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Productivity growth under economic integration, Guyana and the Rest of CARICOM

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Abstract

This study examined productivity growth, technological change and technical efficiency change between Guyana and the rest of the Caribbean [ROC] over the period 2008-2022 using the Malmquist index. Measures of productivity growth was found to be similar but the variation, measured by the standard deviation, over the years was greater in Guyana compared with the rest of the Caribbean [ROC]. Technological change in Guyana was slightly lower than in ROC, but so also was the fluctuation in technological change. Guyana showed a greater technical efficiency change than ROC. But the result did not show, not even in 2022, that oil production in Guyana has influenced productivity growth in Guyana.

Regression results showed that five variables, market size, the literacy rate, access to credit, gross fixed capital formation, access to electricity, all have a greater positive impact on productivity growth in Guyana that in ROC. On the other hand, in ROC, the inflation rate, tax on incomes, profit and capital gains, tax on trade and the exchange rate had a less negative impact on productivity growth than in Guyana.

Keywords: Caribbean; Latin America; Productivity Growth; Technical Efficiency; Technological Change

1. Introduction

In 2019, Guyana joined the oil market as a producer, and so far, it's per capita GDP has increased significantly. The prediction for it is its economy will continue to rise, and revenue from, not just oil, but from natural gas as well will continue to rise.

In the meantime, new waves of free trade have brought with them significant structural changes to countries worldwide. Countries are required to make the necessary changes and become more efficient and productive as they strive to meet the needs of the new international order. Countries in the Caribbean have long been caught in this struggle. Guyana is no different.

As it was with countries of the Caribbean, Guyana has followed a developmental pattern which was centered more one exports from one sector, agriculture, even though it exported minerals on a smaller scale as well, along with sugar, and through this it was able to acquire needed capital and technology. Up until recently, Guyana has always been on the defense with regards to the internation market and practiced self-sufficiency through programs of import substitution.

Although it is not in the hurricane belt, as are the island states of the Caribbean, it is prone to natural disaster, flooding, mainly from heavy rainfall, but also the sea breaking through sea defense dams, which has on several occasions tested the economic resilience of the country. And like other Caribbean countries, Guyana has always faced a debt problem, and together with them it benefitted from foreign aid, trade concessions, and preferential markets; benefits which are being withdrawn in the new international order of trade liberalization.

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Like other Caribbean countries, Guyan has sought the help of DFI [Direct Foreign Investment] and IFI [indirect Foreign Investment] making the tradeoff choice between exploitation of its resources and repatriation of revenue, for capital, technology and manpower development, and in developing its production capabilities. DFI also helps with providing employment, increasing exports, and managing foreign indebtedness.

In more recent years, Guyana's economic development had become tied to remittance and heavily dependent on rice and mineral exports. Following its 2019 entrance into the international oil market, and predictions of fast economic growth, it is expected that its productivity will likewise have to rise.

Unlike other rising economies, Guyana, must first clear ground zero, as far as economic development is concerned, as it is still in still in financial debt, which it is attending to, and its education index and life expectancy are well below the median of the Caribbean region [IMF, (2023)], which it must also attend to.

Economic growth starts with capital formation, both infrastructural capital as well as human capital development, both of which are currently being addressed. For, the kind of development expected for Guyana, productivity must increase significantly. Guyana's labour force has not grown much over the past decade, and it all now depends on how fast the productivity issue could be addressed. Consequently, it is important to examine the state of productivity in Guyana, and to identify courses of action that could be taken to improve it.

The objective of this paper, as a benchmarking exercise, and by way of advising policy development, is to determine productivity growth in Guyana between 2009-2022 against the background of the state of this indicator in the rest of the Caribbean countries, and to examine the differential impact of strategies affecting productivity in Guyana and the Caribbean.

2. Analytical Framework

In the context of a production function, technological change represents technological innovation and represents the extent to which the frontier moves outwards [Färe et. al, 1994; Zhang, 1994]. Technical efficiency, on the other hand, measures how far within the production frontier a country's technology is. Technical efficiency change provides evidence of growth catching up and is directly affected by policies and institutions aimed at promoting diffusion of technology and knowledge [Färe et al., 1994]; Perelman, 1995) from developed countries, and promoting education, training and managerial skills, and other "learning by doing" activities. Policies and institutions related to such activities as access to health care or police protection, access to electricity, access to credit, etc., have indirect, but none the less important, effects on technical efficiency change. This aspect of productivity is particularly important to developing countries (Arrow, 1962; Olson, 1996), where the cost of technological development is often prohibitive.

A measure of technical efficiency change provides information about the extent to which a country is able to attain its growth potential, given globally available knowledge.

Technological change, on the other hand, provides an indicator of innovation within a country. New technological innovations that occur in a country usually create a new "world" production frontier. This usually requires high levels of expenditure on R&D [Perelman, 1995] and thus, is generally both a function of, and a major determinant of, growth and development in developed countries [Olson, 1996]. These technological changes generally filter down to developing countries through foreign investment, trade, and other direct and indirect educational processes, thereby nudging them towards new production frontiers.

Productivity change is the product of both technical efficiency change and technological change. It provides an overall measure of the extent to which a country is able to exploit available knowledge and technology, and its own endogenous creativity or innovation.

3. Methodology

The methodology used was the non-parametric version of Malmquist Productivity Index. This index can further be transformed into indexes technical efficiency change and technological change. In the analysis of productivity change, technical efficiency changes and technology changes that follows, these indexes are used.

For the derivation of the Malmquist, [see Caves, et. al., 1982, and Färe et. al. 1994]. The Malmquist Productivity Growth Index, as defined by Fare et. al. (1994) is as follows:

$$M = \frac{D^t o(x^{t+1}, Y^{t+1})}{D^t o\ (x^t, yt)} \text{........}(1)$$

where: $D^t o(x^t, y^t)$ is distance functions defined with respect to the transformation function S^t, where $\{S^t = (x^t, y^t)$: x^t can produce $y^t\}$, where $x^t \in R^n{}_+$, $y^t \in R^m{}_+$, and the technology consists of the set of all feasible input/output vectors. S^t is assumed to satisfy certain axioms that allow the definition of meaningful output distance functions, and R represents the set of real numbers. And $D^t o\ (x^{t+1}, y^{t+1})$ is defined with regard to S^{t+1} with the same restrictions [Figure 1].

The decomposition of the Malmquist Productivity Index [Färe et. al., 1994] into the indexes of Technical Efficiency Change and Technology change is as shown in Equation 3.

$$\text{Mo}\ (x^{t+1}, y^{t+1}, x^t, y^t) = \left[D^t o \frac{x^{t+1}, y^{t+1}}{D^t o(x^t, yt)}\right] \left[\frac{D^{t+1} o(x^{t+1}, y^{t+1})}{D^{t+1} o(x^t, y^t)}\right] ½ \ldots \ldots(2)$$

where: $D^{t+1}o(x^{t+1},y^{t+1})/D^t o(x^t,y^t)$ measures the change in relative efficiency (i.e., the change in how far observed production is from maximum potential production) between t and t+1 and $D^t o(x^{t+1},y^{t+1})/D^{t+1}o(x^{t+1},y^{t+1})$ * $D^t o(x^t,y^t)/D^{t+1}o(x^t,y^t)$ ½ captures the shift in technology between the two periods evaluated at x^t and x^{t+1} .

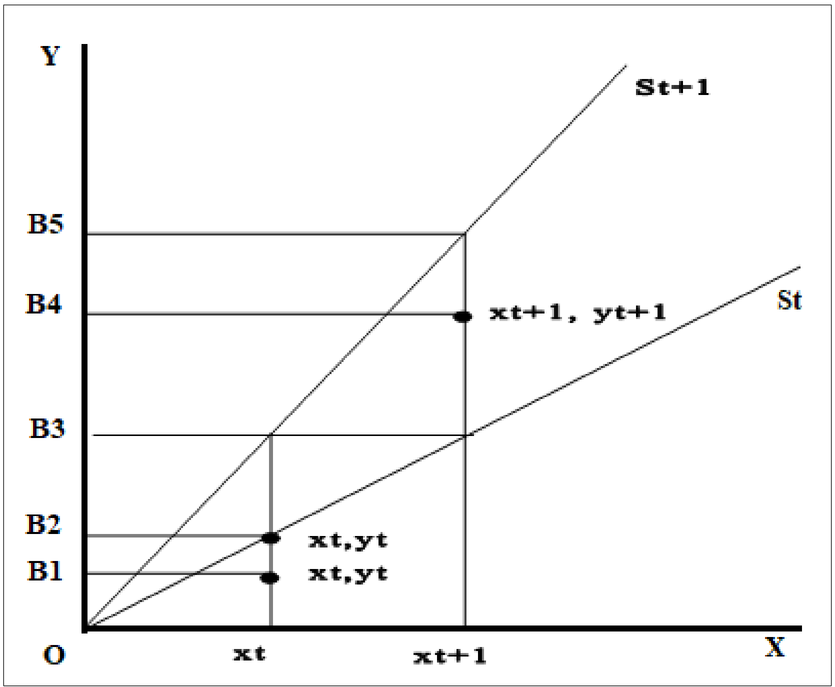

Figure 1 Illustration of the Malmquist index

Thus, the Malmquist productivity index for constant returns to scale technology can be written as [Figure 1]:

$$\text{Mo}\ (x^{t+1}, y^{t+1}, x^t, y^t) = [(0B4/0B5)(0B2/0B1)] * [0B4/0B3)/(0B4/0B5) * (0B1/0B2)/(0B1/0B3)]½ = (0B4/0B5)\ (0B2/0B1) * [(0B5/0B3)\ (0B3/0B2)]\ ½\ 3)$$

where: Technical efficiency change = [0B4/0B5) * (0B2/0B1].

Technological change = [(0B5/0B3) * (0B3/0B2)] ½

Thus, technological change is measured as the geometric means of two shifts: technological change relative to t and technological change relative to t+1. Technical efficiency changes between t and t+1 capture changes in relative efficiency over time, i.e, whether production is getting closer or farther away from the frontier at t+1 than at t.

Improvement in productivity yields a Malmquist index greater than 1. Deterioration in productivity over time yields a Malmquist index of less than 1. Similarly, a technical efficiency changes or technological change index greater than 1 represent improvement in the respective measures, and values less than 1 represent deterioration in the measures.

Although the product of the technical efficiency changes and technological change components must, by definition, equal the Malmquist index, these components may be moving in opposite directions. For example, if the Malmquist index = 1, but the measures of technical efficiency change, and technological change are not necessarily equal to 1.

In this study, linear programming (LP) was used to compute the distance functions. In order to calculate the productivity change of country k between t and t+1, linear-programming problems for $D^to(x^t,y^t)$, $D^{t+1}o(x^t,y^t)$, $D^to(x^{t+1}, y^{t+1})$ and $D^{t+1}o(x^{t+1}, y^{t+1})$ were solved.

In order to calculate $D^to(x^t,y^t)^{-1}$ for each of the k = 1...,K countries, the following LP was solved [Fare et. al. (2)]:

$$(D^to(x^{k,t},y^{k,t}))^{-1} = \max \theta^k$$

subject to: $$\sum_{k=1}^{K} Z^{k,t} y_m^{k,t} \geq \theta y_m^{k,t} \qquad m = 1,....,M;$$

$$\sum_{k=1}^{K} Z^{k,t} x_n^{k,t} \leq x_n^{k,t} \qquad n = 1,....,N;$$

$$Z^{k,t} \geq 0 \qquad k = 1,....,K; \quad .... (4)$$

where: k=1...,K countries using n=1....N inputs ($x_n^{k,t}$) at each time period t=1,...,T to produce m=1,...,M outputs ($y_m^{k,t}$). The intensity variable (Z) measures the intensity with which the input(s) x is used to produce output(s) y. Each Z is at least equal to zero, and each country has observations for each year. Technology assumes constant returns to scale and strong disposability of inputs and outputs.

The computation of $D^{t+1}o(x^{t+1}, y^{t+1})^{-1}$ is exactly like that in Equation (7), but t+1 is substituted for t. To calculate the distance functions $D^{t+1}o(x^t,y^t)^{-1}$ and $D^to(x^{t+1}, y^{t+1})^{-1}$, information for two periods is required. For $D^to(x^{t+1}, y^{t+1})^{-1}$, the LP solved is as follows:

$$D^to(x^{k,t+1},y^{k,t+1}))^{-1} = \max \theta^k$$

subject to: $$\sum_{k=1}^{K} Z^{k,t} y_m^{k,t} \geq \theta y_m^{k,t+1} \qquad m = 1,....,M;$$

$$\sum_{k=1}^{K} Z^{k,t} x_n^{k,t} \leq x_n^{k,t+1} \qquad n = 1,....,N;$$

$$Z^{k,t} \leq 0 \qquad k = 1,....,K; \qquad ....(5)$$

Equation (5) involves observations for both period t and period t+1. The reference technology relative to which ($x^{k,t+1}$, $y^{k,t+1}$) is evaluated is constructed from the observation at t. In Equation (7), $D^to(x^{k,t}y^{k,t}) \in S^t$ and, therefore, is less than 1. However, in Equation (5), $(D^to(x^{k,t+1},y^{k,t+1})$ may take values greater than 1.

The linear programming problem for $D^{t+1}o(x^{t+1}, yt^{+1})$ is solved similarly to Equation (8), but the t and t+1 superscripts are transposed.

3.1. The Regression model

Ordinary least squares were used to examine the relationships between productivity change and specific independent policy variables. This methodology readily accommodated the dependent variable, whose value was continuous and positive. Each parameter estimate was interpreted as the percent change in productivity growth for a one percent change in the respective independent variable.

$$lPRD_{i\,j} = \alpha_0 + \alpha_1 lGDP_{ij} + \alpha_2 lEDU_{ij} + \alpha_3 lCR + \alpha_4 lK_{ij} + \alpha_5 lELEC_{ij} + \alpha_6 lINF_{ij} + \alpha_7 TAX_{ij} + \alpha_8 lEXR_{ij} + \alpha_9 lTTr_{ij} + \alpha_{10} lAGRI_i + \alpha_{11} lMAN_{ij} + \alpha_{12} LSERV_{ij} + e_{ij} \quad \text{.........(6)}$$

where: i and j are the country and year, respectively; $lPRD_{ij}$ is the variable representing the productivity index of each country in each year, and the other variables are as defined in Table 1; and e_{ij}, represents unexplained random errors. The model is estimated in its log form, indicated by the letter '*l*' in front of each variable*, and* each coefficient is expressed in percent terms.

3.2. The data

This study involved observations on the outputs and inputs Guyana and the rest of the Caribbean [ROC], made up of 7 other CARICOM Countries, over the period 2009 to 2022. The measures of output were calculated as the GDP (measured as Constant 2015 US Dollars) divided by the real price. The real price was obtained by dividing constant by the current GDP and standardizing it by the price index. Input included labor and capital. Labor was measured as the number in the Labor Force. Capital was calculated from the gross fixed capital formation expressed in percentage of real GDP divided by the price index (expressed in real terms).

The countries for the rest of the Caribbean involved in this study are the Bahamas, Belize, Barbados, the Dominican Republic, Jamaica, and Trinidad and Tobago, each being a member of CARICOM.

The data used in this study were obtained from the World Bank Group online data [World Bank, 2024]. Because of inconsistencies observed in the data set with respect to some countries, these countries were omitted from the study. Also, in determining the relationship between productivity change and specific policy variables, several observations for some countries were not available, so these countries were not included in the regression analysis.

Table 1 shows the average inter annual changes in outputs and inputs for the countries involved in this study over the period 2008-2022.

The GDP growth rate over the period 2008-2022 in Guyana was higher than the rest of Caricom [ROC] – 0.1337 vs 0.0208. Capital growth rate was positive in Guyana whereas it was negative in the ROC [0.1806 vs. -0.0063] and but the growth rate of labor was lower in Guyana compared with ROC 0.0028 vs. 0.0124].

Table 1 Interannual change in Capital, Labor and GDP [2008-20022**]**

	Guyana			**Rest of Caribbean [ROC]**		
	Capital	**Labor**	**GDP**	**Capital**	**Labor**	**GDP**
2009	0.2323	0.0034	0.1302	-0.2064	0.0037	-0.0958
2010	0.0486	0.0027	0.0877	0.0131	0.0110	0.0587
2011	0.0260	0.0017	0.0844	0.0437	0.0183	0.0349
2012	0.1100	0.0056	0.0675	0.0324	0.0217	0.0142
2013	-0.2409	0.0079	-0.0037	-0.0263	0.0171	0.0167
2014	0.6427	0.0059	0.0829	0.0387	0.0132	0.0359
2015	-0.1765	0.0056	0.0113	0.0204	0.0235	-0.0084
2016	0.3363	0.0052	0.0544	0.0689	0.0145	-0.0043
2017	0.0508	0.0047	0.0082	0.0245	0.0096	0.0308
2018	0.5245	0.0351	0.0991	-0.0477	0.0147	0.0488
2019	-0.0565	-0.0548	0.0981	0.1597	0.0062	0.0163
2020	-0.1234	-0.0127	-0.0137	-0.0928	-0.0308	-0.1202
2021	0.4180	0.0199	0.4136	0.2216	0.0278	0.1488
2022	0.7363	0.0084	0.7523	-0.3387	0.0226	0.1284

Mean	0.1806	0.0028	0.1337	-0.0063	0.0124	0.0218

3.3. Productivity variables

Many economic factors affect productivity growth. In this study, twelve variables that proxied for six factors [groups] are considered. Table 2 shows the expected correlation with the productivity variable.

- **Market-related variables.** As a proxy in this group, market size, measured as the GDP of a country is considered. The larger the market size is, the greater the opportunity to benefit, and the more likely it would be for investors to invest in productivity improving ventures, such as building human capital, acquiring tools and technology, and organize to take advantage of the market.

Table 2 Variables, acronyms, hypothesized relationships with productivity index and rationales

Variables	Description	Acronym	Ho	Rationale
Market Related Variables				
	Market size	GDP(M)	+	Greater the market size, greater the potential to increase productivity
Private sector Related Variables				
	Literacy [Edu. Exp/Capita]	LIT	+	Higher education means higher productivity.
	Credit /Capita [Private Sector]	CRED	+	Higher credit to private sectors, more investment in capital. Increased productivity
Infrastructure Related Variables				
	Fixed capital formation	K [M]	+	Greater capital formation means greater productive infrastructure.
	Access to electricity [% of Pop.].	ELEC	+	Access to electricity means access to power. Increased productivity.
Monetary/Fiscal Policy Related Variables				
	Inflation Rate	INF	-	The impact, negative at least in SR.
	Tax on Income, profit & capital gain [Value],	TAX	-	Higher tax means less investment, less productive capital
Trade Policy Variable				
	Tax on trade [% of Rev.]	TT	-	Higher taxes [higher cost] on trade, trade restrictions, less benefit from market size
	Exchange Rate	EXR	-	Lower ER, increased foreign demand, increased potential to increase productivity.
Productive sectors				
	Agriculture [% GDP]	AGRI	+	Expected to be greater than OTHER.
	Manufacturing [% GDP]	MAN	+	Expected to be greater than OTHER.
	Service [% GDP]	SERV	+	Expected to be greater than OTHER.
	Other [Mining, Construction] [% GDP]	OTHER	Ref.	

Thus, there is likely to be a positive correlation between market size and productivity growth. Lina and Wengb (2019) and Ferraro et. al., (2020) observed a positive relationship between market scale [size] and productivity. This is the expected relationship between the two variables in this study.

Monetary/Fiscal Policy related variables. The inflation rate [INF] and Tax on income, profit and capital gains [TAX] are the variables studied in this group.

Inflation is likely to devalue money, and make investment, including investment in productive assets, more costly, at least in the short run. Thus, INF is likely to have a negative impact on productivity growth. In the long run, however, on the basis of the argument that money has no effect in the long run, INF is not likely to have any effect. Piper et. al (2020), in their studies of the Brazilian economy found an inverse relationship between inflation and productivity. Araujo et. al. (2018) in their investigation of inflations in Brazil found similar results. The result in this study is expected to be similar.

Taxes, on income, on profit or on capital gain are likely to decrease spendable income, and in particular, income spent on productive assets. Thus, TAX is likely to have a negative impact on productivity. Vartia (2008) found that taxes have a depressing effect on investment and productivity. This finding is supported by Ferraro, et. al. (2020) in their study of tax policies on innovation and productivity growth. This negative relationship between TAX and productivity growth is also predicted in this study.

Trade policy variables. Two variables, Tax on trade [TT] and the exchange rate [EXR] are studied in this group. TT is calculated as a percentage of a country's revenue.

A tax on trade reduces the capacity to take advantage of large-scale markets as it means a price increase for a buying country. For a producing country, this effectively means a smaller market. In this regard, TAX stifles innovation and productivity improving strategies in the producing country. It is therefore likely that there will be a negative relationship between TAX and productivity growth. Furceri, et. al. (2019), in their analysis of the macroeconomic consequences of tariffs, observed a negative relation between tariffs and productivity. Kilumelume, et. al. (2021) made the same observation. Taxes on trade are likely to have the same effect in this study.

The exchange rate [EXR] has a mixed effect on productivity, depending on whether one's currency has a low value or a high value. If a country has a low exchange rate, this is likely to increase the demand for goods from that country, and this is likely to incentivize innovation and productivity to meet that demand. If on the other hand, a country has a high exchange rate, the effect on innovation and productivity will be the opposite. Cravino (2014), noted that exchange rates do have an effect on productivity. McLeod and Mileva (2011) observed that weaker exchange rates tend to be correlated with increased productivity factors. In this study the correlation between EXR and productivity growth is expected to be negative.

Human capital/private sector related variables. In this group, two variables are investigated, the literacy rate [LIT], measured by the amount of the GDP expended on education per capita, and domestic credit available to the private sector, expressed in per capita terms.

With regard to LIT, the more literate the population is [i.e. the ability to read instruction, and operate machinery, and computerized systems, etc.] the more productive they are likely to be. Khan et. al., 1991) has documented a positive relationship between literacy and labor productivity. Oladimeji et. al., 2024) showed a direct relationship between digital literacy and productivit**y.** In this study, this positive relationship between literacy and productivity is likely to show up.

With regards to LIT, the greater the availability of domestic credit to the private sector [CR], the more likely it is that innovation will be spurred. Cases where capital was the limitation to innovation, or the expansion of innovation will more likely be revealed as more credit is made available to the population. And productivity in the private sector likely will increase. Or it might be the case that the more availability of domestic credit is, the more it might just come in handy for other domestic use and would not have any effect on productivity. Cecchetti and Kharroubi, (2018), however, found a negative relationship between levels of credit available and productivity growth. Manaresi and Pierri, (2019) for that a reduction in credit supply is directly correlated with total factor productivity. Based on these results, it is expected that the correlation between CR and productivity growth will be positive.

Infrastructure related variables. In this group, two variables are studied. Fixed capital formation [K], derived from the amount GDP spent of Gross Fixed Capital Formation, and the Percent of the Population with Access to Electricity [ELEC].

Productivity has always been modelled as a function of K and L [Labor]. With an increase in K, labor productivity increases, but the productivity of capital is likely to decrease, as the quantity of K increased. Overall, it is expected that in Guyana and ROC countries productivity is likely to increase. This is so because neither Guyana not ROC countries is classified as a high technology region, but regions struggling to acquire capital. Nourzad. F. (1995) found a positive correlation between fixed public capital formation and productivity growth. Trpeski, and Marijana (2019 also found the same result in their study of productivity in Southeastern Europe.Since increased capital formation increases the productive base in the regions in question, it is likely that the correlation between fixed capital formation and productivity will be positive.

With regards to the percentage of the population with Access to Electricity [ELEC], it is likely that while most of this electricity will go into domestic use, some will go into commercial production, and will tend to have a positive effect on technology use and thus on productivity capacity and productivity. Alam et. al., (2018) verified this relationship between access to electricity and productivity in developing countries. This result is likely to hold true in this study.

Productive Sector Variables. The productive in the regions is classified into one of four sectors: the agriculture sector [Agri], the manufacturing sector [Man], the service sector [Serv] and an aggregate of the rest which includes mining and drilling, the other sector [Other]. It is important to determine which productive sector of the economy is correlated with productivity growth. Because the raw data is expressed in percentage of GDP and sum to 100%, one sector, the OTHER sector, is dropped from the regression, and each of the other coefficients is interpreted relative to the other sector, OTHER. There is no priori expectation on the impact of any sector on productivity in either region.

4. Results and discussion

4.1. Productivity indexes

The results for the productivity, the Malmquist index, for the years 2008 – 2022, are shown in Table 3, two groups, Guyan in one and the rest of the Caribbean [ROC] in the other. The Countries that made up the rest of the Caribbean in this analysis are Barbados, Trinidad and Tobago, St. Lucia, St. Vincent and Grenadines, Belize, Dominican Republic, Bahamas and Jamaica.

Table 3 Technical Efficiency change, technological growth and productivity [Malmquist] – 2008-2022

	Technical Efficiency Change		**Technological Change**		**Productivity Malmquist]growth**	
	Guyana	ROC	Guyana	ROC	Guyana	ROC
2008	1.021	1.018	0.996	0.990	1.017	1.008
2009	0.893	0.954	1.110	1.126	0.992	1.074
2010	1.009	1.014	1.042	1.049	1.051	1.064
2011	1.076	0.987	0.989	1.003	1.064	0.989
2012	1.155	1.112	0.860	0.865	0.993	0.960
2013	1.012	0.876	1.186	1.187	1.200	1.038
2014	0.739	1.015	0.982	0.985	0.725	1.000
2015	1.167	1.016	1.016	0.986	1.186	0.999
2016	1.029	1.076	0.845	0.878	0.869	0.944
2017	0.992	0.999	0.985	1.013	0.978	1.012
2018	0.813	1.060	1.029	1.045	0.837	1.107
2019	1.077	0.892	1.080	1.083	1.163	0.966
2020	1.110	0.997	0.961	0.968	1.067	0.965
2021	1.115	1.074	1.025	0.976	1.142	1.040
2022	1.089	0.960	1.154	1.449	1.258	1.342
Mean	1.020	1.003	1.017	1.040	1.036	1.034
Std.Deviation	0.122	0.065	0.093	0.140	0.146	0.097

Based on Table 3, productivity growth, as measured by the Malmquist index were similar with a mean of 1.036 for Guyana and 1.034 for the rest of the Caribbean, but the standard deviation in Guyana is much greater [0.146 vs. 0.097]. The relationship between the years and productivity indexes in Guyana and the rest of the Caribbean is shown in Figure 2. Based on this graph, there is much fluctuation in the productivity index of Guyana over the years. It is quite possible that fluctuation in the rest of the Caribbean is cancelled because of the number of countries involved.

Technological change in ROC was slightly higher in than in Guyana 1.040 vs 1.017], but the path followed through the years was close together, but both sets varied somewhat, ROC more than Guyana [1.140 vs 0.93]. See Figure 3.

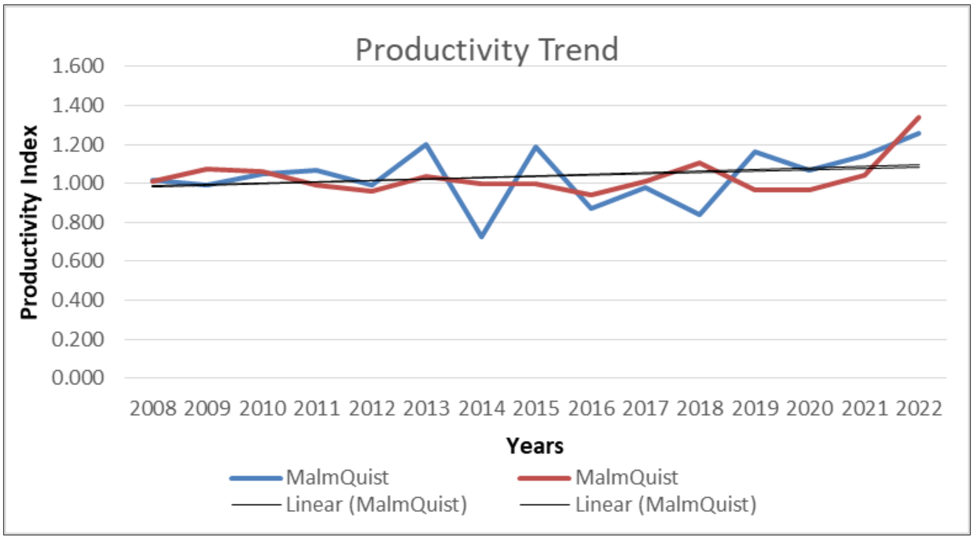

Figure 2 Productivity growth

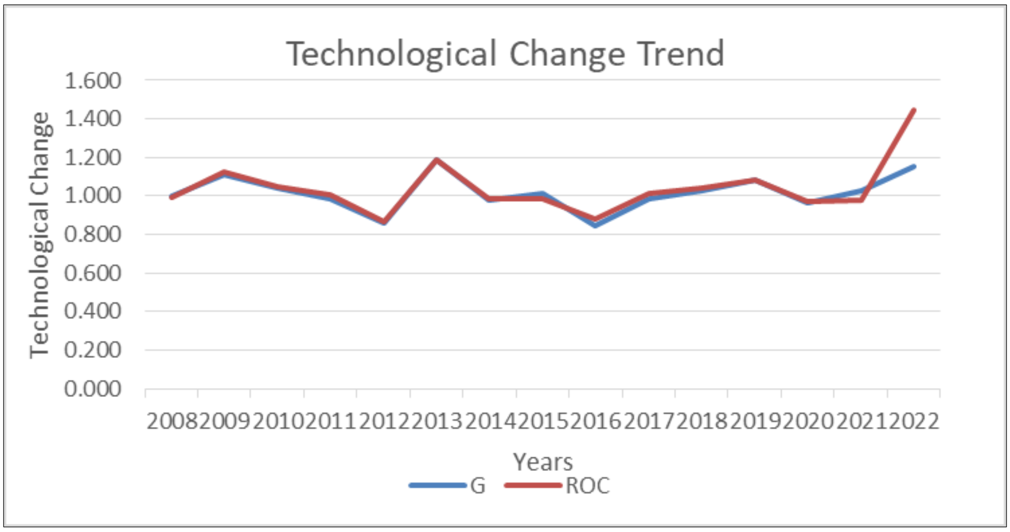

Figure 3 Technological growth

Guyana showed a greater technical efficiency change that ROC [1.020 vs 1.003], but the standard deviation was somewhat higher in Guyana compared with ROC. See Figure 4.

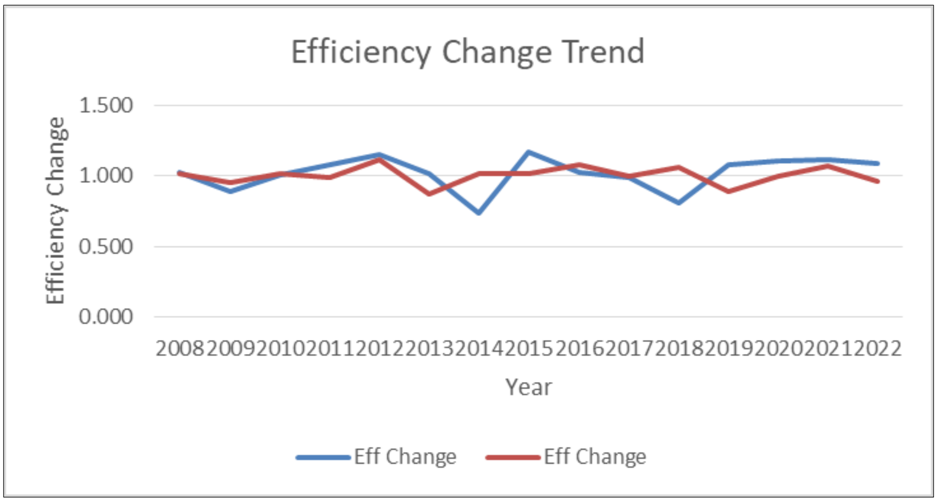

Figure 4 Technical Efficiency Change

Overall productivity growth in Guyana followed the same trajectory [see the trendlines], which was mostly flat over the years. A bit more tilt upwards would have been a better picture as that would show some growth in productivity over those many years. But the trends do show some level of integration between Guyana and ROC.

4.2. Regression analysis

Table 4 shows the regression results. Based on the results, nine variables in the Guyana regression in six groups are significant and the coefficient of each has the expected signs.

Table 4 Regression coefficient for Guyana and ROC

Variables		**GUYANA**			**Rest Of Caribbean [ROC]**		
		Coefficients	***P-value***		***Coefficients***	***P-value***	
Market Related variables							
Market size [GDP]	MARKET	0.284	0.090	**	0.053	0.017	**
Monetary/Fiscal Policy Variables							
Inflation Rate	INF	-0.101	0.006	***	-0.005	0.681	
Taxes on income, profits and capital gains (% GDP)	TAX	-0.192	0.085	**	-0.007	0.048	**
Trade Policy Variable							
Tax on trade [% Rev.]	TT	-0.014	0.805		-10.033	0.177	
Exchange Rate	EXR	-2.663	0.025	**	-0.023	0.004	***
Human Capital/Private sector related variables							
Literacy [Exp. Edu/Capita]	LIT	0.662	1.000	***	0.260	0.202	**
Credit/Capita	CR	0.355	0.001	**	0.013	0.764	
Infrastructure Variables							

	Gross Fixed Capital Formation	K	0.581	0.024	**	0.291	0.015	**
	% of population with access to electricity.	Elec	2.277	0.049	**	0.432	0.302	
Productive sector variables								
	Agriculture [% GDP]	AGRI	0.077	0.242		-0.031	0.457	
	Manufacturing [% GDP]	MAN	0.109	0.379		0.021	0.413	
	Service [% GDP]	MAN	-0.185	0.083	**	-0.021	0.045	**
Intercept			-6.670	0.204		-0.076	0.420	
Intercept			3.434	0.001	***	-0.379	0.044	**
R Square 1			0.362			0.422		
R Square 2			0.437			0.338		

** & *** significance at the 95 & 99 CI levels.

In the groups in question are the market size group, the monetary/fiscal policy group, the trade policy group, the human capital/private sector group, the infrastructure group and the productive sector group. In the ROC model, six variables six groups are significant and each of the coefficients has the expected sign. The groups are the same as outlined for Guyana.

In the market size group, one variable was used, MARKET, which measured the market size as the total GDP in each country represented. In Guyana, the coefficient was positive [0.284] and indicated that for a one percent increase in market size, the productivity index is likely to increase by 0.284 percent. Lina and Wengb, (2019) and Ferraro et. al., (2020) found that market size does play a role in increasing productivity. It seems likely that a larger market incentivizes a greater response in companies to invest in better technology to take advantage of the opportunities presented by larger markets.

In ROC, the coefficient for MARKET was also positive, but smaller [0.053] indicating a smaller impact on productivity. The next group was the monetary/fiscal policy group. This group was proxied for by two variables, the inflation rate [INF] and taxes on income, profit and capital gains [TAX]. IN Guyana, both variables were significant, and both have the expected negative signs [-0.101 & -0.192], which means that productivity is likely to decreased, the greater the INF and TAX are. With regards to INF, in the short run, inflation represents a loss of wealth, which leaves less to be invested in improving productivity. Piper et. al., (2021) and Araujo et. al. (2018) showed that inflation rate has a negative correlation with productivity.

TAX has a similary effect and based on the result, the greater the tax is the more negative will be its effect on productivity. Vartia, (2008) and Ferraro, et. al., (2020) also showed results to verify this.

In ROC, only TAX was significant, and it had the expected negative sign, but the coefficient was smaller. This also indicate that productivity is likely to decrease as TAX increased, but here is had a smaller impact than in Guyana.

With regards to trade policies, tax on trade [TT] and the exchange rate [EXR] were used as proxies. TT was not significant in Guyana, nor was it significant in ROC. EXR was, however, significant in both areas and its coefficient was negative, as expected. Cravino, (2014) and McLeod and Mileva, (2011) found similar results as in this study.

The coefficient in Guyana was larger, more negative, than in ROC [-2.663 & 0.023], showing that Guyan is likely to gain in increased productivity if the exchange rates were reduced further, compared with ROC.

In the next group, the human capital/private sector related group, two variables were used to reflect the group. The literacy rate [LIT] calculated as the percentage of GDP spent on education, and the availability of credit to the private sector [CR]. Both variables are significant in Guyana, and each has the expected positive sign [0.662 & 0.355], indicating the productivity is likely to increase for each percent increase in each variable, but the increase is likely to greater in the case of LIT.

With regard to LIT, Khan et. al., (1991) and Oladimeji et. al., (2024) found that the literacy rate has a positive correlation with productivity. And Cecchetti and Kharroubi, (2018) and Manaresi and Pierri, (2019) provided evidence to support that access to credit has a positive impact on productivity growth.

Of the two variables, only LIT was significant in ROC. The coefficient [0.260] was larger for Guyana than in ROC, indicating that productivity is likely to be more responsive to literacy rates in Guyana than in the rest of the Caribbean.

In the infrastructure group, two variables were used to reflect this group, gross fixed capital formation [K] and the percentage of the population with access to electricity [ELEC]. Both variables were significant in Guyana, and both had the expected positive signs [0.581 & 2.277], indicating that productivity is likely to increase as K and ELEC increased. Nourzad., (1995) and Trpeski, and Marijana (2019) provided evidence to support that an increase in fixed capital formation is positive correlated with productivity growth. Alam e. al., (2018) showed that productivity increases with an increase in ELEC. The result shows that the impact of ELEC, which has a larger coefficient, is likely to have a greater impact of productivity growth in Guyana that K.

In ROC, only K was significant, and it was positive [0.291]. Here again, an increase in K is likely to have a positive impact on productivity. The impact of K in Guyana is likely to be greater.

In the productive sector group, only SERV of the three variable Service, Manufacturing and Agriculture sectors] used for this group. In both Guyana and ROC, the sign on the coefficient was negative, indicating that activities in the service sector is likely to have lower impact on productivity than the other sector. [OTHER].

5. Conclusion

5.1. Productivity Indexes

This study examined productivity growth, technological change and technical efficiency change between Guyana and the rest of the Caribbean [ROC] over the period 2008-2022 using the Malmquist index. Productivity growth was found to be similar but the variation, measured by the standard deviation, over the years was greater in Guyana compared with the rest of the Caribbean. Technological change in ROC was slightly higher than in the Caribbean and so was the fluctuation in technological change.

Guyana showed a greater technical efficiency change that ROC, but the standard deviation was somewhat higher in Guyana compared with ROC. Overall productivity growth in Guyana followed the same trajectory as ROC, a slightly upwards trend over the years.

But the result did not show, not even in 2022, that oil in Guyana has influenced productivity growth in Guyana.

5.2. Regression

Nine variables in six groups are significant in the Guyana model, each with the expected signs. The groups were the market size group, the monetary/fiscal policy group, the trade policy group, the human capital/private sector group, the infrastructure group and the productive sector group. In the ROC model, six variables six groups are significant and each of the coefficients has the expected sign. The groups were the same as outlined for Guyana.

Each of the variable studies had a larger impact in Guyana compared with ROC. The market size variable, the literacy rate, access to credit, gross fixed capital formation, access to electricity all have a greater positive impact in Guyana that in the rest of the Caribbean, the inflation rate variable, tax on incomes, profit and capital gains, tax on trade and the exchange rate had greater negative impact in Guyana than in the rest of the Caribbean. The service sector in Guyana has a greater negative impact on productivity that the other sector [mining, drilling construction] than in the rest of the Caribbean.

The main point in all of this is that an improvement in these variables will bring about increased productivity in Guyana compared with the rest of the Caribbean.

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