
Sensitivity Analysis - Weights

Introduction

A number of initiatives were proposed at the October 18th, 1998 meeting of the Indicators Working Group as part of the on-going development of indicators of regional socio-economic conditions. One of these initiatives was to assess the data and results for robustness. It was proposed to address this issue by examining the sensitivity of the index values to changes in the data and assigned weights. The issue of sensitivity of the results to changes in the data and weights was also raised by a number of the external reviewers¹. This report will address the sensitivity issue as it relates to the selection of the weights. The equally important issue of sensitivity to data changes will be addressed in July when the first data update is produced.

Purpose

A core component of the methodology underlying the development of indicators of regional socio-economic conditions is the selection of the weights. From the on-set of this project we have known that the selection of weights involves a degree of subjectivity and, to a certain degree, reflects a value judgement on the part of the creators. The hope is that the decision-makers that may use the results of this work also share this value statement.

In any event, the sensitivity of the results to the selection of the variables and the weights is useful when examining the interaction of the indices. Such an analysis can help ensure that the results are robust and not driven by changes in one or two variables alone.

Methodology

The method used to assess the sensitivity of the results to the selection of weights was to apply alternate weights to the various data indices and measure the change in the rank ordering of the results. As a rule-of-thumb, changes in the rank order of three or greater were flagged as significant. In addition, changes of three or more occurring within the top ten regions were examined in more detail. For the purpose of this analysis, alternative weights were applied to the data indices developed under the "Revised Index" methodology².

A summary of the alternative weights used is given below. In the case of the seven composite indicators, equal weights were used as the alternative scenario. A more rigorous approach would be to test each variable independently using a constant per cent change to the assigned weight (e.g. examine the impact of a 10% increase in weight for $IA > 1$ year, then apply the same criteria to $IA < 1$ year, etc. for all index variables). This approach could be adopted if further analysis of the sensitivity of the results to the weight selection is required.

¹ See; "Regional Socio-Economic Indicators – External Review", BC Stats, March 1, 1999.

² For a description of the methodology see; "Index Value Calculation", BC Stats, April 1, 1999.

Test	Index	Current Weight	Test Weight	Comments
A1	<i>Overall Stress Index:</i> <ul style="list-style-type: none"> Human Economic Hardship Change in Economic Hardship Crime Health Education Children Youth 	0.25 0.05 0.20 0.20 0.20 0.05 0.05	0.30 0.00 0.20 0.20 0.20 0.05 0.05	The apparent instability of the <i>Impending Change in Economic Hardship</i> indicator has raised concern. Assigning a zero weight eliminated this index.
A2	<i>Overall Stress Index:</i> <ul style="list-style-type: none"> Human Economic Hardship Change in Economic Hardship Crime Health Education Children Youth 	0.25 0.05 0.20 0.20 0.20 0.05 0.05	0.40 0.05 0.15 0.15 0.15 0.05 0.05	One of the external reviewers noted that that the <i>Economic Hardship</i> component was probably the most important as it influences the other components of Crime, Education, Health, Children and Youth, and should have a larger weight.
B	<i>Human Economic Hardship:</i> <ul style="list-style-type: none"> IA > 1 year IA < 1 year % 65+ on GIS 	0.50 0.25 0.25	0.33 0.33 0.33	Equal weights applied.
C	<i>Impending Change in Econ Hardship:</i> <ul style="list-style-type: none"> Change in IA Change in EI Natural resources dependency 	0.40 0.30 0.30	0.33 0.33 0.33	Equal weights applied.
D	<i>Indicators of Crime:</i> <ul style="list-style-type: none"> Change in Crime Rate Property Crime Rate Violent Crime Rate 	0.25 0.50 0.25	0.33 0.33 0.33	Equal weights applied.
E	<i>Indicators of Health Problems:</i> <ul style="list-style-type: none"> PYLL natural causes PYLL accidental causes PYLL suicide/homicide 	0.40 0.30 0.30	0.33 0.33 0.33	Equal weights applied.
F	<i>Indicators of Education Concerns:</i> <ul style="list-style-type: none"> % population without post-sec % did not graduate Gr 12 Math non-completion rate Gr. 12 Eng. non-completion rate % not enrolled in Career Prep. 	0.40 0.30 0.10 0.10 0.10	0.20 0.20 0.20 0.20 0.20	Equal weights applied.
G	<i>Indicators of Children at Risk:</i> <ul style="list-style-type: none"> % children on IA > 1 year % children on IA < 1 year Infant mortality rate Avg. Reading test scores 	0.40 0.20 0.20 0.20	0.25 0.25 0.25 0.25	Equal weights applied.
H	<i>Indicators of Youth at Risk:</i> <ul style="list-style-type: none"> % youth on IA > 1 year % youth on IA < 1 year % 18 pop that did not graduate 	0.50 0.25 0.25	0.33 0.33 0.33	Equal weights applied.

Results

The results are summarized on the attached scatter plots. The x-axis is the rank order of the regions using the current weights (and revised index methodology). The y-axis is the rank order using the alternative weights. If there were no change to the rank order under the alternative weights, the scatter plot would follow the diagonal. Hence, deviation from the diagonal measures the amount of change that has occurred as a result of the alternative weights.

Test		No. with Difference > 3	Per Cent of Total	Difference > 3 In Top Ten	Per Cent Of Total
A1	Overall Stress Index	5	19%	0	0%
A2	Overall Stress Index	4	15%	0	0%
B	Human Economic Hardship	5	19%	0	0%
C	Change in Economic Hardship	1	4%	0	0%
D	Indicators of Crime	7	27%	4	15%
E	Indicators of Health Problems	0	0%	0	0%
F	Indicators of Education Concerns	4	15%	0	0%
G	Indicators of Children at Risk	4	15%	2	8%
H	Indicators of Youth at Risk	2	8%	0	0%

The determination of the sensitivity of the results to the selection of the weights is somewhat subjective. As the weights play an important role in determining the results, it cannot be said that the results are insensitive to the weight selection. What can be gained from the above table are insights into the characteristics on the component composite indicators.

Of the seven composite indicators, the *Indicators of Crime*, and to a lesser extent the *Indicators of Children at Risk* displayed the greatest degree of volatility under the assumption of equal test weights.

In the case of *Indicators of Crime*, assuming equal weights resulted in a change in rank greater than three in 7 out of 26 regions, or 27% of the cases. Four of these areas were among the top ten worst regions. This result would indicate that the heavier weighting put on property crime has a significant impact on the determination of the composite indicator. This is somewhat disturbing given that we feel that the current form of the index could be improved.

The weights applied to the violent/property crime are very subjective. In the current version of the indicators, the property crime has a weight two times the level of the violent crime. In reality, the property crime rate is about six times the level of the violent crime rate. Implicitly, by placing relative weights of only two to one between property and violent crime, each violent crime is weighted three times the significance of each property crime. To better understand crime patterns across BC, it would be useful to have the violent and property crime rates broken out into sub-groups. For example, by far the majority of Violent Crime is categorised as Level 1, which is considered minor crime. Similarly, more than half of Property Crime is theft that is primarily comprised of bicycle theft, shoplifting and theft from motor vehicles. These minor crimes would have far less impact on the public's feeling of personal safety in their communities than more serious assaults or property crimes such as break and entering. Ideally, that data should be compiled to distinguish major from minor crime offences, and weighted according.

The other index that displayed a greater degree of change was *Children at Risk*. Although only 4 out of 26 regions (15%) displayed a change in rank greater than three under an equal weight assumption, 2 were among the top ten worst regions. One factor underlying this result is the presence of extreme values in infant mortality rates in two regions. When the weight assigned to infant mortality is increased from 0.20 to 0.25, these outlier regions receive a proportionately higher score, which resulted in a more dramatic change in rank order.

In the case of the *Overall Stress Index*, eliminating the *Impending Change in Economic Hardship* indicator still has a slight impact despite the low weighting of only 5 per cent. Five out of 26 regions had a change in rank order greater than three (19%), but none were among the top 10. Similarly, increasing the importance of the *Human Economic Hardship* indicator had an impact on the *Overall stress Index*, however, it wasn't large.

In general, one could conclude that the weights are an important, but not the sole, determinant of the results as in most cases the ranking of the top 10 regions were unaffected. However, it is still very important that those attempting to use these indicators for public policy decisions understand and accept the weighting scheme.