac{E_{\bullet j}^t - E_{\bullet j}^o}{E_{\bullet j}^o} - r_{\bullet} \right) = \sum_{i=1}^S E_{ij}^o \left[\left(\frac{E_{ij}^t - E_{ij}^o}{E_{ij}^o} \right) - r_{\bullet} \right] \quad (2)$$

Equation (1) and equation (2) are equivalent. Now (2) can be rewritten using the definition of r_{\bullet} and r_{ij} . Thus, (2) can be written as

$$E_{\bullet j}^o (r_{\bullet j} - r_{\bullet\bullet}) = \sum_{i=1}^S E_{ij}^o (r_{ij} - r_{\bullet\bullet}) \quad (3)$$

Equation (3) was the starting point for Jones. He wanted to divide into two parts the difference in employment between the crude regional growth rate and the expected growth rate. The Jones model defines the expected growth as the growth a region would have if each industry in it had grown at the crude national growth rate. To achieve his partitioning, he added and subtracted the crude national industry rate that is denoted by $r_{i\bullet}$ to the term on the right-hand side of equation (4) below:

The crude national industry rate $r_{i\bullet}$ for an industry is

$$r_{i\bullet} = \frac{E_{i\bullet}^t - E_{i\bullet}^o}{E_{i\bullet}^o}$$

The national employment in an industry is the sum of employment of that industry in different regions. We can rewrite the crude national industry rate in terms of cell growth rates as below.

$$r_{i\bullet} = \sum_{j=1}^R \frac{r_{ij} E_{ij}^o}{E_{i\bullet}^o}$$

Then we can write (3) as equation (4)

$$E_{\bullet j}^o (r_{\bullet j} - r_{\bullet\bullet}) = \sum E_{ij}^o (r_{ij} - r_{i\bullet} + r_{i\bullet} - r_{\bullet\bullet}) \quad (4)$$

Note that (4) and (3) are equivalent. We have simply *added and subtracted* the crude national industry rate to the right side of the equation. Now (4) can be split into two parts. Take the summation sign over the first two growth rates and then over the next two rates on the right-hand side. Then we can write (4) as

$$E_{\bullet j}^o (r_{\bullet j} - r_{\bullet\bullet}) = \sum_{i=1}^S E_{ij}^o (r_{ij} - r_{i\bullet}) + \sum_{i=1}^S E_{ij}^o (r_{i\bullet} - r_{\bullet\bullet}) \quad (5)$$

Equation (5) is the Jones model and is the equation used in traditional shift-share analysis (Statistics Canada 1973). The first term on the right hand side of (5) is called "regional share rate" as it involves the deviation of the specific industry growth rate in the region from the crude industry growth rate in the nation. This deviation tells how better or worse the industry in the region is doing as compared to that industry nationally, a regional consideration. The second term is called the "industry-mix rate" as this term does not *seemingly* involve regional considerations at the cell level (there is no r_{ij} element in the second term but only the deviation of the crude national industry growth rate from the crude national growth rate, an industry consideration). The devil is in the "crude" rates!

The Ray-Srinath Model 1990

The Ray-Srinath model introduces three sets of standardized rates: standardized industry rates, standardized regional growth rates and the standardized national growth rate.

First, it defines a standardized national industry growth rate. What would be the growth rate for an industry, if the proportion of the employment of that industry in a region were the same as the proportion of a region's employment in the nation? That is what if

$$\frac{E_{ij}^o}{E_{i\cdot}^o} = \frac{E_{\cdot j}^o}{E_{\cdot\cdot}^o}$$

For example, if 20% of employment in the nation is located in region j , then under conditions of perfect proportionality we would also expect 20% of employment in industry i to be in region j . The expression is evaluated for each region in turn and summed. The result is the growth rate of the industry freed from the effects of its regional distribution and therefore freed from the impact that its regional distribution has on its national growth rate. Industry and regional effects have been truly separated, as required for the correct partitioning of their effects.

Thus, the standardized national industry growth rate is

$$\hat{r}_{i\cdot} = \sum_{j=1}^R \frac{r_{ij} E_{\cdot j}^o}{E_{\cdot\cdot}^o}$$

To show that the regional share, as defined in the Jones model, is not a purely regional share, we take the first term on the right-hand side of equation (5) and add and subtract the standardized national industry growth rate.

The first term on the right side of equation (5) is now written as

$$\sum_{i=1}^S E_{ij}^o (r_{ij} - \hat{r}_{i\cdot} + \hat{r}_{i\cdot} - r_{i\cdot})$$

Now taking the summation over the difference of the first two growth rates and the second two growth rates, we get two terms for the original Jones regional share term

$$\sum_{i=1}^S E_{ij}^o (r_{ij} - \hat{r}_{i\cdot}) + \sum_{i=1}^S E_{ij}^o (\hat{r}_{i\cdot} - r_{i\cdot}) \quad (6)$$

We refer to the first term in (6) as the "corrected" regional share because it is purely a difference between growth rates, as Jones had intended. We can see that the second term in (6) involves only the difference between the crude national industry rate and the standardized national industry rate. This second term reflects differences in distribution of industries rather than a regional difference in growth rates. This is evident when we write the second term of (6) using the definition of the crude national industry rate and the standardized national industry growth rate (7).

$$\sum_{i=1}^S E_{ij}^o \left[\sum_{j=1}^R r_{ij} \left(\frac{E_{\cdot j}^o}{E_{\cdot\cdot}^o} - \frac{E_{ij}^o}{E_{i\cdot}^o} \right) \right] \quad (7)$$

The term denoted by (7) will be equal to zero if the proportion of industry employment in the j th region is the same as the proportion of a region's employment in the nation. The ratios in (7) describe industry distribution; it is an industrial structure consideration rather than regional share one. The greater the disproportion in the distribution of an industry, the greater is the error in the Jones measure of industry-mix effect.

Since the difference in the second term of (6) does not contain a r_{ij} rate, it is not a regional share consideration. This is where the regional share rate and the industry-mix rate are statistically confounded in the original Jones

definition of regional share.

Now consider the Jones industry-mix term, the second term of equation (5). This can also be partitioned using standardized rates. We will first add and subtract the standardized national industry rate as we did in the case of regional share. Then the second term of (5) becomes

$$\sum E_{ij}^o (r_{i.} - \hat{r}_{i.} + \hat{r}_{i.} - r_{..}) \quad (8)$$

This can now be split into two terms as follows:

$$\sum_{i=1}^S E_{ij}^o (r_{i.} - \hat{r}_{i.}) + \sum_{i=1}^S E_{ij}^o (\hat{r}_{i.} - r_{..}) \quad (9)$$

Notice that the first term in (9) is the same - but with a negative sign - as the second term in (6), a term we obtained when the original Jones regional share rate was dissected.

Therefore, when we add the modified Jones regional share and industry-mix, the two "extracted" terms will cancel and we get the following improved Jones equation (10):

$$E_{.j}^o (r_{.j} - r_{..}) = \sum_{i=1}^S E_{ij}^o (r_{ij} - \hat{r}_{i.}) + \sum_{i=1}^S E_{ij}^o (\hat{r}_{i.} - r_{..}) \quad (10)$$

The first term in (10) we call the "corrected" regional share. The second term on the right side of equation (10) is a measure of the industry-mix effect based on the standardized industry rates and not crude national industry rates as in the original Jones model.

We will further split each of the two terms on the right-hand side of (10) into sub-components.

The corrected regional share component, the first term on the right of the equal sign, will be split into a region effect rate and region-industry interaction effect rate.

We will also split the Jones industry-mix rate - the second term on the right side of equation (10) - into a pure industry-mix effect and an allocation rate.

To achieve this, we use the standardized regional growth rates and the standardized national rate. They are defined as follows. The standardized regional growth rates are

$$\hat{r}_j = \sum_{i=1}^S r_{ij} \frac{E_{i\cdot}^o}{E_{\cdot\cdot}^o}$$

This is the growth rate that would have occurred in a region if employment in each of its industries had been the same proportion of employment as the proportion of that industry's employment in the nation.

Note that in the equation below it is possible to calculate the standardized national rate using standardized regional rates or standardized industrial rates. The standardized national growth rate is simply the weighted average of standardized regional growth rates or standardized industry growth rates. That is

$$\hat{r} = \sum_{i=1}^S \frac{\hat{r}_{i\cdot} E_{i\cdot}^o}{E_{\cdot\cdot}^o} = \sum_{j=1}^R \frac{\hat{r}_{\cdot j} E_{\cdot j}^o}{E_{\cdot\cdot}^o}$$

The "corrected" regional share rate of (10) can now be written as

$$\begin{aligned} & \sum_{i=1}^S E_{ij}^o (r_{ij} - \hat{r}_{i\cdot}) = \\ & \sum_{i=1}^S E_{ij}^o (\hat{r}_{\cdot j} - \hat{r}_{\cdot\cdot}) + \sum_{i=1}^S E_{ij}^o (r_{ij} - \hat{r}_{i\cdot} - \hat{r}_{\cdot j} + \hat{r}_{\cdot\cdot}) \end{aligned} \quad (11)$$

The first term on the right-hand side of (11) defines employment change due to the region effect (common to all industries in the region) and the second term is the change due to the interaction effects between specific industries and specific regions. So, in effect, the Jones "corrected" regional share rate has been partitioned into the Ray-Srinath region effect rate, which applies to all the industries in the region, and the sum of region-industry interaction effects, which reflect the relationship between specific industries in specific regions. Note the subscript j for the region effect and the subscript ij for the region-industry interaction effect in (11).

Similarly, the second term in equation (10) above can be split into two parts.

$$\sum_{i=1}^S E_{ij}^o(\hat{r}_{i.} - r_{..}) = \sum_{i=1}^S E_{ij}^o(\hat{r}_{i.} - \hat{r}_{..}) + \sum_{i=1}^S E_{ij}^o(\hat{r}_{..} - r_{..}) \quad (12)$$

The first term on the right hand side of (12) is known as the Ray-Srinath industry-mix effect rate and the second term as the Ray-Srinath allocation effect. The increase or decrease in employment due to this industry distribution is not attributable to any of the other effects.

The sum of (11) and (12) gives the difference that Jones was trying to account for by the left side of his equation (5) above.

Equation (13) is the Ray-Srinath equation that accounts for the same difference. Where Jones finds two partitions, the Ray-Srinath has established four components.

$$E_{.j}^o(r_{.j} - r_{..}) = \sum_{i=1}^S E_{ij}^o(\hat{r}_{.j} - \hat{r}_{..}) + \sum_{i=1}^S E_{ij}^o(r_{ij} - \hat{r}_{i.} - \hat{r}_{.j} + \hat{r}_{..}) + \sum_{i=1}^S E_{ij}^o(\hat{r}_{i.} - \hat{r}_{..}) + \sum_{i=1}^S E_{ij}^o(\hat{r}_{..} - r_{..}) \quad (13)$$

Thus the difference in rates on the left side of the equation has been partitioned into four component rates: a region effect, the sum of region-industry interaction effects, an industry-mix effect, and an allocation effect. Note that the second component refers to a sum of region-industry interaction effects. Any given region will have as many interaction effects as there are industries in the region. To obtain the value of each region specific and industry specific interaction, one would simply have to insert the appropriate values in the second term of equation (13).

Consider the second term on the right-hand side of the equation, the region-industry interaction term. Once both the region effect and the industry effect have been subtracted and the standardized national rate added, one is left with a region specific and industry specific rate (r_{ij}). The figure "Improvements in Shift-Share Theory" in the Appendix summarises the links between the Jones and Ray-Srinath models.

The Dangers of Using a Defective Model

This section is not aimed at describing the regional development issues of the regions of Maritime Canada but to illustrate how misleading the traditional shift-share model can be. In the discussions below we draw your attention to the Cape Breton region in particular because it was the region under the greatest stress in the 1981-1986 period. If the objective had been to analyze regional growth patterns in the Maritimes over this period we would have used a three-factor Ray-Srinath model for two reasons. First, the R-S model provides a more accurate partitioning of the regional rates. Secondly, because this period is characterized by a great surge of growth in the services industries and a decline in the manufacturing ones, it would be imperative to consider the regional changes in the distribution of the male-female labour force. The required data for a three-factor are available.

The approach taken here is to calculate the partitioning of the regional growth rates first with the traditional shift-share model (Jones) and then with the two-factor Ray-Srinath model and compare the two sets of results as presented in Table 1. Then it is demonstrated that the Jones industry-mix value for the Cape Breton region is in fact incorrect while the Ray-Srinath value is correct (Tables 2 and 3).

First consider the results of the partitioning of the regional growth rates for the Maritimes regions as presented in Table 1 and the proof that the Ray-Srinath model is correct and the traditional model is incorrect is presented in Tables 2 and 3.

Note that in Table 1 the industry-mix value according to the Jones model for Cape Breton is -0.58% . On the other hand, according to the Ray-Srinath model the industry-mix effect value is 2.08% . Now either the industrial structure should be contributing 2.08% to the region's growth or is responsible for a loss of 0.58% . Is the region's industrial structure a contributor to the region's growth or is it not? The answer to the question can be found in Tables 2 and 3.

Recall that two elements are required to determine if a region has an expanding or contracting industrial structure in both the Jones and Ray-Srinath models. The first element defines an industry as being either expanding or contracting and the second one measures the number of employees in these industries. The industry-mix value is a sum of the products of these two components. If the sum is positive, the region has more employees in the expanding industries than in the declining industries. Therefore its industrial structure is good in the sense that it is creating jobs. If the sum is negative the region is losing jobs because of the nature of its indus-

TABLE 1 Partitioning Regional Growth Rates

A) Based on the Jones algorithm(1940)									
Region	crude region rate (%)	-	crude national rate (%)	=	must account rate	=	Jones regional share rate	+	Jones ind.- mix rate
PEI	12.16	-	8.90	=	3.26	=	1.95	+	1.31
Halifax, N.S	12.64	-	8.90	=	3.74	=	2.07	+	1.68
Cape Breton N.S.	2.65	-	8.90	=	-6.25	=	-5.66	+	-0.58
Rest of N.S.	8.29	-	8.90	=	-0.61	=	0.39	+	-1.00
North N.B.	8.78	-	8.90	=	-0.12	=	0.44	+	-0.55
South N.B.	7.44	-	8.90	=	-1.46	=	-1.22	+	-0.24

B) Based on the Ray-Srinath algorithm(1990)													
Region	crude region rate (%)	-	crude national rate (%)	=	must account rate	=	R-S region effect rate	+	R-S ind-mix rate	+	R-S interaction effect rate	+	R-S allocation rate ¹
PEI	12.16	-	8.90	=	3.26	=	2.08	+	0.47	+	-0.66	+	1.37
Halifax, N.S	12.64	-	8.90	=	3.74	=	2.22	+	1.16	+	-1.01	+	1.37
Cape Breton N.S.	2.65	-	8.90	=	-6.25	=	-4.50	+	2.08	+	-5.20	+	1.37
Rest of N.S.	8.29	-	8.90	=	-0.61	=	-0.73	+	-1.36	+	0.11	+	1.37
North N.B.	8.78	-	8.90	=	-0.12	=	-0.14	+	0.10	+	-1.45	+	1.37
South N.B.	7.44	-	8.90	=	-1.46	=	-0.07	+	-0.88	+	-1.88	+	1.37

Note: The allocation rate is equal to the standardised national rate - crude national rate.

trial structure. The essential difference between the Jones and the Ray-Srinath models is the manner in which it is determined whether each of the industries can be considered expanding or contracting.

Because the Jones model relies on the crude national growth rate of industries to determine if an industry is above or below average, it does not separate cleanly the region effect from the industry effect as was demonstrated in the mathematical section above. So an industry might seem to be an expanding industry in nature but its above average rate of growth might be caused in part by the nature of the industry and in part by the regional conditions where the industry is most strongly concentrated. On the other hand the Ray-Srinath model isolates the industry-mix effect from all other effects in such a way that the value reported for the industry represents a correct measure of the nature of the industry: expanding or contracting.

Table 2 shows that the Cape Breton does not have a "bad" industrial structure. There are more good combinations of expanding industries and above average number of employees in those industries in Cape Breton than there are bad combinations. Table 1 shows that Cape Breton's problems lie entirely with its negative values of region effect (-4.50%) and region-industry interaction effects (-5.20%). Interestingly enough, if we use the Jones definition for determining whether an industry is expanding or contracting we end up with the same conclusion: there are more good combinations than bad (Table 3). The problem does not lie with a lack of employees in industries that are classified at the national level as

TABLE 2 The Industrial Structure of Cape Breton as Measured by Ray-Srinath¹

Industry	empl. % of empl.		empl. Cape Breton	% of empl. Cape Breton	R-S Industry effect rate	good combo		bad combo		bad combo R-S is + & Lower % Cape Breton	bad combo R-S is - & Higher % Cape Breton
	Maritimes	Maritimes				good combo R-S is + & Higher % Cape Breton	good combo R-S is - & Lower % Cape Breton				
Employment	719,657		64,379		--	--	--	--	--	--	--
Agriculture	20,898	2.90	520	0.81	-0.37	--	good	--	--	--	--
Forestry ind.	13,826	1.92	850	1.32	1.11	--	--	bad	--	--	--
Fishing ind.	13,551	1.88	1,296	2.01	7.46	good	--	--	--	--	--
Mines ind.	10,414	1.45	4,432	6.88	41.55	good	--	--	--	--	--
Manufact. ind.	107,395	14.92	9,470	14.71	-14.11	--	good	--	--	--	--
Construction	48,770	6.78	4,415	6.86	-0.88	--	--	--	--	--	Bad
Transport serv.	59,320	8.24	5,825	9.05	-5.87	--	--	--	--	--	Bad
Trade serv.	118,855	16.52	10,140	15.75	-1.37	--	good	--	--	--	--
Finances ind.	28,011	3.89	1,775	2.76	-3.77	--	good	--	--	--	--
Education serv.	51,225	7.12	5,015	7.79	-4.90	--	--	--	--	--	Bad
Health serv.	56,595	7.86	6,110	9.49	4.01	good	--	--	--	--	--
Hotels ind.	37,855	5.26	3,510	5.45	13.55	good	--	--	--	--	--
Business s.	53,457	7.43	4,446	6.91	17.88	--	--	--	bad	--	--
Pub. Adm., def.	76,300	10.60	4,240	6.59	4.10	--	--	--	bad	--	--
Other activity	23,185	3.22	2,335	3.63	-5.32	--	--	--	--	--	Bad

positive: 4 + 4 = 8 good combinations
 negative: 3 + 4 = 7 bad combinations

Note: 1. In Ray-Srinath, an industry is expanding if it has a positive industry effect rate. According to the Ray-Srinath model, Cape Breton has a good industrial structure since it contributes 2.08% to the crude regional rate (Table 1).

TABLE 3 The Industrial Structure of Cape Breton as Measured by Jones¹

Industry	empl.	% of empl.	empl. Maritimes	empl. Cape Breton	% of empl. Cape Breton	Jones industry effect rate ²	good combo Jones is + & Higher % Cape Breton	good combo Jones is - & Lower % Cape Breton	bad combo Jones is + & Lower % Cape Breton	bad combo Jones is - & Higher % Cape Breton
Total employ.	719,657		64,379							
Agriculture	20,898	2.90	520	0.81	-0.62		Good			
Forestry ind.	13,826	1.92	850	1.32	-2.31		Good			
Fishing ind.	13,551	1.88	1,296	2.01	16.12	Good				
Mines ind.	10,414	1.45	4,432	6.88	-8.49					Bad
Manufact. ind.	107,395	14.92	9,470	14.71	-13.62		Good			
Construction	48,770	6.78	4,415	6.86	-1.22					Bad
Transport serv.	59,320	8.24	5,825	9.05	-5.27					Bad
Trade serv.	118,855	16.52	10,140	15.75	-0.03		Good			
Finances ind.	28,011	3.89	1,775	2.76	-2.10		Good			
Education serv.	51,225	7.12	5,015	7.79	-3.68					Bad
Health serv.	56,595	7.86	6,110	9.49	5.01	Good				
Hotels ind.	37,855	5.26	3,510	5.45	14.84	Good				
Business s.	53,457	7.43	4,446	6.91	18.85				Bad	
Pub. adm., def.	76,300	10.60	4,240	6.59	3.55				Bad	
Other activity	23,185	3.22	2,335	3.63	-5.27					Bad

positive: 3 + 5 = 8 good combinations

negative: 2 + 5 = 7 bad combinations

Note: 1. Cape Breton has an above average industrial structure but the Jones algorithm says it does not. Jones industry-mix rate = -0.58% (table 1).

2. Jones industry effect rate: crude national rate of the industry minus the overall national rate.

expanding. In short, the traditional model is inaccurate and misleading.

Note: a very special case! If an industry has the same rate of growth in every region and the same can be said of all the industries in the system, the Jones and Ray-Srinath will report identical values for the impact of regional conditions (region effects) and industrial structure (industry-mix) on a region's growth rate. In such circumstances the region effect will be zero ("regional share" in Jones and "region effect" in Ray-Srinath). If the growth rate of the industries is the same for all regions, regional conditions are not influencing industry growth rates, a very improbable scenario. However, as soon as specific conditions in some of the regions are involved in industry growth rates, the industry-mix as measured by the traditional model (Jones) becomes distorted. If the traditional regional share value is negative, the industry-mix will capture some of this negative value. If, on the other hand, the regional share is positive, the industry-mix will have a larger positive value than the industrial structure warrants.

Two Considerations Concerning the Choice of Data: Good Results Require Good Data

First, a warning! An excessively large industry growth rate can be a problem. An excessively large growth rate in a single industry can result in a very large value for that region's standardized regional rate. Such a high rate can occasionally lead to erroneous interpretations. If the large rate represents a great surge in the region's development, then it is justified. On the other hand, it might represent just a small increase in employment in absolute numbers and the high value of the standardized regional rate misrepresents what is truly happening.

One can find an example of such a problem in the case of the northwest region of New Brunswick, one of 15 regions in one Atlantic data set used by Lamarche. The mining industry in that region went from 6 employees in 1981 to 83 in 1986, a 1283.3% increase! The resulting very high value of standardized regional growth rate for the northwest region pushed it to the top of the region effect rate rankings. One would be tempted to conclude from the high ranking of its region effect rate that this region has unusually good regional dynamics, when in fact the high ranking is due to an abnormality in the industrial structure. Creating 77 jobs is not a particularly great achievement!

One can deal with the problem of unwarranted high growth rates in several ways: combine several regions together or if the data is available, use a three-year average of industry values in the base and final years.

Secondly, one should be aware that the allocation rate is sensitive to the fineness of the industrial classification which one uses. If the classification is too fine, several industries might not be represented in some of the regions. On the other hand, if the classification is not fine enough, "there might be wide variations of performance in the component parts" (Cunningham 1969: 127).

Conclusions

Significance of Partitioning Shift-Share Components into Finer R-S Components.

The Ray-Srinath model enhances our understanding of regional growth patterns because it corrects the errors that have become entrenched since Jones introduced the model in 1940. The rates are correctly standardized and weighted. The results are free from the distortions produced by using the crude rates. The regional growth rates have been partitioned into finer components. The restriction on the number of effects that can be extracted is determined by the limitations of the data, not the model. The analyst is able to pinpoint more precisely and more accurately the levers propelling regional growth.

Isolating and measuring the region-industry interaction rate is a major contribution of the Ray-Srinath algorithm to regional development analysis. By its incapacity to extract the interaction effect rate from the regional share rate, the traditional regional share and industry-mix rates are highly suspect. An analyst should not confuse the impact of regional conditions on all industries in a region with region specific and industry specific interaction effects. With finer components, better regional development strategies can be devised.

That this paper has in effect established that mathematical links do exist between the Jones and Ray-Srinath models is a useful contribution to regional studies. The Ray-Srinath is not just another shift-share algorithm among many, it is an important development in shift-share methodology. A shift-share algorithm needs to partition the crude regional growth rate into a minimum of four components for them to be clean and useful measurements in development planning. One model has been proven to be a better, more accurate and more powerful analytical tool.

One final comment regarding the type of data that is suitable for a shift-share analysis. Cunningham states that although the technique "has usually been applied to the problem of different rates of growth of

employment, there is no reason in principle why it could not be used on other aspects of a region's performance (Cunningham 1969: 132). The KDL-ShiftShare© program created by Lamarche allows a researcher to run a shift-share analysis using either the Jones or the Ray-Srinath model. The inclusion of the Jones model was made to allow comparisons for users familiar with the traditional model. One important other feature of the program when the Ray-Srinath algorithm is used is that it allows a researcher to include employment and value-added data values. The program then classifies the regions according to four types. Type I in the case when employment and value added growth rates are above average and type IV when both rates are below average (Casler 1989). It is quite interesting to follow the migration of a region up or down the type ladder through time. Because the classification is based on standardized regional growth rates, the comparisons among regions are statistically sound. The classification of the regions in this manner is not to be confused with the use of shift-share in the measurement of productivity changes.

References

- Casler, S.D.1989. "A Theoretical Context for Shift and Share Analysis". *Regional Studies* , 23: 43-48.
- Cunningham, N.J. 1969. "A Note on the Proper Distribution of Industry". *Oxford Economic Papers*, 21: 122-127.
- Dunn, E.S. Jr. 1959. "Une technique statistique et analytique d'analyse régionale: Description et projection". Kraus Reprint, reprinted in 1974. *Économie Appliquée*, Tome XII, 1-2: 521-530.
- _____. 1960. "A Statistical and Analytical Technique for Regional Analysis". *Papers and Proceedings of the Regional Science Association*, 6 : 97-112.
- Jones, J.H. 1940. "A Memorandum on the Location of Industry". *The Royal Commission on the Distribution of the Industrial Population*. London. Appendix II. London: His Majesty's Stationery Office, Cmnd 6135.
- Ray, D. M. 1990. *Standardizing Employment Growth Rates of Foreign Multinationals and Domestic Firms in Canada: From Shift-Share to Multifactor Partitioning*. Working paper No. 62. Geneva: International Labour Organisation, International Labour Office.
- _____. 1996. "Employment Creation by Small Firms", in J.N.H.Britton (ed.). *Canada and the Global Economy*. McGill-Queen's University Press: 175-194.

Rosenfeld, F. 1959. "Commentaire à l'exposé de M. Dunn". Kraus Reprint, reprinted in 1974. *Économie Appliquée*, Tome XII, 1-2: 521-530.

Statistics Canada. 1973. *Growth Patterns in Manufacturing Employment by Counties and Census Divisions*. Cat. No. 5-3307-512. Ottawa: Statistics Canada

Appendix

Figure A: Improvements in Shift-Share Theory

Jones original model (1940) as expressed in the Dunn equation (1960)

crude regional growth rate – national rate = regional share rate + ind.-mix rate

- Problem #1 with the Jones model: it does not take into account the region-industry interaction effects and the effect of the regional distribution of industry.
- Problem #2: the regional share rate and the industry-mix rate are confounded.¹

Ray-Srinath Shift-Share: The Multi-factor Partitioning Model² (1990)

crude regional rate – national rate = region effect rate + region-industry interactions rate³ + industry-mix effect rate + allocation rate

- The corrected regional share has been split into the region effect rate, that applies to all industries in the region, and the sum of the

1. The statistical term "confounded" describes the inability of the model to separate rates correctly.

2. Multifactor Partitioning. Ray uses this term to indicate that the Ray-Srinath model can handle more than two factors (Ray, 1990). The KDL ShiftShare© Program can process up to four factors: regions, industries, industry categories, and industry subcategories (rlamarch@cyberus.ca).

3. Region-industry interaction rate is the sum of all the specific region-industry interaction effects within a region.

region-industry interaction effects expressed as a rate.

- The Jones industry-mix rate has been also partitioned in the Ray-Srinath model. The Jones industry-mix rate is partitioned into the Ray-Srinath industry-mix effect rate and the allocation rate.