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Productivity Growth under Economic Integration in the Mercosur and Sica blocs

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ABSTRACT: *This study compared productivity growth between the Mercosur and Sica blocs.*
***Productivity Indexes.** Between the period 2008 and 2022, the Mercosur and Sica blocs showed a divergent pattern of productivity growth with the index in Malmquist slightly increasing while that of Sica is decreasing over, with wider variation than Mercosur over the period. In terms of technological change, the index for Mercosur is greater than that of Sica, but variation in technological change in Mercosur being greater compared with Sica Technical efficiency change was lower in Mercosur compared with Sica.*
***Regression results.** Of the variables studied, in the Mercosur region, an increase in market size in the market group, the literacy rate and access to credit in the human capital/private sector group, gross fixed capital formation, percent of the population with access to electricity in the infrastructure group, are likely to have a greater positive impact on productivity in Mercosur than in Sica. In the productive sector, increasing operations in the manufacturing sector is likely to have a greater impact than the other sectors, which includes mining, drilling and construction, on productivity. In Sica, increasing production in the agriculture sector is likely to have a similar impact.*

Keywords: *Caribbean, Latin America, Productivity Growth, Technical Efficiency, Technological Change.*

I. INTRODUCTION

One of the main goals of economic integration is to increase markets size by lowering and eventually eliminating trade barriers. Achieving this goal is the backbone to economic development. Except, maybe, in planned production systems, production is largely demand driven, and the production process is shaped by market opportunities. With a big enough market, all the benefits of specialization, economy of scale, cost reduction, and maximizing production capabilities are made possible.

Many countries have recognized that economic integration is the solution to low productivity, low returns to labor, and poverty. Economic integration not only offers an enlarged market, which motivates specialization, productivity and productive efficiency, but it nurtures the transfusion of technology and managerial skills across countries. And in so doing, enables them to at least catch up and meet the level of productivity and productivity efficiency needed to trade, and prosper.

Within Latin America, there are many blocs of economic integration. Countries have come to recognize that competing alone in the international market does not guarantee any kind of protection against economic downswings, and the limit to their prosperity depends on them alone. With economic integration, in principle, the risk of failure is distributed among member countries, which reduces the chance of complete failure. On the other hand, there is much to be gained.

But economic integration in Latin America, as it is in other parts of the world, has not actually made the big headways the idea of economic integration promises and many countries in the various economic integrated systems within the region are still faced with low productivity and low returns to labor (ECLAC [1]). Basic to economic integration, a participating country trade self-dependency and self-sufficiency for inter-dependency in which countries head more towards specialization and trade, which enables them to get, not just thing they need, but to get them cheaper and is greater abundance, rather that producing everything they need themselves. But this requires careful and strict harmonizing of policies across countries in the various blocs and coordinating domestic policies towards achieving the policy goals. This turned out to be a challenge across integration efforts in general, and in Latin America in particular (ECLAC [1]). If there is so much to be gained, countries should lean more towards harmonizing policies, but this is not the case.

Vargas-Alzate [2] has suggested a very likely reason why, and that is the level of asymmetries amongst countries. Countries vary with regards to natural endowment, stages of development, level of productive infrastructure, levels diversified economic base, level of political commitment to the cause and benefits to be derived from specific policies.

A single policy could have various impacts on member countries. A reduction in tariffs, for example, could mean little to some countries, or a loss of a crucial source of revenue to other countries. It is likely that those country to go ahead and implement that policy if it means such as serious loss of revenue.

The size of a country could be a source of economic disparity. For example, if seventy percent of the exports of a small country constitute five percent of a large country's imports, this opens up the question of economic power. Protecting an infant industry, or important industry, could also lead to disagreements, just as protection an invention could.

Asymmetry within the Latin American region conflict with harmonizing policies implementation (Vargas-Alzate [1]). In many common markets, there are bodies [courts, for example] that look into these asymmetries and try to level the playing fields. But even in those, these limitations manifest and pose challenges. And, it seems, that this kind of problem will continue, perhaps till countries actually become one with one single governance, and still there is the chance that there will arise problems due to asymmetry.

Problems in Latin American economic integration have been reflected in a number of ways. One of the main criticisms pertaining to economic integration in Latin America, apart from the need to further reduce tariffs, and reduce high trade costs, is the need to improve productivity (ECLAC [1]). Improving productivity in a country does not depend on only capital input, but also on good policies and institutions within related countries. And countries must not only harmonize cross-border policies but must also coordinate domestic policies towards achieving productivity goals.

This paper seeks is to examine, as a benchmarking exercise, and by way of advising policy, productivity growth in Latin American economic blocs over the period 2008-2022 and analyze, comparatively, their strategies to improve productivity growth.

Specifically, the blocs that will be examined are Mercosur and Sica. Mercosur, the South Common Market of South America, and Sica, the Central American Integration System, are two bodies pursuing economic integration in the Latin America region. Both systems, formed around the same time, share, in general, the same kind of pre-independence history, but are in different geographic locations, and have, since their independence, pursued different political strategies towards attaining their goals.

II. BACKGROUND.

The gains from economy of scales through economic integration have long been recognized in Latin America, as it has been in many parts of the world, and much effort has been made to integrate economically among countries of the region to realize these gains. Mercosur and Sica are two bodies of economic integration, the former in the central and south of South America and the other is Central America. While much progress has been made towards this goal, particularly in the earlier stages, the logistics of deeper economic integration appear to be much more challenging.

SICA, the Central American Integration System, with the support of the United Nation was launched in 1991, with the broad goal of economic integration. Initially this body included the States of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama, later other countries joined as members.

Initially, there was substantial progress, and GDP grew by just over 4% by 2010 but more recently the movement has experienced stagnation evidenced by slow economic growth with GDP moving up by just about 2% (ECLAC, [2]).

On account of its geographic location, the region is prone to setbacks as a result of hurricane, together with flooding, but as was the case with other regions, suffered shocks caused by the 2008 financial crisis and more recently from distractions caused by the rise of China as an economic partner, and other political problems within the region.

Productivity growth within the region continues to be hindered by low levels of capital accumulation. Harmonizing policies, addressing these structural problems, as well as implementing necessary fiscal reforms, are important priorities for the governments of the region (SICA [3]; ECLAC, [2]).

MERCOSUR, the Southern Common Market, a South American trade bloc was established by the Treaty of Asunción in 1991. Initially its membership included the states Uruguay, Brazil, Argentina Bolivia and Paraguay, but later grew as other countries joined.

In its inception stage, the bloc experienced rapid growth, with internal trade moving from about 4 billion in the 1990s and quickly reaching $41 billion by 2010 (ECLAC, [2]). Thereafter, amidst problems related to the 2019 pandemic, and other world problems, trade slowed down, but following the pandemic, it again rose and surpassed it 2010 level. External exports also grew, but subjected to external economic fluctuations at the time there was much fluctuation in external exports.

The progress in the regions, as in other economic blocs, is set back by asymmetry problems, as countries at different stages of economic prosperities and faces different challenges, ranging from political instability, changes of government, protectionist tendencies regarding key industries, distraction from other outside opportunities, which together affected synchronizing institutions and trade policies and ultimately are resulting is economic stagnations and low productivity across this bloc (Mongan, [4]).

III. ANALYTICAL FRAMEWORK

If looked at through a production function, technological change measures the extent to which the frontier moves outwards (Färe et. al,[5]; Zhang [6]). On the other hand, technical efficiency measures how far within the production frontier a country's technology is.

Technical efficiency change provides evidence of growth catching up. And the rate of catching up is directly related to the kind of policies and institutions in place to promote diffusion of technology and knowledge (Färe et al., [5]; Perelman [7]) usually from developed countries. Other factors, such as access to health care or police protection, have indirect effects on technical efficiency change. This aspect of productivity is particularly important to developing countries (Arrow, [8]; Olson, [9]), where the cost of technology development is often prohibitive.

Technological change, on the other hand, provides an indicator of innovation within a country. New technological innovations that occur in developed countries usually create a new "world" production frontier. This usually requires high levels of expenditure on R&D (Perelman, [7]) and thus, is generally both a function of, and a major determinant of, growth and development in developed countries (Olson,[9]). Technological changes that occur in developed countries 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 innovativeness.

IV. METHODOLOGY

The methodology used was the non-parametric Malmquist Productivity Index. This index can further be transformed to yield indexes of technical efficiency change, and technology change. For the derivation of the Malmquist, see Fare et. al [5] and Caves, et. al. [10].

The Malmquist Productivity Growth Index, as defined by Fare et. al. [1994] is as follows:

$$M^t = D^t o(x^{t+1}, y^{t+1})/D^t o(x^t,y^t) \ldots\ldots\ldots \quad (1)$$

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 [Fig. 1].

The decomposition of the Malmquist Productivity Index (Färe et. al.,[5]) into the indexes of Technical Efficiency Change and Technology Change is as shown in Equation 2.

$$Mo(x^{t+1}, y^{t+1}, x^t,y^t) = [D^{t+1}o(x^{t+1},y^{t+1})/D^t o(x^t,y^t)] * [\_D^t o(x^{t+1},y^{t+1})/D^{t+1}o(x^{t+1},y^{t+1}) * D^t o(x^t,y^t)/D^{t+1}o(x^t,y^t)\_]^{½} \ldots\ldots (2)$$

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}

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

$$\begin{aligned} Mo(x^{t+1}, y^{t+1}, x^t,y^t) &= (0B4/0B5)(0B2/0B1) * [\_(0B4/0B3)/(0B4/0B5)*(0B1/0B2)/(0B1/0B3)]^{½} \\ &= (0B4/0B5)(0B2/0B1)*[(0B5/0B3)(0B3/0B2)]^{½} \ldots\ldots (3) \end{aligned}$$

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 captures 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.

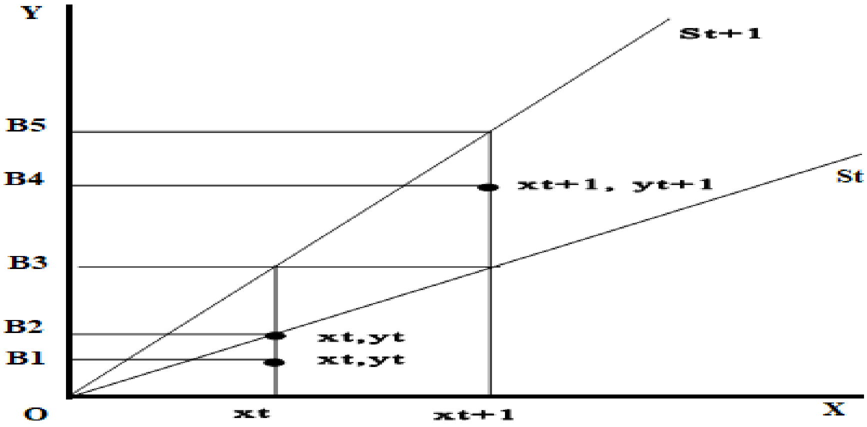

Figure 1: Malmquist Index.

Improvement in productivity yields a Malmquist Index greater than1. A Malmquist Index of less than 1 means productivity is deteriorating over time. This interpretation is also true for technical efficiency change and technological change. Although the product of the technical efficiency changes and technological change indexes 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 may 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 $D^t o(x^t,y^t)$, $D^{t+1} o(x^t,y^t)$, $D^t o(x^{t+1}, y^{t+1})$ and $D^{t+1} o(x^{t+1}, y^{t+1})$ were solved.

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

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

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

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

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

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. The 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 [4], but t+1 is substituted for t. To calculate the distance functions $D^{t+1} o(x^t,y^t)^{-1}$ and $D^t o(x^{t+1}, y^{t+1})^{-1}$, information for two periods is required.

For $D^t o(x^{t+1}, y^{t+1})^{-1}$, the LP solved is as follows:

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

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

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

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

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. Thus, $D^t o(x^{k,t} y^{k,t}) \in S^t$ [Equation 4] is less than 1. And $(D^t o(x^{k,t+1}, y^{k,t+1})$ [Equation 5] may take values greater than 1.

4.1 The Regression model

Ordinary least squares, in the log form were used to determine the relationships between productivity change and specific independent policy variables. Each parameter estimate was interpreted as the percent change in productivity growth for a one percent change in the respective independent variable.

$$lPRD_{ij} = \alpha_o + \alpha_1 lGDP_{ij} + \alpha_2 lEDU_{ij} + \alpha_3 lCR + \alpha_4 lK_{ij} + \alpha_5 lELEC_{ij} + \alpha_6 LlINF_{ij} + \alpha_7 TAX_{ij} + \alpha_8 l\,EXR_{ij} + \alpha_9 lTTr_{ij} + \alpha_{10} IlAGRI_i + \alpha_{11} lMAN_{ij} + \alpha_{12} LSERV_{ij} + e_{ij} \quad (6)$$

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. The other variables are as defined in Table 1; and e_{ij}, represents unexplained random errors. Mercosur countries included, Bolivia, Brazil, Paraguay, Uruguay and Argentina. SICA countries included Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. The model is estimated in its log form, indicated by the letter '*l*' in front of each variable.

V. THE DATA

This study involved observations on the outputs and inputs Mercosur and Sica countries over the period 2008 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. Inputs 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 data source for data used in this study was the (World Bank[11]). Because of inconsistencies observed in the data for some countries, these countries were omitted from the study. Also, in determining the relationship between productivity change and specific policy variables, observations for some countries were not available, so these countries were not included in the regression analysis.

Inter-annual changes of Capital, Labor and GDP in Mercosur and Sica blocs [2008-2022].

Table 1 shows the average annual changes in outputs and inputs for the countries involved in this study over the period 2009-2022. The countries are divided into groups based on whether they are Mercosur or Sica countries.

Based on Table 1, the GDP growth rate was slightly lower in the Mercosur bloc compared with the Sica bloc [0.031 vs 0.054], as was the growth rate in labor [0.014 vs. 0.021]. However, the growth rate of capital was higher in Mercosur compared with Sica [0.052 vs. 0.045.

5.2 Productivity variables.

Many economic factors affect productivity growth. In this study, twelve selected variables were used as proxies for six factors are considered. Table 2 shows the expected correlation between the productivity variable and the productivity index.

Market-related variables.

In this group, the GDP of each country was used as a proxy for market size. The rationale for including this variable is the larger the market size, the more incentive there would be for investors to invest in productivity improving ventures, such as training to improve human capital building, and technological and organization improvement, to enhance productivity growth. Lina and Wengb [12] and Ferraro et. al [13] showed a positive relationship between market scale [size] and productivity. In this study, a positive relationship is expected.

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, and Domestic Credit [per capita, CR], available to the private sector.

Regarding LIT, the more literate the population is, the greater is their ability to read instruction, and operate machinery and computerized systems, and the more productive they are likely to be. Thus, there is expected to be a positive relationship between literacy and productivity growth. This relationship has been shown in Khan et. al [14] which has documented a positive relationship between literacy and labor productivity. Oladimeji et. al. [15] has also shown a direct relationship between digital literacy and productivity.

Table 1. Interannual change in capital, labor and GDP.

	Mercosur				**Sica**		
	Capital	Labor	GDP		Capital	Labor	GGDP
2008	-0.048	0.022	0.005		-0.184	0.024	-0.006
2009	0.226	0.003	0.099		0.024	0.017	0.075
2010	0.223	0.011	0.104		0.024	0.017	0.075
2011	0.145	0.019	0.066		0.134	0.024	0.065
2012	0.032	0.016	0.033		0.087	0.046	0.054
2013	0.080	0.012	0.051		0.106	0.022	0.117
2014	0.009	0.019	0.024		0.025	0.027	0.042
2015	-0.103	-0.003	-0.024		0.129	0.014	0.052
2016	-0.068	0.021	-0.072		0.033	0.004	0.059
2017	0.095	0.019	0.055		0.055	0.030	0.049
2018	0.038	0.030	0.044		-0.006	0.031	0.029
2019	-0.034	0.013	-0.004		-0.003	0.016	0.065
2020	-0.090	-0.027	-0.074		-0.026	-0.032	-0.031
2021	0.214	0.029	0.115		0.217	0.041	0.118
2022	0.067	0.024	0.035		0.064	0.028	0.053
Mean	0.052	0.014	0.031		0.045	0.021	0.054

Source: Author's computation from World Bank data (World Bank [11]).

With regard to CR, the greater the availability of domestic credit to the private sector [CR], the more likely it is that innovation will be spurred. And private sector cases in which capital was the limiting factor in innovation will, with an increase in CR, become more innovative and productive, and productivity in the private sector will increase. On the other hand, the availability of domestic credit might just come in handy for other domestic uses and would not have any effect on productivity. Cecchetti and Kharroubi [16], found a negative relationship between low levels of credit and productivity growth. This was supported by Manaresi and Pierri, [17] which showed that a reduction is credit supply is directly related to total factor productivity.

In this paper it is likely that in the countries involved, available credit might go into domestic use as income is usually very low in these countries compared with elsewhere. But there is still the possibility that some will be put to productive use. Thus, overall, a positive correlation between CR and the productivity index is expected.

Infrastructure related variables. I n this group, two variables are studied, fixed capital formation [K] derived from the amount GDP spent of gross fixed capital formation, and expressed in per unit labor term, 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, although the productivity of capital is likely to decrease, as the quantity of K increased. Overall, it is expected that in the Mercosur and Sica blocs, productivity is likely to increase. This follows because neither region is classified as a high technology region, but regions struggling to acquire capital. Nourzad [18] found a positive correlation between fixed capital formation and productivity growth. Trpeski, and Marijana [19], 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 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 productive capacity and productivity. Alam et. al [20] has verified this relationship between access to electricity and productivity in developing countries. This result is likely to hold true 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 [INF] results in increased costs, and makes investment, including investment in productive assets, more expensive, at least in the short run. This is likely to have a negative impact on productivity, again, in the short run. In the long run, however, on the basis of the argument that money has no effect in the long run, INF is likely to have no effect in the long run. Piper et. al.,[21], in their studies of the Brazilian economy found an inverse relationship between inflation and productivity. Araujo et. al.[22] in their [2018] investigation of inflations in Brazil found similar results. The result in this study is expected to be similar.
With regards to taxes, on income, on profit or on capital gain [TAX], these are likely to reduce income available to spend, and in particular, income spent on productive assets. Thus, TAX is likely to have a negative impact on productivity. Vartia [23] found that taxes have a depressing effect on investment and productivity. This finding is supported by Ferraro, et. al. [13] 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.

Table 2: Variables, their 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]	CR	+	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 restriction, 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.	

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

Tax on trade makes traded goods more expensive and effectively reduces the demand. This reduces the capacity to take advantage of large-scale markets opportunities and thus stifles innovation and productivity gain strategies. A larger trading market provided more opportunities to explore innovation, much more than a smaller market. Thus, TT is likely to stifle productive efforts, and therefore it is likely to have a negative impact on productivity growth. Furceri, et. al. [24], in their analysis of the macroeconomic consequences of tariffs, observed a negative relation between tariffs and productivity. Kilumelume, et. al. [25] made the same observation. TAX is likely to have the same effect in this study.

Regarding the exchange rate [EXT], the effect on productivity depends on whether the rate is high or low. 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, and this is assuming that the inputs used in the production process are not imported, otherwise a low exchange rate will have a positive impact on productivity growth.

Cravino [26] noted that exchange rate does have an effect on productivity. McLeod and Mileva, [27] noted that weaker exchange rates tend to be correlated with increased total factor productivity. In this study a negative correlation is expected.

Productive Sector Variables. It is important to determine which productive sector of the economy is correlated with productivity growth. Four sectors are examined, 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]. Because the raw data is expressed in percentage of GDP and together, they sum to 100, OTHER is dropped from the regression, and each coefficient obtained for the rest is interpreted relative to OTHER. There is no priori expectation of the impact of any sector on productivity.

IV. RESULT AND DISCUSSION

6.1 Productivity indexes.

The results for the productivity, the Malmquist index for the period 2008-2022, are shown in Table 3, and the trends followed by the indexes are shown in Figs. 2 to 4.

Based on the mean for both regions, the Mercosur region shows a higher Malmquist productivity index than the Sica region [1.0221 vs. 0.7616], but the variation on the index across the time period was lower in the Mercosur region compared with the Sica region [0.0248 vs. 0.0032].

The trend shown in Fig. 2, shows a divergent patterns of productivity growth between the two regions with the trend line for Mercosur showing a constant increase, though a slow increase, in productivity over the time period is similar in both regions across the time period. That for Sica shows a constant downwards pattern of productivity growth.

Table 3: Technical Efficiency Change, Technology Change, Productivity Change

	Technical Efficiency Change		**Technological Change**		**Productivity Growth [Malmquist Index]**	
Years	M	S	M	S	M	S
2008	0.9318	0.9805	0.9930	0.7294	0.9253	0.7152
2009	0.9610	1.1256	1.0939	0.7401	1.0512	0.8330
2010	0.8844	0.9643	1.0614	0.7375	0.9387	0.7111
2011	0.9646	1.0470	0.9902	0.7533	0.9551	0.7887
2012	1.1756	1.0467	0.8662	0.7641	1.0183	0.7998
2013	0.8492	0.9956	1.1893	0.7715	1.0099	0.7681
2014	1.0406	1.0529	0.9844	0.7890	1.0244	0.8307
2015	1.0651	0.9586	0.9780	0.7871	1.0416	0.7546
2016	1.1068	1.1624	0.8848	0.7886	0.9793	0.9167
2017	0.9357	0.9304	1.0379	0.7706	0.9711	0.7169
2018	0.9692	0.9819	1.0510	0.7594	1.0187	0.7456
2019	0.9724	1.0638	1.0697	0.7862	1.0402	0.8363
2020	1.0648	1.0764	0.9723	0.7632	1.0353	0.8215
2021	0.9949	1.0040	0.9544	0.7983	0.9495	0.8015
2022	0.6225	0.4902	1.6913	0.7777	1.0529	0.3812
Mean	0.9692	0.9920	1.0545	0.7677	1.0221	0.7616
Std. Dev.	0.1282	0.1528	0.1937	0.0209	0.0248	0.0032

Source: Author's computation from World Bank data (World Bank [11]). M =Mercosur. S = Sica.

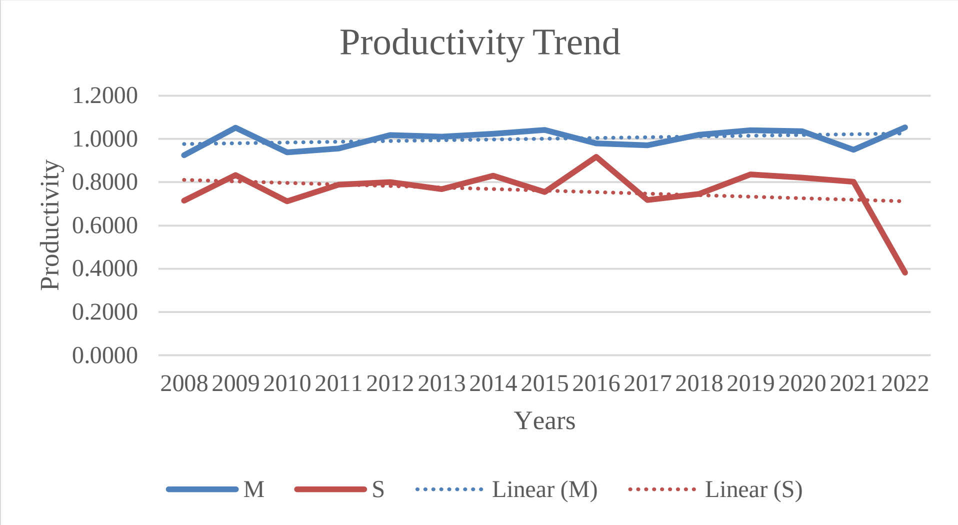

Figure 2: Productivity trend

In terms of technological change over the same period, the index for Mercosur is greater than that of Sica [1.0545 vs. 0.7677], but there is a greater variation in technological change in Mercosur compared with Sica [0.1937 vs. 0.0209]. Based on the trend across the time period, both regions show a slight upward trend, indicating that technological growth in both regions is increasing over that time period, although, the rate fluctuates more in Mercosur [Fig. 3].

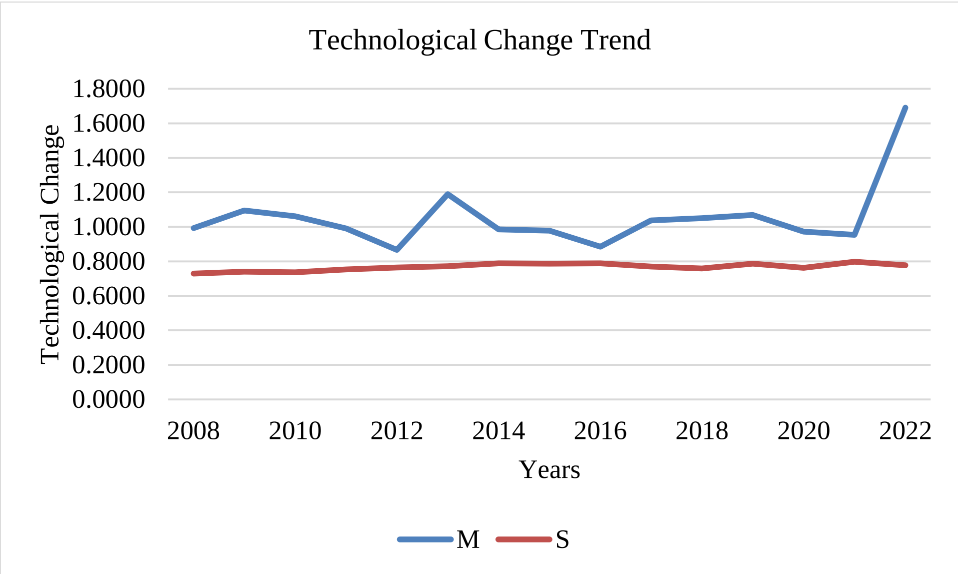

Figure3: Technological change trend.

Technical efficiency change is lower in Mercosur compared with Sica [0.9692 vs. 0.9920]. The trends shown in Fig. 4, show downwards sloping technical efficiency change in both regions, which indicates a deterioration of technical efficiency in both regions.

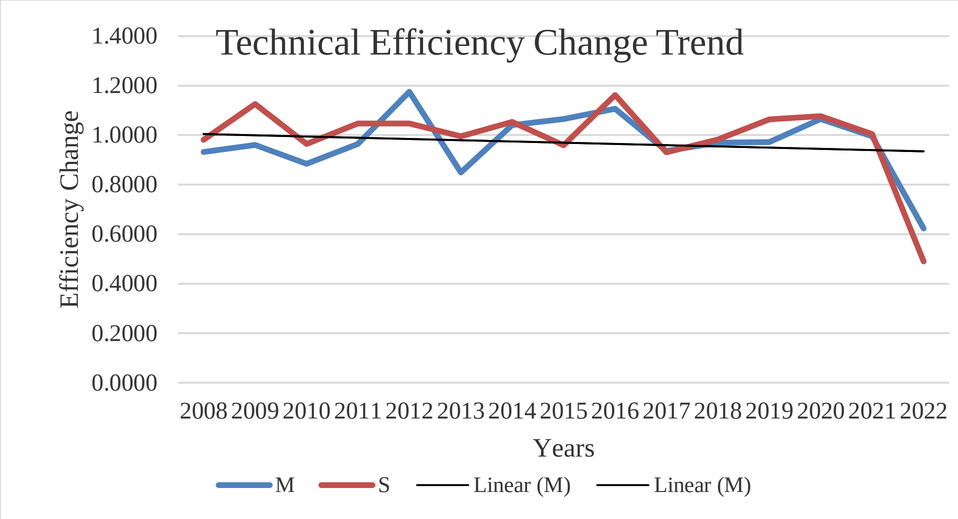

Figure 4: Technical efficiency change trend

Overall, productivity change in Mercosur is very slow, about 2.2 percent over the period 2008 to 2022. That of Sica is rather decreasing, at a rate of 24% over the period, then increasing.

6.2 Regression analysis

The regression results for the Mercosur and the Sica economic blocs are shown in Table 4. In the Mercosur region, eight variables in six groups were found to be significant. The groups were the following: the market related, the human capital/private sector, infrastructure, monetary/fiscal policy, the trade policy and the productive sector groups, were significant. Based on the R square [0.632], the variables considered explain only 63 percent of the variation of productivity growth in the region.

In the Sica region, five variables in four groups were significant and these groups were the same as for the Mercosur region, except the Human capital/private sector related group and the trade policy group. The variables studied explained 54 percent [R square = 0.541] of the variability in productivity growth.

With regards to the response of variables in each group, this is also shown in Table 4.

In the market group, one variable was studied, the market size, and it was modeled as the GDP in each country. In Mercosur, this variable was significant and had a positive coefficient [0.210] indicating that productivity is likely to increase by 0.21 percent for a one percent increase in market size. This positive relationship was also shown in the work of Lina and Wengb [12] and Ferraro et. al [13] and suggest that as countries in the Mercosur block engage larger market, there would be more incentive for firms to invest more to increase their productivity.

In the Sica group of countries, the result is similar, but the coefficient is somewhat smaller [0.091] indicating that productivity is less responsive to the size of the markets in this group compared with Mercosur countries.

In the Human Capital/Private Sector group, in Mercosur block, of the two variables, the literacy rate [LIT] and credit per capita [CR] in the private sector, both variables, LIT and CR, were significant and both had the expected positive signs [0.792 & 0.432] indicating that productivity is likely to increase with an increase in LIT and CR in this region. This result for LIT matched the findings of Khan et. al [14] and Oladimeji et. al. [15] and that for CR is as predicted by Cecchetti and Kharroubi, [16] and Manaresi and Pierri, [17]. Again, it is reasonable to expect that if credit is available to the private sector this will motivate innovation and in so doing, increase the engagement of the private sector in production and their productivity as well.

In the Sica group, neither variable was significant.

In the Monetary/Fiscal policy group, in the Mercosur region, of the two variables used to represent this group of variables, INF was not significant, TAX was. The coefficient had the expected negative sign [-0.331] indicating that as TAX increases in this region, productivity is likely to decrease. As suggested by Cecchetti and Kharroubi [16] and Manaresi and Pierri, [17], an increase in tax reduces the capital available to invest in measures to improve productivity.

The variable was also significant in the Sica block, but again the coefficient was smaller, i.e., less negative, suggesting that productivity is likely to decrease much less in this block as TAX increases. INF was not significant in the SICA block as well.

Tax on trade [TT] and the exchange rate [EXR], were the variables studied in the Trade Policy group. In the Mercosur region, only EXR was significant, and it had the expected negative signs [-0.025], suggesting that in this region, productivity is likely to decrease as EXR decreases. The behavior observed with regard to EXR was as predicted in Cravino [26] and McLeod and Mileva [27]; as the exchange rate increases, home goods become more expensive to foreign buyers and the home market loses its price attraction. Eventually production and productivity decrease as a result. A lower exchange rate will bring about the opposite and desired effect.

Table 4: Variables, acronyms, hypothesized relationships with productivity index and rationales.

			Mercosur				**Sica**		
Variables			*Coefficients*	*P-value*			*Coefficients*	*P-value*	
Market Related variables									
	Market size [GDPT]	GDP(M)	0.210	0.027	**		0.091	0.038	**
Human capital/ Private sector related variables									
	Literacy rate	LIT	0.792	0.014	**		0.130	0.816	
	Credit/Capita	CR	0.432	0.018	**		0.237	0.456	
Monetary/Fiscal Policy Variables									
	Inflation Rate	INF	-0.067	0.391			-0.009	0.898	
	Tax on income, profit and capital gains.	TAX	-0.339	0.016	**		-0.178	0.623	**
Trade Policy Variable									
	Tax on trade	TT	-0.208	0.198			-0.097	0.789	
	Exchange Rate	EXR	-0.025	0.044	**		-0.050	0.818	
Infrastructure Variables									
	Gross Fixed Capital formation	K	0.535	0.034	**		0.110	0.003	***
	Electricity	ELEC	0.611	0.050	**		0.921	0.530	
Productive sector Variables									
	Agriculture [% GDP]	AGR	-0.032	0.886			0.160	0.433	**
	Manufacturing [%GDP]	MAN	0.846	0.144	**		0.193	0.573	
	Service [% GDP]	SERV	-0.313	0.519			-0.499	0.355	**
Constant		Intercept	2.648	0.519			0.034	0.987	
R Square			0.632				0.541		

*** & *** means significance at the 95% and 99% CI levels*.

. In the Sica countries, the results for neither variable [TT nor EXR] were significant.

The infrastructure group is represented by two variables, gross fixed capital formation [K] and the percent of the population with access to electricity [ELEC]. In Mercosur countries, both variables were significant, and each had the expected positive signs [0.535 & 0.611], indicating that productivity is likely to increase as K and ELEC increase. Results similar to that of K were found by Nourzad. F. [18] and Trpeski, and Marijana [19]. ELEC has a larger coefficient than K suggesting that productivity is likely to increase much more as a result of ELEC than with K in this block.

In the Sica block, the results were similar for K. ELEC was not significant. The coefficients for K [0.110] suggest that productivity is likely to increase, but less than in Mercosur with a one percent increase in K. In the productive sector group, in the Mercosur region, only the manufacturing sector, MAN was found to be significant, and positive [0.0.846] suggesting that this sector has a greater impact of productivity compared with the other sector [OTHER].

In the Sica region, both the agriculture sector [AGR] and the service sector [SERV] were found to be significant, but while AGR had a positive sign [0.160], SERV had a negative sign [-0.499] indicating that AGR is likely to result in a greater increase in productivity compared with the other sector [OTHER] and SERV is likely to have the opposite effect.

VII. SUMMARY.

7.1 Productivity Indexes.

Between the period 2008 and 2022, Mercosur region shows a higher Malmquist productivity index with a lower variation in the index across the time period in the Mercosur region compared with the Sica region. The trend shows divergent patterns of productivity growth between the two regions with the trend line for Mercosur showing a fairly constant but slow increase in productivity over the time period.

Technological change over the same period was likewise greater, but the variation in the index was also greater in Mercosur than that in Sica. The trend in this measure across the time period in both regions was a slightly upward trend, indicating that technological growth in both regions was increasing over that time period, although the rate fluctuated more in Mercosur.

Technical efficiency change was lower in Mercosur compared with Sica. The trends show downwards sloping technical efficiency changes in both regions.

Overall, productivity growth in Mercosur was very slow across the time period, but Sica showed a decreasing, rather than increasing trend over the same period.

7.2 Regression

The results for the Mercosur and the Sica economic blocs show that in the Mercosur region, eight variables in six groups were found to be significant. The groups were the following: the market related, the human capital/private sector, infrastructure, monetary/fiscal policy, the trade policy and the productive sector groups, were significant. Based on the R square, the variables considered explain only 63 percent of the variation of productivity growth in the region.

In the Sica region, five variables in four groups were significant and these groups were the same as for the Mercosur region, except the Human capital/private sector related group and the trade policy group. The variables studied explained 44 percent of the variability in productivity growth.

Of the variables studied, in the Mercosur region, an increase in market size in the market group, the literacy rate and access to credit in the human capital/private sector group, gross fixed capital formation, percent of the population with access to electricity in the infrastructure group, are likely to have a greater positive impact on productivity in Mercosur than in Sica. So also, is a decrease in tax on incomes, profit and capital gain in the monetary/fiscal policy group and exchange rate in the trade policy group.

In the productive sector, increasing operations in the manufacturing sector is likely to have a greater impact than the other sectors, which includes mining, drilling and construction, on productivity. In Sica, increasing production in the agriculture sector is likely to have a similar impact, increasing production in the service sector is more likely to have a weaker impact on productivity than in the other sector.

Policies based on variables or groups of variables with a stronger impact are likely to impart a comparative advantage to the region in which the variables show such impacts.

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