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Experimental Economic Activity Indexes for Canadian Provinces and Territories

by Nada Habli, Ryan Macdonald and Jesse Tweedle

This article in the Economic Insights series reports on a set of experimental monthly economic activity indexes that have been estimated for the provinces and territories up to March 2020. The COVID-19 pandemic has accentuated the need for timely information on aggregate economic activity with more geographical detail. This article describes how more timely economic data can be summarized in indexes that generally reflect the broad movements of the provincial and territorial economies.

Introduction

Timely measures of economic activity in the provinces and territories support the ability of governments to make informed policies, and enhance the ability of analysts and researchers to understand and examine how economies are performing. The severity of the impacts from the COVID-19 pandemic has varied across provinces and territories, and this has led to economic restrictions that have varied in type, severity and duration. However, timely statistics that capture the broad economic impact of these restrictions are not available.

Currently, the most recent, comprehensive measure of economic activity for provinces and territories produced by Statistics Canada is annual real gross domestic product (GDP) for 2019. Statistics Canada produces timely and higher frequency statistics on specific economic activities/markets, such as international trade, manufacturing sales, building starts, wholesale trade sales, retail trade sales and consumer prices. However, a single, aggregate statistic is not available.

To address the requirement for a more up-to-date measure of aggregate economic activity, a set of experimental economic activity indexes have been estimated. The indexes are developed using statistical techniques that combine a large array of monthly data to produce aggregate measures that are representative of how overall provincial and territorial economic activity has progressed from January 2002 to the present.

This article first gives an overview of the statistical methods and data used to create the indexes. A more detailed, technical explanation is given in Habli et al. (2020). It then presents the year-to-year growth rates for the provinces and territories for March 2020 to illustrate the effect of the COVID-19 pandemic across Canada.

The results show that the largest effects are in Alberta where the impact of COVID-19 coincided with a decline in oil prices. Saskatchewan, the other major oil producing province, and provinces that were more affected by COVID-19 restrictions (Ontario, Quebec, Nova Scotia, and New Brunswick) also exhibit declines in activity across the indexes. In all cases, these declines have been historically large. For the remaining provinces and territories, the indexes present mixed messages (some decline, some increase), or the degree of decline is of a smaller magnitude.

Data inputs

A broad set of monthly provincial and territorial data series form the components from which the indexes are constructed. Each variable is publicly available on Statistics Canada's Common Output Data Repository and spans the January 2002 to March 2020 time period. Table 1 lists data sources considered. Each potential data series represents a specific aspect of economic activity. Data series with suppressions are not considered. Input series in current dollars are deflated using provincial and territorial deflators whenever possible, and Canada-level deflators when provincial and territorial deflators are not available.[1] Series in natural units, such as electricity production or employment are used as is. Seasonally-adjusted data are used when they are available. In cases where only non-seasonally adjusted data are available, the series are seasonally adjusted prior to use. In cases where the routines for seasonal adjustment do not produce desirable results, these series are not used.[2] When necessary, an input series is created by linking together series from different data vintages to create a single series that covers the entire time period.

The resulting data set contains 1,353 series that are spread unevenly across the provinces and territories. Ontario and Quebec have the most series, while the smallest number of input series are available for the territories. To use the series in statistical models, the growth rates for all series are calculated.[3]

1. This will produce better results for larger provinces that make important contributions to the Canada-level deflators.
2. This can occur, for example, if a series contains many zeros. Seasonal adjustment can produce unrealistic negative numbers in this case.
3. The growth rates are assumed to be covariance stationary and are demeaned and scaled to have unit variance.

Table 1
Input data sources

Table number	Table title
12100099	Merchandise imports and exports, customs-based, by Harmonized commodity description and coding system (HS) section, Canada, provinces and territories, United States, states
12100119	International merchandise trade by province, commodity, and Principal Trading Partners
14100036	Actual hours worked by industry, monthly, unadjusted for seasonality
14100201	Employment by industry, monthly, unadjusted for seasonality
14100222	Employment, average hourly and weekly earnings (including overtime), and average weekly hours for the industrial aggregate excluding unclassified businesses, monthly, seasonally adjusted
14100287	Labour force characteristics, monthly, seasonally adjusted and trend-cycle, last 5 months
14100292	Labour force characteristics by territory, three-month moving average, seasonally adjusted and unadjusted, last 5 months
14100355	Employment by industry, monthly, seasonally adjusted and unadjusted, and trend-cycle, last 5 months
16100048	Manufacturing sales by industry and province, monthly (dollars unless otherwise noted)
18100004	Consumer Price Index, monthly, not seasonally adjusted
18100204	Electric power selling price index, monthly
18100205	New housing price index, monthly
20100008	Retail trade sales by province and territory
20100074	Wholesale trade, sales
21100019	Monthly survey of food services and drinking places
24100002	Number of vehicles travelling between Canada and the United States
25100001	Electric power statistics, with data for years 1950 - 2007
25100015	Electric power generation, monthly generation by type of electricity
34100003	Building permits, values by activity sector
34100066	Building permits, by type of structure and type of work
34100158	Canada Mortgage and Housing Corporation, housing starts, all areas, Canada and provinces, seasonally adjusted at annual rates, monthly

Note: HS: harmonized system.

Source: Statistics Canada.

Estimating aggregate economic activity

Four indexes of economic activity are estimated using different statistical methods: 1) a simple model that uses only three data series that are available for every province and territory; 2) a principle components analysis (PCA) based index; 3) a weighted average of the simple model-based index and the PCA-based index; and 4) a least absolute shrinkage and selection operator (LASSO) based index.

Each method is an approach to combine the input data series to produce a single aggregate series for every province and territory. The four statistical methods are applied to the input data for each province and territory separately, and the estimated parameters for each model essentially give the weights by which the data series are combined.

Ideally, historical estimates of monthly real GDP would already exist for each province and territory. In that case, model parameters could be chosen so that the resulting index would fit the monthly historical GDP data as closely as possible. The estimated parameters and input data would then be used to calculate an economic activity index in the most recent period, where the input data are already available, but real GDP is not.

Since real GDP for provinces and territories are only available at Statistics Canada annually, the models are estimated using annual data. Across the different modelling strategies, the use of annual data to estimate parameter values and then predict monthly growth rates is implemented based on the following steps:

- Step 1: Monthly growth rates are bottom- and top-coded at the 5th and 95th percentiles. This is done to reduce volatility observed in the input series when estimating model parameters. The annual average of the monthly growth rates are then calculated.

- Step 2: Estimate models using the annual data.

  Simple index—This index uses only total employment from the Survey of Employment, Payroll and Hours, total exports and total retail sales as input data. The advantage of this method is that the input data used to create the index for each province and territory is the same. The approach provides a simple basis for comparison to more complex methods. An ordinary least squares (OLS) regression is estimated with real GDP as the dependent variable and the three input data series as the input variables. The estimated parameters are used to determine the relative contributions of each of the input series to the index.

  PCA based index—PCA is a variable reduction technique that produces linear combinations of the inputs data series that capture the variation in the dataset. The linear combination of series that explains the largest fraction of the variation in the data set is called the first principal component, and so forth. Annual real GDP is then regressed on all possible combinations of the first ten principal components in order to find the combination that explains the most of its annual growth. The estimated parameters from that particular combination is used to create the PCA-based index.

  Weighted index—Examinations of the simple index and the PCA index suggest that a combination of these indexes may improve on the two components. A weighted combination of the indexes is calculated by maximizing the correlation of the weighted index with annual real GDP growth[4].

  LASSO index—The LASSO algorithm selects series from the input data set to be included in a regression to explain annual real GDP growth. Unlike an OLS regression that will yield unbiased predictions, the LASSO algorithm trades off increased bias against more precise estimates (lower standard errors in the prediction).[5]

- Step 3: Using the estimated model parameters and the non-top and non-bottom-coded input data, predicted monthly growth rates for the economic activity index are calculated.[6]

- Step 4: Calculate chain indexes based on the monthly growth rate estimates.

Quality evaluation

Basing the model parameters on annual rather than monthly data may have important consequences for the quality of the indexes. At an annual frequency, variables may appear to move together, while at a monthly frequency their movements may be less synchronized. As well, parameters estimated using annual data may overestimate the strength of the relationship between variables at the monthly frequency. Conversely, important monthly variation in the data may be masked by aggregation to the annual level, and parameter estimates using annual data may underestimate the strength of the relationship between variables at the monthly frequency as a consequence.

The four approaches also have different strengths and weaknesses, which affects their use (Table 2). The simple index and the LASSO index have the strength that their models are parsimonious, and the indexes they produce are less noisy than PCA-based indexes. However, these indexes rely on a greatly reduced number of series. In the case of the simple index, the three data series used in the regression

4. Input series are filtered prior to remove the 25% of series with the highest variance for each province and territory before applying PCA.
5. Input series are filtered to remove the 15% of series with the highest variance for each province and territory before apply LASSO. For smaller economies, LASSO fails to produce a feasible result. In these cases, there is a small number of potential inputs and a more traditional modelling strategy that removes inputs based on their statistical significance is used.
6. This requires adjusting parameter estimates and monthly series variances to account for differences between annual and monthly frequencies.

are often statistically insignificant. Additionally, the simple index is likely too parsimonious to be able to fully reflect overall economic conditions. Rather, its strengths lie in that it is straightforward to understand, consistent across the provinces and territories and it provides a base against which more sophisticated models can be compared. The simple indexes and the LASSO indexes also tend to focus on employment series rather than a broad range of inputs, and so may not present ideal predictors of overall monthly activity fluctuations if changes in production are not contemporaneously aligned with changes in labour variables at the monthly frequency.

The PCA index has the strength that it has produced good results when used by other researchers in a similar context (see Evans, Liu and Pham-Kanter, 2002; and Federal Reserve Bank of Chicago, 2020)[7]. However, it produces the noisiest activity indexes making them difficult to interpret, and in some cases (e.g., Newfoundland and Labrador or Nunavut) the index can grow or decline sharply. The PCA index uses the set of principal components that explains the most variation in annual GDP, regardless of whether a specific principal component is statistically significant or not. These inclusions err on the side of adding additional information, but if this information is not statistically significant, it tends to cause more variation in the index. In comparison, the parsimonious LASSO approach is designed to deliver an index with less variance.

Table 2
Characteristics of index estimation approaches

Criteria	Simple index	PCA index	Weighted index	LASSO index
Consistent inputs across geographies	Yes	No	No	No
Consistent model-types across geographies	Yes	Yes	Yes	No
Model specification	3 inputs, some insignificant variables	Variable number of principle components. Some insignificant variables	Combination of Simple and PCA	Variable input selection
Model fit	Goodness of fit can vary across provinces and territories	Generally good in-sample fit	Improved in-sample fit compared to the simple or PCA indexes	Generally good in-sample fit
Interpretability	Easy to understand inputs and contributions	Difficult to understand what contributes to changes Difficult to interpret principle components High variability indexes	Difficult to understand what contributes to changes	Inputs based on correlations Interpretable contributions Low variance index
Model suitability	Models can perform poorly based on statistical significance Inputs align with expectations about important variables	Models can perform poorly based on statistical significance Comprehensive use of input data	Inherits properties of input indexes	Modelling approach not well suited to current set-up

Note: PCA: principle components analysis; LASSO: least absolute shrinkage and selection operator.
Source: Statistics Canada.

Combining the indexes provides an additional alternative method. Since the simple index is relatively stable, but focuses on a limited number of series and the PCA is more variable but includes linear combinations of all inputs, these series are combined to produce a weighted index that has better characteristics than the components.

7. The Chicago Fed National Activity Index (CFNAI) uses the first principle component from amongst 85 monthly series to provide an indication for the strength of monthly economic activity in the United States.

Across the methods, the indexes that are produced generally return similar types of information on economic cycles and major economic shocks in the provinces and territories. For example, the indexes illustrate the recessions and commodity cycles that have affected Alberta and Saskatchewan as well as the business cycles for the remaining provinces and territories. The periods of stronger or slower growth in the indexes also appear to correspond with what are understood to be periods of better or worse provincial and territorial economic performance.

There are also some geographies where discrepancies arise, such as in Newfoundland and Labrador where the PCA index presents different information compared to the simple index or Manitoba, Yukon, and Nunavut where the simple index does not perform well. In situations where the models have performed the best, there tends to be a positive correlation across measures for the implied changes in aggregate economic activity. The indexes, therefore, appear to capture relevant information for economic cycles, periods of stronger or weaker growth, and are useful for understanding aggregate economic performance.

Table 3 provides an overview of which models appear to behave sufficiently well to warrant their use. The decisions are not based on a particular statistical test or threshold, but are instead based on assessments of model performance and the behavior of the resulting indexes. Indexes marked as fit-for-use are those which support the use of the experimental index. Those marked not-fit-for-use are those where a clear failure has occurred either in the modelling or in the behavior of the resulting index.

Table 3
Model use by index type

	Simple index	PCA index	Weighted index	LASSO index
Newfoundland and Labrador	Fit-for-use	Not-fit-for-use	Not-fit-for-use	Fit-for-use
Prince Edward Island	Not-fit-for-use	Fit-for-use	Not-fit-for-use	Fit-for-use
Nova Scotia	Fit-for-use	Fit-for-use	Fit-for-use	Fit-for-use
New Brunswick	Fit-for-use	Fit-for-use	Fit-for-use	Fit-for-use
Quebec	Fit-for-use	Fit-for-use	Fit-for-use	Fit-for-use
Ontario	Fit-for-use	Fit-for-use	Fit-for-use	Fit-for-use
Manitoba	Not-fit-for-use	Fit-for-use	Not-fit-for-use	Fit-for-use
Saskatchewan	Fit-for-use	Fit-for-use	Fit-for-use	Fit-for-use
Alberta	Fit-for-use	Fit-for-use	Fit-for-use	Fit-for-use
British Columbia	Fit-for-use	Fit-for-use	Fit-for-use	Fit-for-use
Yukon	Not-fit-for-use	Fit-for-use	Not-fit-for-use	Fit-for-use
Northwest Territories	Fit-for-use	Fit-for-use	Fit-for-use	Not-fit-for-use
Nunavut	Not-fit-for-use	Not-fit-for-use	Not-fit-for-use	Fit-for-use

Note: PCA: principle compoments analysis; LASSO: least shrinkage and selection operator.

Source: Statistics Canada.

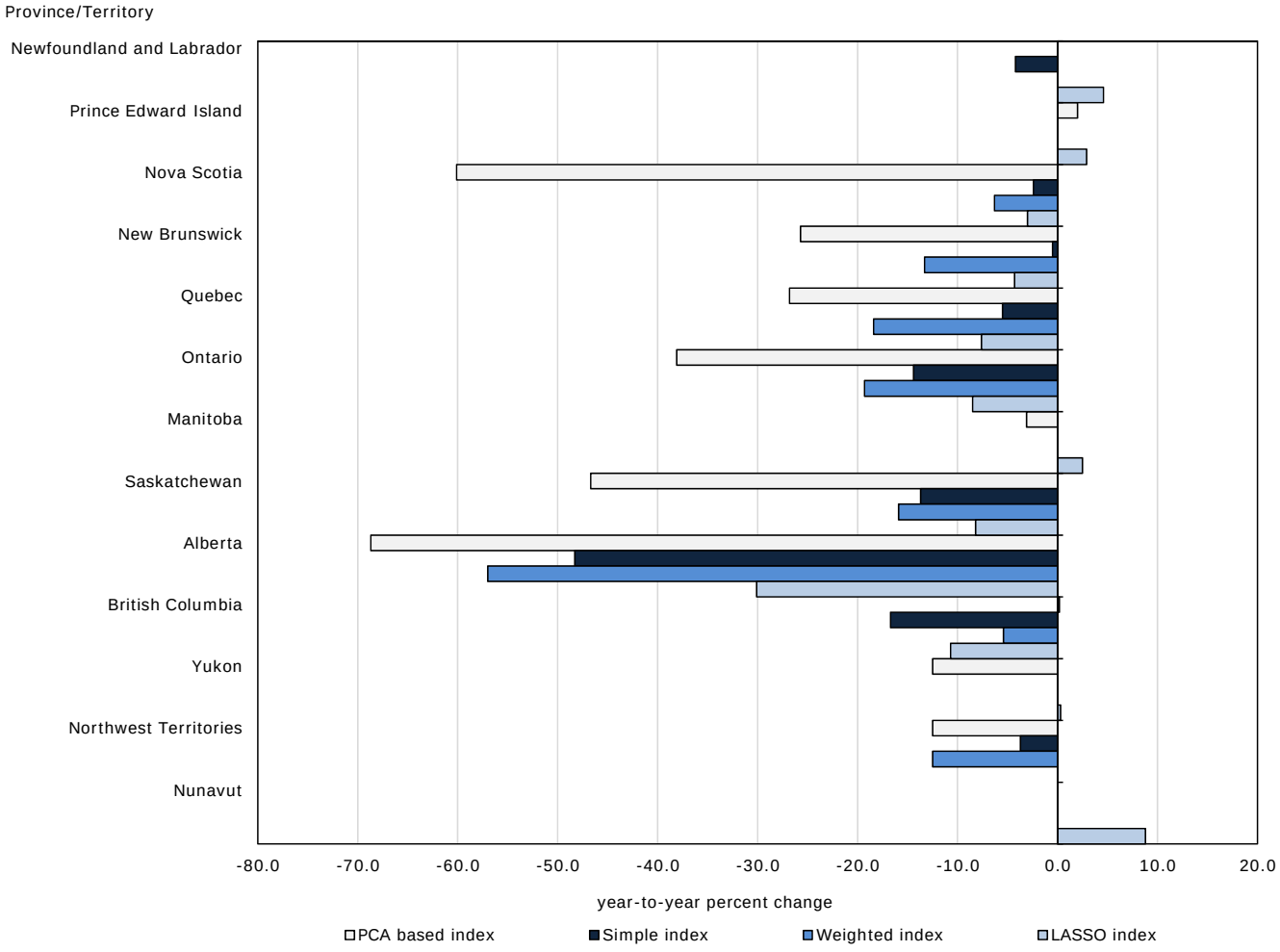
However, care should be taken when making comparisons across provinces and territories. The index levels are not comparable in the same way as nominal GDP, and are dependent on the base period chosen. This means it is not possible to ascertain which provinces or territories have higher or lower levels of economic activity. And, the indexes appear to magnify cycles. Since the indexes can have different inputs, this could reflect fundamental differences in the size of the cycles affecting the regional economies. But it could equally reflect differences in the inputs used. As a result, while comparisons of growth can be made, care should be taken with respect to the conclusions that are drawn until such time as the properties of the indexes and their approaches are better understood.

Finally, the indexes are not measures of real GDP. While the models employed to create parameter estimates use annual real GDP, the outputs from the indexes use a sub-set of the information needed to produce a real GDP measure, and are not based on economic theory. Rather, the indexes are constructed from inputs that correlate with real GDP growth at an annual frequency. As a result they provide a prediction for what changes in aggregate economic activity could look like, but they are not GDP.

How large is the effect of COVID-19

The monthly activity indexes are quite volatile and contain cycles that are accentuated. As a result, it can be difficult to examine month-to-month changes in the activity indexes. To interpret changes in economic activity using the indexes, it is useful to examine moving averages, year-to-year growth rates, convert the indexes to a quarterly frequency or to use techniques that are aimed at identifying trends and cycles.

Chart 1
Year-to-year changes in economic activity indexes, March 2020



Note: PCA: principle components analysis; LASSO: least absolute shrinkage and selection operator. Series not available for all combinations of indexes and geographies. The simple index is not availabe for Prince Edward Island, Manitoba, Yukon and Nunavut. The PCA index is not available for Newfoundland and Labrador and Nunavut. The weigthed index is not available for Newfoundland and Labrador, Prince Edward Island, Manitoba, Yukon and Nunavut. The LASSO index is not available for Northwest Territories.
Source: Statistics Canada, authors calculations based on data from the Common Ouput Data Repository (CODR) table 36-10-0633.

In Chart 1, the provincial and territorial year-to-year growth rates for March 2020 are compared across the indexes identified as fit-for-use. Across the indexes, the simple index and LASSO based index show the least variability while the PCA based index has the most variability.

Across provinces, the largest declines are found in Alberta where all indexes indicate a reduction in activity (Table 4). The second largest declines are in Saskatchewan and Nova Scotia, followed by New Brunswick, Quebec, Ontario and the Northwest Territories. In all of these jurisdictions, all indexes indicate a decline in activity, but the magnitude of the declines can vary importantly across provinces. The size of the declines shown in Alberta speak to the size of the dual shock from the pandemic and from falling oil prices. The declines in Quebec, and Ontario remain large (they are the largest in each of their provincial time series), and are more consistent across measures. For the remaining provinces and territories, the size of the declines is either of smaller magnitude, positive, or there is disagreement between the measures as to whether a decline occurred.

Table 4
Comparing changes in activity across provinces and territories, year-to-year growth rates

Province/Territory	Average	Standard deviation	Spread	Number negative
Newfoundland and Labrador	0.2	6.2	-4.2 to 4.6	1 out of 2
Prince Edward Island	2.4	0.6	2.0 to 2.9	0 out of 2
Nova Scotia	-17.9	28.2	-60.1 to -2.4	4 out of 4
New Brunswiick	-11.0	11.2	-25.7 to -0.5	4 out of 4
Quebec	-14.6	9.9	-26.8 to -5.5	4 out of 4
Ontario	-20.0	12.8	-38.1 to -8.5	4 out of 4
Manitoba	-0.3	4.0	-3.1 to 2.5	1 out of 2
Saskatchewan	-21.1	17.3	-46.7 to -8.2	4 out of 4
Alberta	-51.0	16.2	-68.7 to -30.1	4 out of 4
British Columbia	-8.2	7.2	-16.7 to 0.2	3 out of 4
Yukon	-6.1	9.1	-12.5 to 0.3	1 out of 2
Northwest Territories	-9.6	5.1	-12.5 to -3.7	3 out of 3
Nunavut	8.8	…	8.8 to 8.8	0 out of 1

… not applicable
Source: Statistics Canada.

The size of the declines in the indexes for Alberta illustrates an important feature of the economic activity indexes: their volatility and cyclicality. Despite considerable effort to address issues related to the variance of the inputs, the monthly indexes continue to show large swings in activity, particularly around business cycles and commodity cycles. While these cycles are undoubtedly present, their magnitude in the indexes appears too large and possibly comes from using all series with an equal weighting and from not imposing economic restrictions on model inputs.

In the indexes, small value series are not weighed for their contribution to overall growth. These series are typically subject to greater variability than larger aggregates, and may exhibit greater cyclicality. This would tend to accentuate volatility and/or cycles in the indexes relative to measures of total economy real GDP.

This means that while comparisons across the provinces and territories are possible, caution needs to be exercised when drawing conclusions. For example, it is clear from the indexes, as well as other sources such as the Labour Force Survey, that Alberta is in the midst of a large downturn. However, it is

unlikely that there has been an approximately 69% decrease in economic activity, such as is implied by the PCA-based activity index.

Conclusion

Measures of aggregate economic activity are important for informing decisions about fiscal and monetary policy, for determining the characteristics of business cycles and for examining economic performance. Here, four indexes based on different methodological approaches are presented. The methodologies are based on: 1) a simple index; 2) PCA index; 3) a weighted combination of the simple index and the PCA index; and, 4) LASSO index. In almost all cases, all approaches produce roughly similar types of information (e.g., periods of growth, business cycles, etc.). However, the degree of cyclicality and the variance of month-to-month changes can differ importantly across methods. As a general rule, PCA produces the greatest variability and the largest cycles while the simple index is the most stable.

The assessments of the indexes made thus far suggest that the simple and LASSO indexes present results related to a set of fundamental inputs (often heavily influenced by employment series), that the PCA index relates to some form of short-term activity (but the signal is noisy), and that the weighted index presents a compromise between the two.

The indexes as currently estimated correlate with annual measures of real GDP, but should not be interpreted as being a real GDP measure. The indexes display greater variability and cyclicality than that of real GDP measures, and are constituted from measures of gross outputs, employment, relative prices and important ratios such as the unemployment rate. This makes the indexes appropriate for understanding economic activity, but they are not real GDP. Moreover, the indexes do not inform about differing levels of economic activity among the provinces and territories.

At the current time, the correlations between the different approaches, their positive correlation with provincially produced measures of sub-annual real GDP and examinations of their properties against known provincial and territorial economic performance supports their use as indicators of business cycles, for understanding the magnitude of shocks relative to a provinces' or territory's history and for understanding how regional economies are progressing. Inter-provincial growth comparisons are also supported, but with the caveat that model performance is difficult to understand in all situations, that the models look to be accentuating business cycles, and that level comparisons across provinces are not possible using the index values.

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