Agricultural Productivity Changes in the Caribbean: Challenges for Trade

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Introduction

Throughout its history, the Caribbean has been very dependent on agricultural production and exports as a source of food and foreign exchange. Even with recent increases in the importance of tourism in some countries, agriculture is still important, not only as a source of revenue, but also as an employer, especially of the rural population. In the face of drastic changes in world trade regulations, partnerships and opportunities, the type and share of commercial agricultural commodities produced in the Caribbean has also changed, largely in response, and not proactively, to this changing world scenario. Given the relatively small land base of these countries, and increasing population, sustaining or increasing agricultural output per capita will rely more and more on increasing productivity in the agricultural sector.

Caricom and the CSME

The Caribbean region is a very diverse region economically, politically and socially. The main trading group is CARICOM, which is in the process of forming the CSME (CARICOM Single Market and Economy). CARICOM, which was formed in 1973, has removed most barriers to trade in goods among the 14 member countries. However, the CSME is envisioned to move towards further integration in the labour, capital and entrepreneurial markets. Already, the free movement of skilled workers and entrepreneurs has been implemented. This moved the member countries closer to the formation of a Single Market. The Single Economy is envisaged to mirror the European

Union in terms of the level of integration, and have a single currency, single monetary and fiscal policies, a single judiciary and unified national administrative bodies.

This paper will assess the historical levels of productivity of CARICOM countries, together with their levels of trade in agricultural commodities with the U.S. and the implications of the emerging trade agreements. The follow-up study will analyze the total factor productivity measures for all CARICOM countries using Malmquist productivity indexes, over two decades, and compare these results with already defined measures of productivity for this region.

Productivity Measure

Malmquist productivity indexes, were developed by Caves, Christensen and Diewert (1982), who constructed these measures for technologies with varying returns to scale. They assumed overall efficiency, as defined by Farrell (1957), and a translog structure for the output distance functions, which provides the foundation for the index. Caves *et al.* found that even though the index could not be estimated directly, the geometric mean of two Malmquist productivity indexes was equivalent to a scaled Törnqvist-Theil productivity index (Hutchinson and Langham 1999).

Subsequently, Färe *et al*. (1992) developed a non-parametric approach for calculating a Malmquist (input-based) index. Here, inefficiencies in production were allowed, and the underlying production function was not assumed to have a specific functional form. The Malmquist index therefore differentiated between changes in relative efficiency and shifts in the production frontier. This index is based on output distance functions, which are independent of the units of measurement of the data.

Furthermore, the requirement of only input and output *quantities*, in general, is a great advantage in most Caribbean countries since assembling good input price data is difficult. It is important to note though, as Perrin and Fulginiti (p. 1356) have pointed out, that productivity is (still) a value-laden concept because we use in its measure only those inputs and outputs that we value (Hutchinson and Langham 1999).

A basic reference for this approach was the work by Färe *et al.* (1994b).[1] A production technology S^t, transforms an input vector $x^t \in R_+^N$ into a feasible output vector $y^t \in R_+^M$, where t represents any specified time. The productivity change between consecutive years can be illustrated, using distance functions, in a single input/single output, constant returns-to-scale framework (see Figure 1).

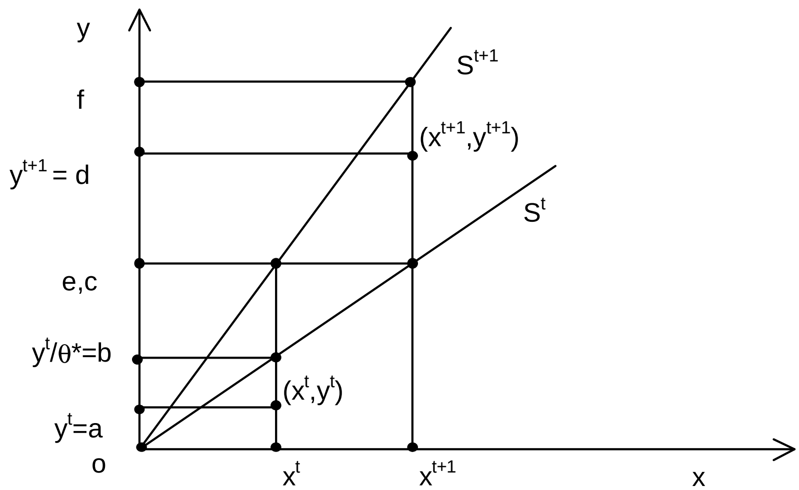
Observed production points are $(\mathbf{x}^t, \mathbf{y}^t)$ and $(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$. The output distance function for period t, $D^t_0(\mathbf{x}^t, \mathbf{y}^t)$, is the reciprocal of the maximum factor θ, given $\mathbf{x}^t$, required to inflate the output vector $\mathbf{y}^t$, such that $\mathbf{y}^t/\theta \in \mathbf{S}^t$ (i.e. the reciprocal of the Farrell measure of technical efficiency). It is defined at t as:

$$(1) \qquad D^t_0(\mathbf{x}^t, \mathbf{y}^t) = \inf\{\theta: (\mathbf{x}^t, \mathbf{y}^t/\theta) \in S^t\} = \{\sup[\theta: (\mathbf{x}^t, \theta\, \mathbf{y}^t) \in S^t]\}^{-1}.$$

So when production is relatively efficient, $D^t_0(\mathbf{x}^t, \mathbf{y}^t) = 1$, and for production inside the boundary, such as point $(\mathbf{x}^t, \mathbf{y}^t)$, in Figure 1, the Farrell measure of technical efficiency is ob/oa (= θ), so that the distance function assumes the value oa/ob, which is < 1.

[1] Also see Färe *et al.* 1994a.

Figure 1: The Malmquist Index and Output Distance Functions



Source: Färe *et. al.*, 1994b, p.70

In order to appraise productivity changes however, it is necessary to compare actual production in one period with the production possibilities of another. Therefore, two other output distance functions are defined: D^t_0 ($\mathbf{x}^{t+1}$, $\mathbf{y}^{t+1}$) and D^{t+1}_0 ($\mathbf{x}^t$, $\mathbf{y}^t$). The former, using the case shown in Figure 1, represents the maximum deflation, θ, needed on the output vector $\mathbf{y}^{t+1}$, given $\mathbf{x}^{t+1}$, such that $\mathbf{y}^{t+1}/\theta$ is feasible using technology $\mathbf{S}^t$. Therefore, if $\mathbf{y}^{t+1}$ is outside this set, technical progress has occurred, and D^t_0 ($\mathbf{x}^{t+1}$, $\mathbf{y}^{t+1}$) > 1. The measure of D^{t+1}_0($\mathbf{x}^t$, $\mathbf{y}^t$)) follows correspondingly.

The Malmquist index (decomposed) is therefore defined as:

$$(2) \qquad M_o\left(\mathbf{x}^{t+1},\mathbf{y}^{t+1},\mathbf{x}^t,\mathbf{y}^t\right)=\left[\frac{D_o^{t+1}\left(\mathbf{x}^{t+1},\mathbf{y}^{t+1}\right)}{D_o^t\left(\mathbf{x}^t,\mathbf{y}^t\right)}\right]\times\left\{\left[\frac{D_o^t\left(\mathbf{x}^{t+1},\mathbf{y}^{t+1}\right)}{D_o^{t+1}\left(\mathbf{x}^{t+1},\mathbf{y}^{t+1}\right)}\right]\left[\frac{D_o^t\left(\mathbf{x}^t,\mathbf{y}^t\right)}{D_o^{t+1}\left(\mathbf{x}^t,\mathbf{y}^t\right)}\right]\right\}^{1/2}$$

where the ratio outside the curly brackets measure relative efficiency change between years *t* and *t*+1, and that inside measures the shift in the production frontier in that time.

Solutions for the component distant functions: D^t_0 ($\mathbf{x}^t$, $\mathbf{y}^t$); D^{t+1}_0 ($\mathbf{x}^t$, $\mathbf{y}^t$); D^t_0 ($\mathbf{x}^{t+1}$, $\mathbf{y}^{t+1}$); and D^{t+1}_0 ($\mathbf{x}^{t+1}$, $\mathbf{y}^{t+1}$), obtained by solving four different linear programming (LP) problems for each country, k^* ($k^* \in$ K) as:

$$\text{Max } \theta^{k*} = [D_0^t(\mathbf{x}^{k*,\ t}, \mathbf{y}^{k*,\ t})]^{-1}$$

$$\text{s.t.} \quad y_m^{k*,\ t}\,\theta^{k*} \le \sum_{k=1}^{K} y_m^{k,\ t}\, z^{k,t} \qquad m = 1,\ldots,M$$

$$\sum_{k=1}^{K} x_n^{k,\ t} z^{k,\ t} \le x_n^{k*,\ t} \qquad n = 1,\ldots,N$$

$$z^{k,\ t} \ge 0 \qquad k = 1,\ldots,K$$

$$\sum_{k=1}^{K} z^{k,\ t} \le 1 \text{ (NIRS)}$$

Similarly, $D_0^t(\mathbf{x}^{k*,\ t+1}, \mathbf{y}^{k*,\ t+1})$ was solved as:

$$\text{Max } \theta^{k*} = [D_0^t(\mathbf{x}^{k*,\ t+1}, \mathbf{y}^{k*,\ t+1})]^{-1}$$

$$\text{s.t.} \quad y_m^{k*,\ t+1}\,\theta^{k*} \le \sum_{k=1}^{K} y_m^{k,\ t} z^{k,\ t} \qquad m = 1,\ldots,M$$

$$\sum_{k=1}^{K} x_n^{k,\ t} z^{k,t} \le x_n^{k*,\ t+1} \qquad n = 1,\ldots,N$$

$$z^{k,t} \ge 0 \qquad k = 1,\ldots,K$$

$$\sum_{k=1}^{K} z^{kt} \le 1 \text{ (NIRS)}$$

For distance functions in which the reference technology is time t+1, all t's are replaced with t+1, and vice versa, where applicable. In the LP, non-increasing returns-to-scale (NIRS) was assumed. The $z^{k,t}$ variable is an intensity variable, which forms the technology of the group of countries being studied, based on the observed inputs and outputs.

Discussion and Conclusion

In 1996, the total value of CARICOM's trade for food and live animals was $ 1,059,287.04 (US $ '000) of imports and $893,175.93 (US $ '000) of exports, with a net food import balance of $166,111.11 (US $ '000). By 2001, the level of food imports grew by approximately 16 percent to $1,235,479.26 (US $ '000) of imports, while exports fell by approximately 16 percent also to $752992.59 (US $ '000).

The growth rates of food production, as well as measures of agricultural productivity are given in tables 1 and 2 below.

Table 1: Average Annual Growth Rates of Agricultural Production for Selected Countries (%)

Country	**Crop and Livestock Production**		**Per Capita Food Production**	
	1983-1992	**1993-2002**	**1983-1992**	**1993-2002**
Barbados	-1.5	1.6	-1.9	1.2
Dominican Republic	-1.5	-0.8	…	…
Guadeloupe	-0.8	1.8	-2.5	1.0
Guyana	-0.3	3.8	0.1	3.4
Haiti	-0.9	0.6	-3.0	-0.8
Jamaica	2.8	1.4	1.9	0.7
Martinique	0.7	2.5	-0.4	1.9
Saint Lucia	19.7	9.1	…	…
Saint Vincent and the Grenadines	15.4	-1.7	…	…
Suriname	0.4	-2.3	-0.7	-2.6
Trinidad and Tobago	3.1	8.1	…	…

Source: FAO (2005)

Table 2: Total Factor Productivity for Selected Countries

Country	Total Factor Productivity		Efficiency Change		Technological Change	
	1961-81	1981-2000	1961-81	1981-2000	1961-81	1981-2000
Barbados	2.9	0.9	0.3	-1.8	2.6	2.7
Dominican Republic	0.2	0.5	0.0	0.0	0.2	0.5
Guadeloupe	-0.6	1.7	-2.4	0.1	1.8	1.6
Guyana	1.2	1.8	-0.3	0.8	1.5	1.0
Haiti	-1.4	-0.2	0.0	0.0	-1.4	-0.2
Jamaica	0.6	1.6	0.3	-0.8	0.2	2.4
Martinique	-1.5	2.1	-1.4	0.0	-0.1	2.1
Saint Lucia	-0.7	-3.0	0.0	-2.9	-0.7	-0.2
Saint Vincent and the Grenadines	-1.0	0.2	-2.9	1.4	1.9	-1.2
Suriname	3.3	-4.3	1.8	-4.0	1.4	-0.3
Trinidad and Tobago	-1.6	0.5	-0.7	-1.2	-0.9	1.7

Source: FAO (2005)

These tables show that for many countries, the level of total factor productivity fell between 1961 and 2000. Given the continued increase in total food imports by CARICOM countries, this suggests that these countries are becoming more and more vulnerable to global shocks in the food system, and are becoming more and more dependent on food imports.

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