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Time Series Characteristics of Canada's Beyond GDP Indicators

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Abstract

This paper investigates the time series properties of three Beyond-Gross Domestic Product (BGDP) measures in Canada, namely, gross national disposable income (GNDI), human development index (HDI), and index of economic freedom (IEF), along with Gross Domestic Product (GDP). GDP is the most used metric for measuring economic growth and is susceptible to influence by numerous factors beyond the value of production measured by GDP. BGDP measures have been suggested in the literature as alternative indicators that can capture economic progress in a more holistic way (Kimmerer, 2020). This paper generates and evaluates the descriptive statistics of GDP and BGDP indicators. To evaluate the potential existence of a long run relationship between GDP and BGDP indices, we performed Augmented Dickey Fuller stationarity and Johansen cointegration tests. The results demonstrate that per capita GDP is cointegrated with the BGDP indicators. Furthermore, this study shows for the first time in the literature that BGDP measures are cointegrated when paired with each other. The paper contributes to the literature by highlighting the time series properties of BGDP indicators in Canada. This insight facilitates understanding the behavior of BGDP measures, thereby further enhancing the use of these measures for econometric studies and policy making.

Keywords: Economic growth, Beyond-GDP measures, Disposable income, Human development, Economic freedom, Cointegration.

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1. Introduction

Historically, Gross domestic product (GDP) has been the most widely used measure of economic growth. The challenge with using GDP as the fundamental growth metric is that although GDP is considered a leading indicator for measuring macroeconomic development, it does not capture certain crucial socio-economic factors and interactions that represent the overall wellbeing of the society and economy (Seaford, 2014; Volejníková & Řezníček, 2016). As a result, the predominant use of GDP has led to an arguably limited understanding of the breadth of socio-economic and wellbeing aspects of the society that can affect the overall economic growth. Broader perspectives gained from using other complementary (and arguably more comprehensive) measures of economic growth are, therefore, required in economic development studies (Ngepah, 2017; Rani & Mandal, 2020). These complementary measures have been referred to in the literature as beyond-GDP (BGDP) or alternative growth metrics (IMF, 2011; Kubiszewski et al., 2013; Seaford, 2014; Whitby et al., 2014).

In economic studies, the use of BGDP indicators is, however, limited (Boarini & D'Ercole, 2013; Chancel et al., 2014; European Commission, 2013; IMF, 2011). This paper introduces three BGDP indicators and evaluates their time series characteristics in the Canadian context. The long run relationships between pairs of alternative growth metrics were evaluated, as well as their long-term behavior with GDP. The BGDP measures evaluated are Gross National Disposable Income (GNDI), Human Development Index (HDI), and the Index of Economic Freedom (IEF). Table 1 summarizes the definitions and scope of the BGDP measures, including GDP.

Table 1: Summary of the composition of each variable

Variable	Components
GDP	Productivity/output: Monetary value of the final goods and services produced in a country or the total income and total expenditure.
GNDI	A nation's available income for final consumption and gross savings.
HDI	A nation's average achievements in health/life expectancy, knowledge/education, and the standard of living.
IEF	Covers twelve (12) freedoms under four pillars of economic freedom: 1. Rule of Law: Government integrity, property rights, and judicial effectiveness. 2. Government Size: Fiscal health, government spending, and tax burden. 3. Regulatory Efficiency: Business freedom, monetary freedom, and labor freedom. 4. Open Markets: Investment freedom, trade freedom, and financial freedom.

Sources: Capelli & Vaggi, 2014; Coyle, 2017; Miller et al., 2021; Pettinger, 2019; UNDP, 2020.

1.1 Purpose of the Study

The objective of this paper is to provide initial insights on the nature and attributes of BGDP indicators to improve their general understanding, thereby facilitating their increased use for economic growth and developmental studies. This article, therefore, analyzes the time series properties of GDP and BGDP indicators in Canada. Beginning with time series plots, we present the descriptive statistics, assess the stationarity of all the variables using unit root tests, and utilize cointegration tests to investigate whether a long run relationship exists between pairs of the alternative growth measures, as well as with GDP.

2. Brief Review of the Literature

In the body of literature, the use of BGDP indicators for economic growth and developmental studies is yet to be considered ubiquitous. The need for a better understanding of the measures of economic growth has been underscored by several authors (Fraumeni, 2017; Kimmerer, 2020; Lange et al., 2018; Pais et al., 2019; Rani & Mandal, 2020). Kimmerer (2020) presented a summary of 40+ alternative measures of growth and wellbeing and highlighted the reasons for their development to more holistically capture economic progress. Among these are GNDI, HDI, and IEF, which are the focus of this paper due to the availability of time series data for these measures in Canada.

GNDI in the literature has been used to evaluate aspects of growth and the economy such as the impact of disposable income on demand, (Bohlmann & Inglesi-Lotz, 2021). Due to its ability to measure the standard of living of constituents, it has been argued that GNDI is a better indicator of wider-scale economic development (Capelli & Vaggi, 2013). The standard of living can dictate both the levels of production of individual members of the society, as well as their choices and consumption patterns that can impact a nation's overall output and economic progress (Capelli & Vaggi, 2013). GNDI captures the ensemble of in-country output, net-income receipts from abroad, as well as unilateral transfers (notably remittances) (Capelli & Vaggi, 2013, 2014). These complementary inflows and outflows ultimately affect the overall growth dynamics of the local economy and provide resources that are essential to funding infrastructure development, technology innovation, as well as the provision of goods and services that drive economic development.

HDI was developed by the United Nations Development Programme (UNDP) (Miranda et al., 2020; UNDP, 2020). It uses a people-centric approach to reflect the overall economic well-being. HDI accounts for longevity, gender equity, education (access and level), standard of living, income inequality, per capita GDP referenced to the purchasing power parity (PPP), and health achievements (Deb, 2015; UNDP, 2020). Higher values of HDI imply an improvement in human development (UNDP, 2020).

IEF aims to capture the importance of understanding the relationship between governments and individuals when evaluating individual autonomy and its impact

on economic freedom (Miller et al., 2021a, 2021b, 2021c). Twelve components of economic freedoms are accounted for by the IEF metric under four broad themes, namely, the size of the government, the rule of law, market openness, and regulatory efficiency. The size of government is comprised of fiscal health, tax burden, and government spending (Miller et al., 2021). The rule of law consists of government integrity, property rights, and judicial effectiveness (Miller et al., 2021). Market openness is made up of investment freedom, financial freedom, and trade freedom (Miller et al., 2021). Regulatory efficiency relates to labor freedom, monetary freedom, as well as business freedom (Miller et al., 2021). Higher values of IEF are considered indicative of more economically free societies which is essential for continued economic progress and prosperity (Miller et al., 2021c).

3. Data and Methodology

The data utilized were retrieved from various databases. GDP and GNDI were obtained from the Organization for Economic Cooperation and Development (OECD). HDI was extracted from the UNDP. IEF data was obtained from the Heritage Foundation and population [which was used to derive per capita GDP (GDPpc) and GNDI (GNDIpc)] was collected from the OECD. The time series period covered in this study was from 1995 - 2019.

Time series plots of the variables were generated to visually assess the behavior and trend of the variables during the period evaluated. The descriptive statistics of all the time series variables were calculated, including the quantiles and measures of symmetry. Furthermore, the Augmented Dickey-Fuller (ADF) test was run to assess the stationarity of both GDP and the BGDP measures for the level and first difference of each variable. The stationarity of the variables was determined by considering the ADF test asymptotic p-values. Johansen cointegration (JC) tests were run to evaluate if the growth indicators are cointegrated.

Given the limited literature on the use of BGDP indices, the tests were performed for multiple scenarios to gain a broad perspective of the scenarios in which the growth measures, when paired with each other, could be cointegrated. The five scenarios evaluated are referred to as the “no constant”, “restricted constant”, “unrestricted constant”, “restricted trend”, and “unrestricted trend” scenarios. Vector autoregression (VAR) was performed to determine the optimal lag length used for the cointegration tests.

4. Results and Discussion

The time series plots are presented in Figures 1 and 2 by level and first difference, respectively. Tables 2 and 3 contain the descriptive statistics, quantiles, and measures of symmetry. ADF unit root test results are shown in Table 4 while Figure 3 highlights the time series trends for paired growth measures used to visually assess the co-movements of the variables. Results from vector autoregression (VAR) lag length selection for JC testing are indicated in Table 5.

The Johansen test results are reported in Tables 6 - 21. Tables 6 - 17 show the JC results for pairs of variables for the "unrestricted constant" and "unrestricted constant and trend" scenarios whose choice, as the reference scenarios for detailed reporting, was informed by the visual observation of the time series behavior from the time series plots (Figure 1). The results for all the scenarios evaluated are summarized in Table 18 - 20. Table 21 contains a summary of the number of scenarios in which the pairs of growth variables exhibit cointegration.

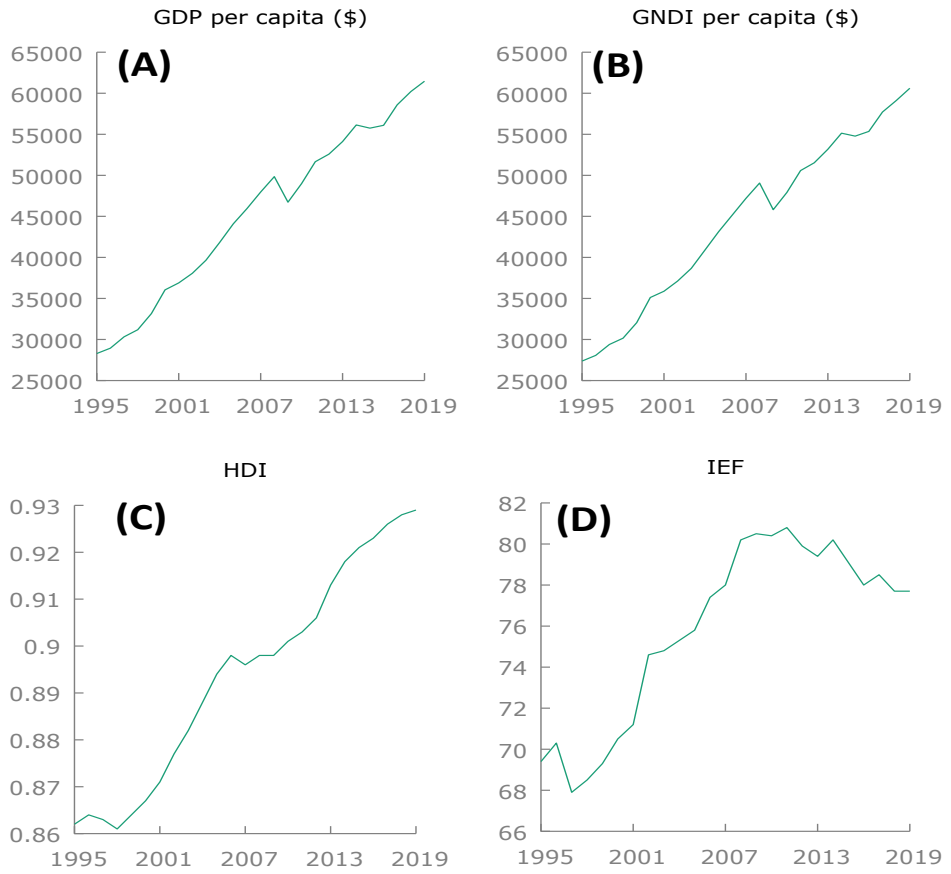

Figure 1: Time series plot by level

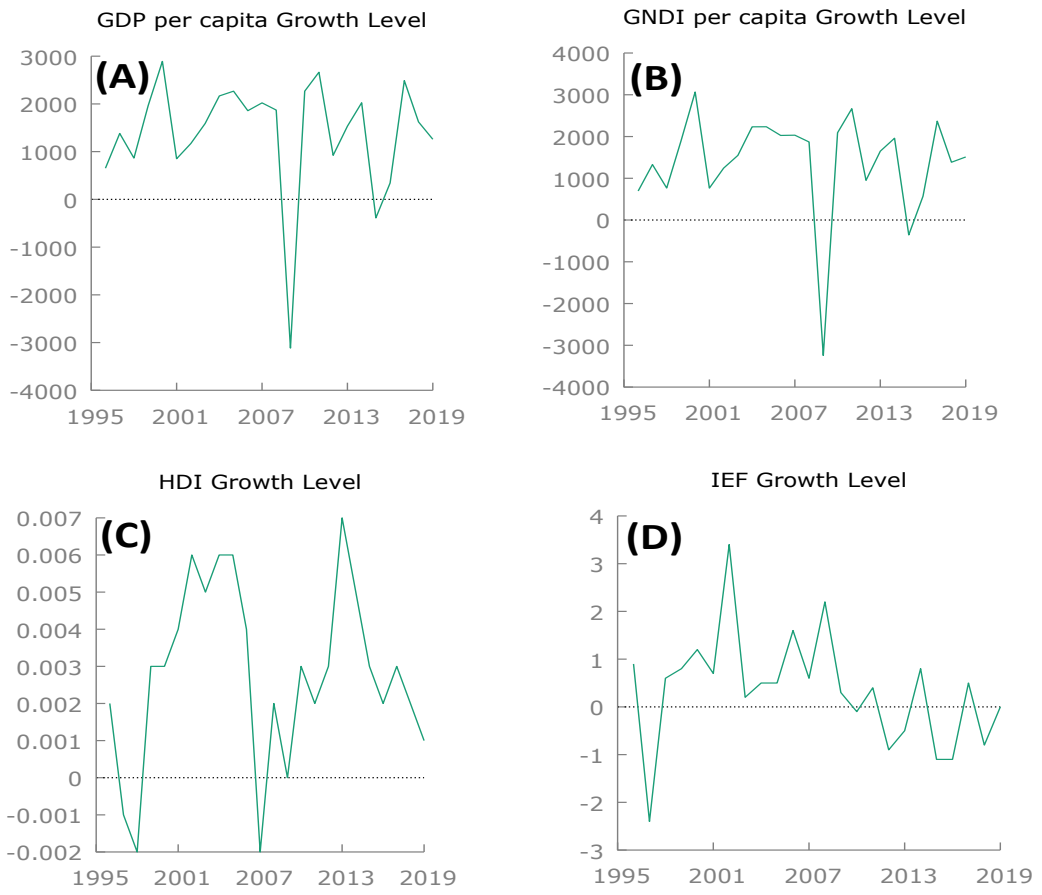

Figure 2: First difference (growth level) time series plots

Table 2: Summary Statistics of Canada's Population, GDP, and BGDP indices

Variable	Mean	Median	Min.	Max.	Std. Dev.	Variance	C.V.
Population	33.10	32.89	29.30	37.59	2.4962	6.2310	0.075
GDPpc ($)	45382	46726	28290	61466	10408	108326464	0.229
GNDIpc ($)	44439	45818	27369	60613	10420	108576400	0.234
HDI	0.89	0.90	0.86	0.93	0.0231	0.0005	0.026
IEF	75.82	77.70	67.90	80.80	4.3564	18.9781	0.057

Note: (a) Population is in Millions (b) C.V. is the coefficient of variation. (c) Variance is in squared units

Table 3: Summary Statistics: Quantiles and Measures of Symmetry

Variable	5% Perc.	95% Perc.	IQ Range	Skewness	Skewness Comment	Ex. kurtosis	Kurtosis Comment
Population	29.40	37.43	4.49	0.17	Positive fairly symmetrical	-1.1629	Platykurtic
GDPpc ($)	28486	61088	18462	-0.18	Negative fairly symmetrical	-1.2100	Platykurtic
GNDIpc ($)	27577	60160	18481	-0.18	Negative fairly symmetrical	-1.2136	Platykurtic
HDI	0.86	0.93	0.05	-0.03	Negative fairly symmetrical	-1.2842	Platykurtic
IEF	68.08	80.71	8.80	-0.59	Negative moderately Skewed	-1.1397	Platykurtic

Note: (a) Population is in Millions

Table 4: Summary results of ADF unit root tests

Variable	Type	p-value	Stationarity
GDPpc	Level	0.3565	Non-stationary
	First difference	0.0004	Stationary at the 1% level
GNDIpc	Level	0.3777	Non-stationary
	First difference	0.0010	Stationary at the 1% level
HDI	Level	1.677E-024	Stationary at the 1% level
	Level*	0.3501	Non-stationary
	First difference	0.5258	Non-stationary
	First difference*	0.0020	Stationary at the 1% level
IEF	Level	0.7582	Non-stationary
	First difference	0.7469	Non-stationary
	First difference*	5.457E-006	Stationary at the 1% level

Note: (a) Unless otherwise indicated, the ADF results were derived from tests that were performed using the "constant and trend" scenario. (b) *refers to a test with constant only.

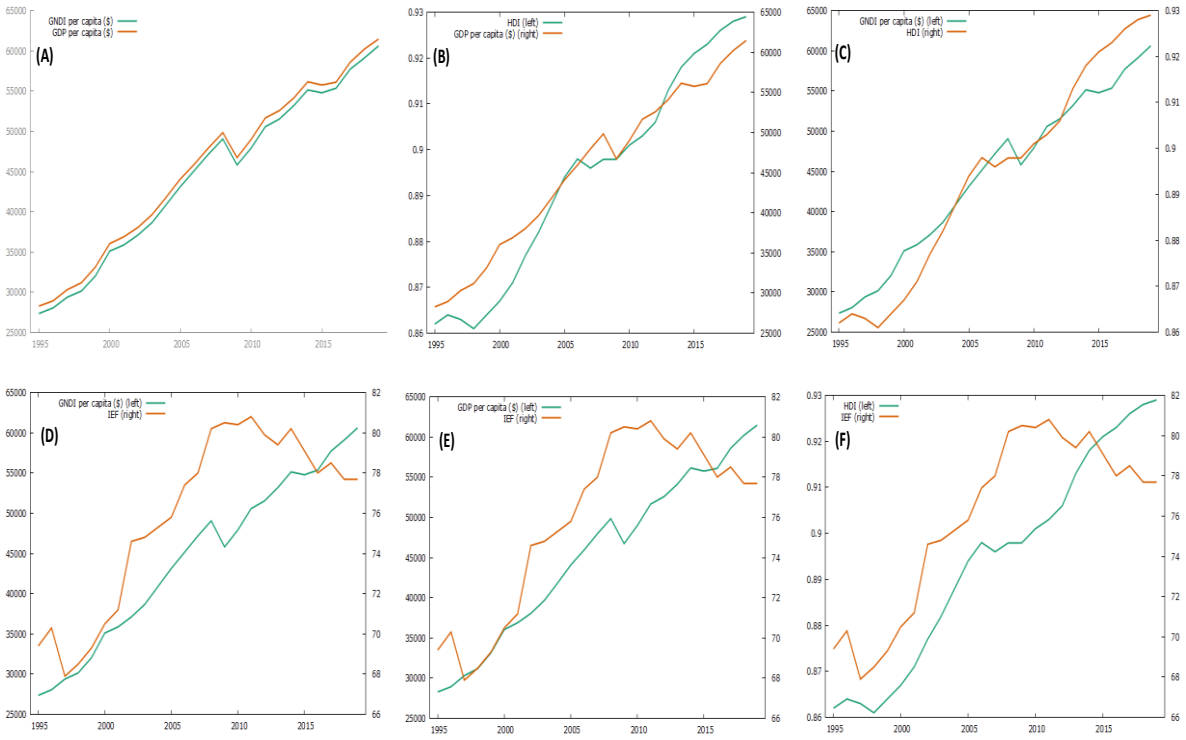

Figure 3: Paired growth indicators time-series plots (by level)

Table 5: Summary of VAR lag selection results for growth indices paired cointegration testing

Variables	Scenario	Lag Length
GDPpc vs GNDIpc	With constant	7
	With constant and trend	7
GDPpc vs HDI	With constant	7
	With constant and trend	7
GDPpc vs IEF	With constant	7
	With constant and trend	7
GNDIpc vs HDI	With constant	7
	With constant and trend	7
GNDIpc vs IEF	With constant	7
	With constant and trend	7
HDI vs IEF	With constant	7
	With constant and trend	7

Table 6: JC test results for GDPpc and GNDIpc with unrestricted constant

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.705820	35.269	[0.0000]	22.02400	[0.0018]
1	0.520890	13.245	[0.0003]	13.24500	[0.0003]

Note: (a) The JC test was run with a lag length of 7 obtained from the paired growth indicators VAR lag selection (Table 5). (b) Lmax is the Lambda max test. This note applies to all the other paired cointegration tests subsequently reported for the paired growth indices.

Table 7: JC test results for GDPpc and GNDIpc with unrestricted constant and trend

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.842420	34.878	[0.0001]	33.26100	[0.0001]
1	0.085895	1.6166	[0.2036]	1.61660	[0.2036]

Table 8: JC test results for GDPpc and HDI with unrestricted constant

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.840960	35.113	[0.0000]	33.09500	[0.0000]
1	0.106070	2.0184	[0.1554]	2.01840	[0.1554]

Table 9: JC test results for GDPpc and HDI with unrestricted constant and trend

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.953340	61.654	[0.0000]	55.16800	[0.0000]
1	0.302580	6.4866	[0.0109]	6.48660	[0.0109]

Table 10: JC test results for GDPpc and IEF with unrestricted constant

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.990610	84.081	[0.0000]	84.03400	[0.0000]
1	0.002631	0.047425	[0.8276]	0.04743	[0.8276]

Table 11: JC test results for GDPpc and IEF with unrestricted constant and trend

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.993630	134.350	[0.0000]	91.01000	[0.0000]
1	0.909970	43.336	[0.0000]	43.33600	[0.0000]

Table 12: JC test results for GNDIpc and HDI with unrestricted constant.

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.844440	35.197	[0.0000]	33.49300	[0.0000]
1	0.090329	1.7041	[0.1918]	1.70410	[0.1918]

Table 13: JC test results for GNDIpc and HDI with unrestricted constant and trend

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.971190	74.556	[0.0000]	63.84700	[0.0000]
1	0.448390	10.708	[0.0011]	10.70800	[0.0011]

Table 14: JC test results for GNDIpc and IEF with unrestricted constant

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.994770	94.671	[0.0000]	94.55800	[0.0000]
1	0.006206	0.11206	[0.7378]	0.11206	[0.7378]

Table 15: JC test results for GNDIpc and IEF with unrestricted constant and trend

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.999790	198.270	[0.0000]	152.26000	[0.0000]
1	0.922380	46.008	[0.0000]	46.00800	[0.0000]

Table 16: JC test results for HDI and IEF with unrestricted constant

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.809060	30.323	[0.0001]	29.80400	[0.0000]
1	0.028422	0.519	[0.4713]	0.51900	[0.4713]

Table 17: JC test results for HDI and IEF with unrestricted constant and trend

Rank	Eigenvalue	Trace Test	p-value (Trace)	Lmax Test	p-value (Lmax)
0	0.906690	47.347	[0.0000]	42.69300	[0.0000]
1	0.227830	4.6539	[0.0310]	4.65390	[0.0310]

Table 18: Summary of GDP and growth indicators paired variables JC testing

Variables	Scenario	Cointegrated?
GDPpc vs GNDIpc	No constant	No
	Restricted constant	Yes
	Unrestricted constant	Yes
	Restricted trend	Yes
	Unrestricted trend	No
GDPpc vs HDI	No constant	No
	Restricted constant	No
	Unrestricted constant	No
	Restricted trend	Yes
	Unrestricted trend	Yes
GDPpc vs IEF	No constant	Yes
	Restricted constant	Yes
	Unrestricted constant	No
	Restricted trend	Yes
	Unrestricted trend	Yes

Note: (a) The maximum number of cointegrating vectors is given by n-1 where n is the number of variables tested. (b) The "Restricted trend" scenario corresponds to a test with a restricted trend and an unrestricted constant. (c) The "Unrestricted trend" scenario corresponds to a test with an unrestricted trend and an unrestricted constant. (d) This note also applies to Tables 19 and 20.

Table 19: Summary of GNDI and other growth indicators paired variables JC testing

Variables	Scenario	Cointegrated?
GNDIpc vs HDI	No constant	Yes
	Restricted constant	No
	Unrestricted constant	No
	Restricted trend	Yes
	Unrestricted trend	Yes
GNDIpc vs IEF	No constant	Yes
	Restricted constant	Yes
	Unrestricted constant	No
	Restricted trend	Yes
	Unrestricted trend	Yes

Note: (a) The results of the cointegration test for GNDI with GDP are reported in Table 18.

Table 20: Summary of HDI and IEF paired variables JC testing

Variables	Scenario	Cointegrated?
HDI vs IEF	No constant	Yes
	Restricted constant	Yes
	Unrestricted constant	No
	Restricted trend	Yes
	Unrestricted trend	Yes

Note: (a) The results of the cointegration test for GDPpc vs HDI, GNDIpc vs HDI, GDPpc vs IEF, and GNDIpc vs IEFs are reported in Tables 18 and 19.

Table 21: Summary of cointegrated scenarios for paired growth indicators JC testing

Variables	Number of Cointegrated Scenarios
GDPpc vs GNDIpc	3
GDPpc vs HDI	2
GDPpc vs IEF	4
GNDIpc vs HDI	3
GNDIpc vs IEF	4
HDI vs IEF	4

Note: This summary table was derived from Tables 18, 19, and 20. The cointegrated scenarios refer to the scenarios referred to as the "No constant", "Restricted constant", "Unrestricted constant", "Restricted trend", "Unrestricted trend" scenarios, respectively.

4.1 Time Series Plots

From the time series plots (Figure 1), GDPpc, GNDIpc, and HDI show an increasing trend throughout the period studied. The 2008 - 2009 global financial crisis resulted in a short-duration decrease in both GDPpc and GNDIpc. Although the IEF shows an overall increase during the study period, it decreases post-2014 indicating a possible decline in economic freedom in Canada, despite the overall increase in output, gross disposable income and improvement in human development.

Figure 2 shows that there are no trends in the growth level (first difference) of the time series of the economic progress indicators. A short-duration decrease in the growth level related to the 2008-2009 global financial crisis is reflected in GDPpc, GNDIpc, and HDI. For IEF, post the 2008 - 2009 global financial crisis, the growth level fluctuates around a mean of zero.

The paired variables time series plots (Figure 3) provided a hint of possible co-movement between the growth metrics of varying degrees, more strongly evidenced between GDPpc and GNDIpc which are the more monetary-based indicators. As a result, the JC test was performed to further evaluate the existence of cointegration between the paired variables.

The decision to test multiple scenarios (e.g., "constant", "constant and trend", etc.) in this research was informed by variations in the time series trends observed upon visual assessment of the time series plots (Figures 1 and 2).

4.2 Descriptive Statistics

Over the 1995 - 2019 time series period, Canada's mean and median population were about 33.1 million and 32.9 million, respectively (Table 2). The mean ($44, 439) GNDIpc is lower than the corresponding value for GDPpc (Table 2), indicating that the mean per capita national disposable income is approximately 97% of the average national output ($45, 382).

Canada's HDI value of greater than 0.8 throughout the time series period studied (Table 2) places it in the UNDP category of countries with a "very high" level of human development (UNDP 2020). With the maximum HDI of 0.93 in 2019, Canada was ranked 16th in the UNDP's 2020 Human Development Report for "very high" levels of achievement in health/life expectancy, the standard of living, and education (UNDP 2020). Canada's HDI increased through the period studied from a minimum of 0.86 in 1998 to a maximum of 0.93 in 2019 (Figure 1 and Table 2).

Higher values of IEF signify greater economic freedom (Miller et al. 2021a, 2021c). Canada's minimum IEF of 67.9 in 1997 (Table 2) indicated a country that enjoyed "moderate" economic freedom according to Miller et al. (2021b). During the post-1997 period, the IEF values remained greater than 70 (Figure 1) connoting a system that is "mostly economically free" (Miller et al. 2021b) with periods where greater than 80 IEF values were achieved (2008 - 2011 and 2014), signifying a "free economic system" based on four pillars of economic freedom, namely, the rule of law, government size, regulatory efficiency, and open markets (Figure 1).

Table 3 shows that the time series of population and the growth measures are fairly symmetrical, except for IEF which is moderately negatively skewed. All the datasets have excess negative kurtosis (Table 3).

4.3 Stationarity

The null hypothesis of the ADF unit root test is that the time series is non-stationary. The ADF test results reported in Table 4, therefore, demonstrate that all the variables were integrated of order 1, i.e., I(1), indicating that the time series were non-stationary at level and stationary when first-differenced. HDI and IEF were I(1) in a "constant only" scenario while GDPpc and GNDIpc were I(1) in a "constant and trend" scenario. The confirmation of the I(1) status allowed for the cointegration test to be performed between the paired growth indicators.

4.4 Cointegration

The optimal lag length for cointegration testing is 7, based on the Akaike Information Criterion (AIC) (Table 5). The null hypothesis of the JC test is that a unit root exists. As such, a p-value < 0.05 obtained from the unit root test of the error term of the cointegrating regression would lead to the rejection of the null hypothesis. This would indicate that the variables being evaluated are cointegrated. The cointegration test results for paired growth variables demonstrate for the first time in the literature (to the best of our knowledge) that the growth indices are cointegrated with one another (Table 6 - 20). Up to four cointegrating vectors were

observed for the relationship between GDPpc and IEF, GNDIpc and IEF, and HDI and IEF (Table 21). Three cointegrating vectors were found for the relationship between GDPpc and GNDIpc, and for the relationship between GNDIpc and HDI. The least number of cointegrating vectors (2) was found for the relationship between GDPpc and HDI.

5. Summary and Conclusion

This evaluation provides a perspective of the time series characteristics of Canada's Beyond-GDP (BGDP) growth indicators. The BGDP measures were evaluated in tandem with the more popular growth measure GDP. GDPpc, GNDIpc, and HDI show, respectively, an overall increase during the study period (1995 - 2019), suggesting an overall increase in output, disposable income, and an improvement in human development. IEF, the indicator of economic freedom, does increase overall from a moderately-free to a free economy from 1997 to 2014. The economy declines to a mostly-free economy subsequently, despite the continued increase in Canadian output, disposable income, and improvement in human development.

This assessment showed that GDPpc is cointegrated with the BGDP indicators. This finding, however, does not preclude the use of BGDP indicators in Canada, as they are able to account for aspects of the overall economic wellbeing that GDP by virtue of its composition is unable to capture (Capelli & Vaggi, 2013).

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