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INTERNATIONAL AGRICULTURAL TRADE AND DEVELOPMENT CENTER

PRODUCTIVITY GROWTH, TECHNICAL PROGRESS AND AND EFFICIENCY CHANGE IN THE CARIBBEAN: KEY INGREDIENTS FOR 'INTERNATIONAL COMPETITVENESS'

By
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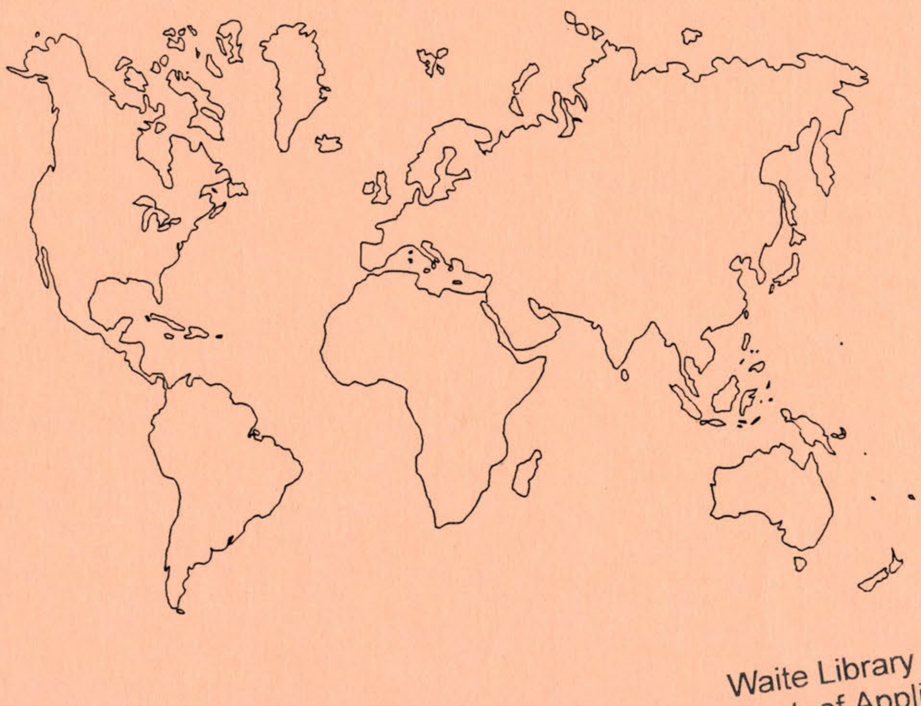

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Productivity Growth, Technical Progress and Efficiency Change in the Caribbean: Key Ingredients for 'International Competitiveness'

Sharon D. Roberts and Max R. Langham

Abstract: Malmquist indexes of multifactor productivity (MFP) in the agricultural sectors were estimated by years for the period 1961 through 1986 for Barbados, Belize, Cuba, Dominican Republic, Guyana, Jamaica, Suriname, and Trinidad and Tobago. The estimated indexes show average growth rates in MFP over the 26 years of -2.3, 9.3, 3.1, 3.9, 0.7, 0.1, -1.1, and -0.7 percent, respectively. The estimated Malmquist indexes were partitioned into indexes of relative efficiency and technical efficiencies. Technical efficiencies among the countries were compared by years and Belize defined the technical efficiency frontier in 8 of the 26 years; Cuba, 4; Barbados, Guyana, and Trinidad and Tobago, 3 each; Dominican Republic and Suriname, 2 each; and Jamaica, 1. Tornqvist-Theil (T-T) indexes for Jamaica and Trinidad and Tobago were available from a separate study. T-T indexes compare a country against its own performance in a base year rather than with other countries for each year. The average rates of growth shown by the T-T indexes were -1.0 and -0.5 for the two countries, respectively. The T-T estimate suggest that Jamaica's MFP performance is weaker when compared to its historical performance than when contemporaneously compared with other Caribbean countries.

Keywords: Multifactor Productivity, Malmquist Indexes, Caribbean Agriculture, Relative Efficiency, Technical Efficiency

Productivity Growth, Technical Progress and Efficiency Change in the Caribbean: Key Ingredients for 'International Competitiveness'

Sharon D. Roberts and Max R. Langham*

The theme for this conference rests on the idea of trade. One of our early lessons in economics was that the gains from trade stem from exploiting comparative advantage. The idea of such gains was developed from David Ricardo's thoughts on comparative cost early in the last century and added to by John Stuart Mill and other classical English economists. Much more recently international competitiveness has become a part of popular jargon though we economists have no solid conceptual idea of what it means. One gets the impression that international competitiveness is thought of much like a game where someone loses and someone wins and the outcome will be determined today or in the very near future -- it is a here and now phenomenon. This way of thinking is not at all consistent with the tenants of trade theory where everyone has a comparative advantage in something and gains from exploiting it through trade to the benefit of all parties to the trade.

The idea of competitiveness is closer to the concept of having an absolute advantage today which provides no rationale for trade. Absolute advantage does permit the producer to gain more economic rents than a higher cost producer. However, the

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process of getting into a position to capture more rents is a long-term one. Trade is here and now based on comparative advantage. You can gain from trade as the poorest participant in the exchange if you are exchanging something in which you have a comparative advantage. However, to capture more rents beyond the gains from trade you need to become a lower cost producer in what you are trading -- including the trader in his or her role as a producer.

In summarizing this introduction, we argue that if competitiveness has any economic meaning it must be based on the producers' ability to capture rents in whatever they are producing for sale. If a producer or group of producers of an economic good are increasing their rents relatively faster than other producers of the good, they are becoming 'more competitive'. We agree with the statement, "To live well, a country must produce well" (Dertouzos, et al). We would add that it is a country's producers who must produce well and that sound economic policies are central to their success. It is towards these ends that we view productivity growth, technical change, efficiency changes, and the economic policies which foster them as key ingredients for international competitiveness.

Productivity Measures[1]

Accurate tracking of productivity in an economy or its sectors requires large amounts of information. In this paper, we report Malmquist indexes of MFP which were estimated for Barbados, Belize, Cuba, Dominican Republic, Guyana, Jamaica, Suriname, and Trinidad and Tobago using a data set assembled from a number of sources by the

[1] In this paper we are using the term productivity to mean multifactor productivity (MFP). MFP is a ratio of a quantitative index of outputs (Y) to a quantitative index of the inputs (X) used, i.e., MFP = Y/X.

USDA.[2] A great advantage of the Malmquist approach is that it is based on assumptions about the technology and requires only information on the quantities of outputs and inputs. No information on prices is required. Assembling good price information on the inputs used is very problematic in nearly every country since the major focus of agricultural data systems has historically been on the commodities produced.

Malmquist Indexes

Malmquist indexes are based on distance functions over the technologies being used. The technologies and hence the distance functions are independent of the units of measurements in which they are represented in the data. Although price information is not needed to construct Malmquist indexes of MFP, the method assumes that the decision makers used the inputs in the production process in order to do the best they can from an economic perspective. So, rational economic behavior is assumed. Indeed as Perrin and Fulginiti (p. 1356) have clearly pointed out, productivity is a value-ladened concept simply because we record only those inputs and outputs that we value in measuring productivity.

The output-based Malmquist productivity change index is specified as the geometric mean of two Malmquist productivity indexes. A basic reference for our approach was the work by Färe *et al* (1994b).[3]

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[2] These data are entitled "World Agriculture: Trends and Indicators in (TR)-View Format" and the acronym WATIVIEW which identifies the operating program TS-View. A description of the data set can be found on the internet with the address: http://usda.mannlib.cornell.edu:70/0/data-sets/international/91017/readme.1. Francis Urban (Phone: (202) 786-1705) was the project coordinator for this effort.

[3] Other important references are by Färe et al (1992 and 1994a). In agriculture, Perrin et al have done pioneering work.

The Malmquist index is defined as:

$$(1)\ M_0(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}, \mathbf{x}^t, \mathbf{y}^t) = [(D^t_0(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) / D^t_0(\mathbf{x}^t, \mathbf{y}^t))\ (D^{t+1}_0(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) / D^{t+1}_0(\mathbf{x}^t, \mathbf{y}^t))]^{1/2}.$$

where it is assumed that for each time period t, some production technology S^t transforms inputs x into feasible outputs y.

Malmquist indexes are based on distance functions over the technologies being used. As proposed by Färe (1988), the output distance function is defined at t as:

$$(2)\ D^t_0(\mathbf{x}^t, \mathbf{y}^t) = (\sup\{\theta: (\mathbf{x}^t, \theta\mathbf{y}^t) \in S^t\})^{-1}.$$

That is, the distance function is the reciprocal of the maximum proportional expansion of the output vector $\mathbf{y}^t$, given inputs $\mathbf{x}^t$. When observed production is not technically efficient[4], the distance function assumes a value < 1. When production occurs on the frontier, that is, when production is technically efficient, the distance function has a value of 1.

Figure 1 is adapted from Färe et al (1994b, p.70) to demonstrate how the Malmquist index approach measures a productivity change. The figure illustrates the production of one output from a single input in two time periods, t and $t+1$. Assuming a constant returns-to-scale technology, the line S^t and S^{t+1} represents the production frontiers in time t and $t+1$ respectively. So that the observed production at the point ($\mathbf{x}^t$, $\mathbf{y}^t$) is technically inefficient at time t, as it lies below S^t. Given $\mathbf{x}^t$, the maximum feasible production is at $\mathbf{y}^t/\theta^*$, so that the greatest proportional increase in output is the ratio *ob/oa*, and the distance function in this case assumes a value of *oa/ob*, which is less than 1.

[4] This technical efficiency is based on the terminology of Farrel (1957).

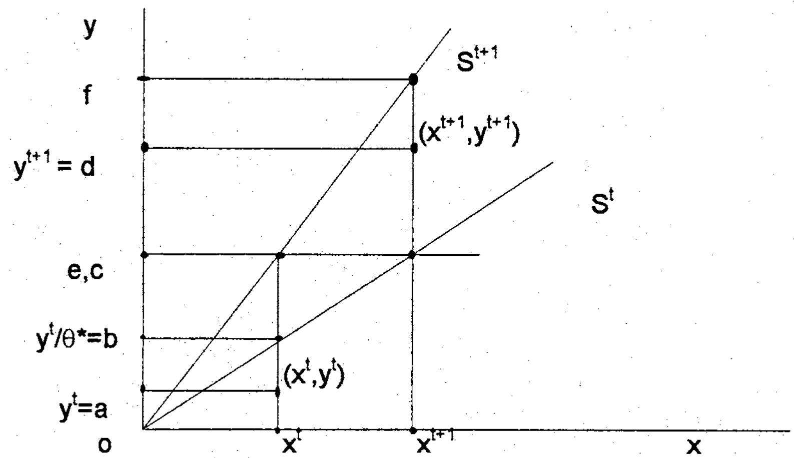

Figure 1: The Malmquist Index and Output Distance Functions

The Malmquist index requires the use of distance functions from two different time periods, so that a similar function can be calculated for observed production at $(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$ relative to S^{t+1}. In addition to relating observed production to the frontier in the same period, comparisons can also be made to a different time period. For example, production at $(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$ is outside the feasible production set in period *t*. This implies that technical change has occurred, so that the value of the distance function is *od/oe*, which is greater than 1. A distance function which measures observed production at $(\mathbf{x}^t, \mathbf{y}^t)$ relative to the production technology in period *t+1* can also be similarly defined.

Solutions for the distant functions required to compute the indexes were obtained by solving four different linear programming problems for each country in each year for: $D^t{}_0\ (\mathbf{x}^t, \mathbf{y}^t)$, $D^{t+1}{}_0\ (\mathbf{x}^t, \mathbf{y}^t)$, $D^t{}_0\ (\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$, and $D^{t+1}{}_0\ (\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$. The linear programming problems were formulated for each country, k = 1,…,8 as:

$$\text{Max } \theta^{k*} = (D^t_0 (\mathbf{x}^{k*,t}, \mathbf{y}^{k*,t}))^{-1}$$

$$\text{s.t.} \quad \theta^{k*} \mathbf{y}^{k*,t} \leq \sum_{k=1}^{8} z^{k,t} \mathbf{y}^{k,t}$$

$$\sum_{k=1}^{8} z^{k,t} \mathbf{x}_n^{k,t} \leq \mathbf{x}_n^{k*,t}, \quad n = 1,\ldots,N$$

$$z^{k,t} \geq 0 \qquad k = 1,\ldots,8$$

$$\sum_{k=1}^{8} z^{k,t} \leq 1 \text{ (NIRS)}$$

For the calculation of $D^{t+1}_0 (\mathbf{x}^{k*,t+1}, \mathbf{y}^{k*,t+1})$, *t* was replaced by *t+1*:

$$\text{Max } \theta^{k*} = (D^t_0 (\mathbf{x}^{k*,t+1}, \mathbf{y}^{k*,t+1}))^{-1}$$

$$\text{s.t.} \quad \mathbf{y}^{k*,t+1} \theta^{k*} \leq \sum_{k=1}^{8} \mathbf{y}^{k,t} z^{k,t}$$

$$\sum_{k=1}^{K} \mathbf{x}_n^{k,t} z^{k,t} \leq \mathbf{x}_n^{k*,t+1} \quad n = 1,\ldots,N$$

$$z^{k,t} \geq 0 \qquad k = 1,\ldots,8$$

$$\sum_{k=1}^{8} z^{kt} \leq 1 \text{ (NIRS)}$$

In the work reported here, 4*8*26 = 832 problems were solved. These solutions were based on the assumption of a non increasing returns-to-scale technology (NIRS) as per the last constraint. NIRS permits a decomposition of change into technical change and relative-efficiency change. To obtain these components, the Malmquist Index of MFP can be constructed as:

$$(3) \quad M_0 (\mathbf{x}^{t+1}, \mathbf{y}^{t+1}, \mathbf{x}^t, \mathbf{y}^t) = (D_0^{t+1} (\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) / D_0^t (\mathbf{x}^t, \mathbf{y}^t)) \times [(D_0^t (\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) / (D_0^{t+1} (\mathbf{x}^{t+1}, \mathbf{y}^{t+1})) (D_0^t (\mathbf{x}^t, \mathbf{y}^t) / D_0^{t+1} (\mathbf{x}^t, \mathbf{y}^t))]^{1/2},$$

where the ratio outside the square brackets measure relative efficiency change and that inside measures technical change. The estimated Malmqvist Indexes of MFP for the selected Caribbean countries are presented in Table 1. The results of the decomposition of these measures into relative efficiency changes and technical efficiency changes are presented in Tables 2 and 3 respectively.

Discussion

The estimates of MFP for the eight countries for the period 1961-86 show largest growth in MFP on average in Belize, Cuba, and Dominican Republic. These countries also had the largest variation in their MFP growth. Guyana and Jamaica had very little growth and Barbados, Suriname, and Trinidad and Tobago showed declining MFP on average. If these estimates of MFP change in the agricultural sectors are indicative of reality, the extremes would be defined by Barbados and Belize. At the end of the period, Barbados would be obtaining only 55 percent as much output per unit of inputs in 1986 as in 1961, and Belize would be receiving over 10 times (1008 percent) more outputs per unit of inputs in 1986 as in 1961. These results are for only one sector of the economy and hence provide only a very partial picture of how the countries are doing. However, the estimates would suggest that Belize has put itself in a much stronger position vis-à-vis international competitiveness and sustainability, and that Barbados seems to have de-emphasized the role of agricultural production in its economy.

Table 1
Estimates of Malmquist Indexes of MFP for Selected Caribbean Countries, 1961-86

Year	Barbados	Belize	Cuba	DomRep	Guyana	Jamaica	Suriname	Trinidad & Tobago
1961	0.325951	0.408829	0.665441	1.141082	0.999519	0.987591	1.034606	0.891889
1962	1.151494	0.911709	0.865520	1.134852	0.895578	0.994542	0.865483	1.043283
1963	0.828488	3.170429	1.019416	0.929082	1.082813	0.916774	0.968002	0.919865
1964	1.217515	0.451632	1.185601	0.807099	0.960990	1.090031	1.027944	0.917148
1965	0.894137	1.040679	0.745679	0.938136	1.058066	1.005481	1.064184	0.997301
1966	1.122072	0.903888	1.285291	0.947962	1.000832	1.073714	0.961416	1.064742
1967	0.846505	0.992844	0.927243	1.006381	0.958576	0.993893	0.981725	1.020123
1968	0.982929	0.854824	0.884486	0.927721	1.073877	0.896600	0.949330	0.978013
1969	1.096802	1.049279	1.591339	0.955749	0.982118	1.044678	0.918226	1.010750
1970	0.974471	2.261253	0.838632	0.937535	0.965636	1.057902	0.621645	0.919628
1971	0.881639	0.744175	0.968787	0.890206	0.761416	0.977965	0.858870	1.029044
1972	1.195826	0.675820	2.864976	2.809683	1.430130	1.385360	1.058466	0.826733
1973	0.714646	1.351724	0.341760	0.342982	0.762153	0.641536	0.973927	1.055398
1974	0.977215	0.946524	0.942499	1.069347	1.112189	1.051930	1.233524	1.123519
1975	1.088889	1.812935	1.049966	1.112391	1.110185	1.115435	0.921857	1.173121
1976	1.129377	1.738513	0.992554	1.194405	1.149409	0.973196	1.030820	1.007609
1977	0.845059	0.560731	1.108030	0.977645	0.924124	1.051761	1.055514	0.801659
1978	1.161018	0.937178	1.067811	0.885585	0.973449	0.994803	1.293012	1.018097
1979	1.026526	1.044028	0.468065	1.104820	1.299058	0.876943	1.266658	0.983448
1980	0.889319	1.006453	1.006485	0.959270	0.759852	0.925449	0.735851	0.929879
1981	0.857795	1.225893	1.080751	1.154483	1.127924	1.123724	1.003314	1.179045
1982	0.999017	0.795023	0.978798	1.125385	0.894812	1.001789	0.932367	0.780667
1983	1.107266	0.882309	1.085213	0.818677	0.825075	0.905548	1.072206	1.001018
1984	1.079702	0.811755	0.896101	0.930019	1.116794	1.146839	1.001410	0.970939
1985	1.070164	0.794906	0.954158	0.954565	0.738185	0.890109	0.947362	1.209616
1986	0.945739	1.042932	0.998504	0.955268	1.229523	0.890748	0.925364	0.960728
Avg.	0.977291	1.092933	1.031273	1.038859	1.007395	1.000552	0.988580	0.992818
St..D.	0.186373	0.588486	0.443823	0.397004	0.169933	0.130259	0.142776	0.107282

Table 2
Estimated Indexes of Relative Efficiency of Selected Caribbean Countries, 1961-86

Year	Barbados	Belize	Cuba	DomRep	Guyana	Jamaica	Suriname	Trinidad & Tobago
1961	1	0.432355	1	1	1.274101	1.259718	1	1
1962	1	0.906740	1	1	1.000259	1	1	1
1963	1	2.794551	1	1	1.187596	1	1	1
1964	1	0.613006	1	1	0.941908	1	1	1
1965	1	1.003864	1	1	1.160889	1	1	1
1966	1	0.854121	1	1	0.983426	1	1	1
1967	1	0.999201	1	1	0.978950	1	1	1
1968	1	0.870178	1	1	1.063148	1	1	1
1969	1	1.007551	1	1	0.797135	1	1	1
1970	1	2.171767	1	1	1.034315	1	0.700770	1
1971	1	0.977631	1	1	0.690448	1	0.883322	1
1972	1.661497	0.775331	8.851931	6.988233	2.589196	2.114717	1.316116	1
1973	0.601867	1.185155	0.112970	0.143098	0.492922	0.472877	0.936252	1
1974	1	0.749844	1	1	1.120217	1	1.128716	1
1975	1	1.484539	1	1	1.047158	1	0.825722	1
1976	1	1	1	1	1.148904	1	1.007261	1
1977	1	1	1	1	0.978662	1	1.289020	1
1978	1	0.916453	1	1	0.950311	1	1.083423	1
1979	1	0.879194	1	1	1.298303	1	1	1
1980	1	1.241095	1	1	0.847364	1	0.978135	1
1981	1	1	1	1	1.001010	1	1.022354	1
1982	1	1	1	1	0.938882	1	1	1
1983	1	1	1	1	0.862183	1	1	1
1984	1	0.993826	1	1	1.183544	1	1	1
1985	1	0.689867	1	1	0.762980	1	0.966646	1
1986	1	1.096719	1	1	1.252137	1	1.010692	1
Avg.	1.010129	1.063192	1.267881	1.197359	1.060998	1.032589	1.005709	1
St.D.	0.154068	0.472288	1.556584	1.192988	0.363241	0.249823	0.117641	0

Table 3
Estimated Indexes of Technical Efficiency of Selected Caribbean Countries, 1961-86

Year	Barbados	Belize	Cuba	DomRep	Guyana	Jamaica	Suriname	Trinidad & Tobago
1961	0.325951	0.945585	0.665441	1.141082	0.784489	0.783978	1.034606	0.891889
1962	1.151494	1.005480	0.865520	1.134852	0.895346	0.994542	0.865483	1.043283
1963	0.828488	1.134504	1.019416	0.929082	0.911769	0.916774	0.968002	0.919865
1964	1.217515	0.736750	1.185601	0.807099	1.020258	1.090031	1.027944	0.917148
1965	0.894137	1.036674	0.745679	0.938136	0.911428	1.005481	1.064184	0.997301
1966	1.122072	1.058267	1.285291	0.947962	1.017700	1.073714	0.961416	1.064742
1967	0.846505	0.993638	0.927243	1.006381	0.979188	0.993893	0.981725	1.020123
1968	0.982929	0.982356	0.884486	0.927721	1.010092	0.896600	0.949330	0.978013
1969	1.096802	1.041414	1.591339	0.955749	1.232060	1.044678	0.918226	1.010750
1970	0.974471	1.041204	0.838632	0.937535	0.933599	1.057902	0.887088	0.919628
1971	0.881639	0.761202	0.968787	0.890206	1.102786	0.977965	0.972318	1.029044
1972	0.719728	0.871654	0.323655	0.402059	0.552345	0.655104	0.804234	0.826733
1973	1.187382	1.140546	3.025239	2.396835	1.546194	1.356666	1.040240	1.055398
1974	0.977215	1.262294	0.942499	1.069347	0.992833	1.051930	1.092856	1.123519
1975	1.088889	1.221211	1.049966	1.112391	1.060188	1.115435	1.116425	1.173121
1976	1.129377	1.738513	0.992554	1.194405	1.000439	0.973196	1.023389	1.007609
1977	0.845059	0.560731	1.108030	0.977645	0.944273	1.051761	0.818850	0.801659
1978	1.161018	1.022614	1.067811	0.885585	1.024348	0.994803	1.193451	1.018097
1979	1.026526	1.187483	0.468065	1.104820	1.000581	0.876943	1.266658	0.983448
1980	0.889319	0.810940	1.006485	0.959270	0.896725	0.925449	0.752300	0.929879
1981	0.857795	1.225893	1.080751	1.154483	1.126785	1.123724	0.981376	1.179045
1982	0.999017	0.795023	0.978798	1.125385	0.953061	1.001789	0.932367	0.780667
1983	1.107266	0.882309	1.085213	0.818677	0.956960	0.905548	1.072206	1.001018
1984	1.079702	0.816797	0.896101	0.930019	0.943601	1.146839	1.001410	0.970939
1985	1.070164	1.152259	0.954158	0.954565	0.967503	0.890109	0.980051	1.209616
1986	0.945739	0.950956	0.998504	0.955268	0.981940	0.890748	0.915574	0.960728
Avg.	0.977161	1.014473	1.036741	1.025252	0.99025	0.992139	0.98545	0.992818
St.D.	0.185700	0.226295	0.471696	0.320315	0.165178	0.132403	0.114427	0.107282

The indexes across countries *for a given year* can be used to construct a production frontier to represent the reference technology which defines the set of possible outcomes that the countries have in that year. Figure 2 adapted from Färe et al (1994 b, p.74) provides a visual representation.

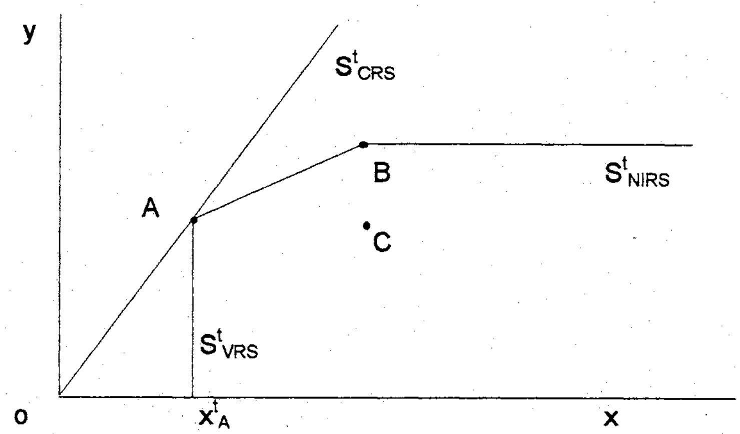

Figure 2: Construction of a Reference Technology S^t

Malmquist productivity indexes for every country in a particular year are based on their distance from the production frontier in that year. A country showing the greatest technical efficiency in a particular year will lie on the frontier and have an index of 1 in that year. If one graphed the frontier in each year, an upward shift in the frontier over the years represents technical change. Comparisons for each year from the estimates of the technical efficiency of the eight countries studied is given in Table 4. Belize set the technical efficiency frontier in eight of the 26 years; Cuba, four; Barbados, Guyana, and Trinidad and Tobago, three each; Dominican Republic and Suriname, two each; and Jamaica, one.

A Comparison with Törnqvist-Theil Estimates from Disaggregated Data

In this section, we compare the Malmquist estimates for Jamaica and Trinidad and Tobago with Törnqvist-Theil (T-T) indexes developed from disaggregated data. For these latter indexes, data are required on quantities of agricultural commodities produced and

Table 4
A Comparison of Technical Efficiencies in the Agricultural Economies of Eight Caribbean Countries by Years, 1961-86

Year	Barbados	Belize	Cuba	DomRep	Guyana	Jamaica	Suriname	Trinidad & Tobago
1961	0.285651	0.358282	0.583167	1	0.875940	0.865487	0.906689	0.781617
1962	1	0.791761	0.751649	0.985547	0.777753	0.863697	0.751617	0.906026
1963	0.261317	1	0.321539	0.293046	0.341535	0.289164	0.305322	0.290139
1964	1	0.370946	0.973788	0.662907	0.789304	0.895292	0.844297	0.753295
1965	0.840209	0.974149	0.700705	0.881554	0.856457	0.944838	1	0.937151
1966	0.873010	0.703255	1	0.737546	0.778681	0.835386	0.748014	0.828405
1967	0.829806	0.973259	0.908952	0.986528	0.939667	0.974287	0.962359	1
1968	0.915309	0.796017	0.823638	0.863899	1	0.834919	0.884021	0.910731
1969	0.689232	0.659368	1	0.600594	0.617165	0.656478	0.577015	0.635157
1970	0.430943	1	0.370870	0.414609	0.427036	0.467839	0.274912	0.406689
1971	0.856755	0.723171	0.941443	0.865080	0.739926	0.950362	0.834629	1
1972	0.825704	1	0.371311	0.461260	0.633675	0.751564	0.922653	0.948465
1973	0.725287	1	0.826227	0.737037	0.988657	0.752121	0.797627	0.809587
1974	0.774158	1	0.746656	0.847146	0.786531	0.833348	0.865770	0.890061
1975	0.600622	1	0.579153	0.613586	0.612369	0.615265	0.508489	0.647084
1976	0.649622	1	0.570921	0.687027	0.661145	0.559787	0.592932	0.579581
1977	0.762668	0.506061	1	0.882327	0.834024	0.949217	0.952604	0.723500
1978	0.897918	0.724803	0.825832	0.684901	0.752853	0.769369	1	0.787384
1979	0.790208	0.803681	0.360311	0.850478	1	0.675061	0.975059	0.757047
1980	0.883588	0.999968	1	0.953088	0.754956	0.919486	0.731109	0.923887
1981	0.699731	1	0.881604	0.941749	0.920083	0.916658	0.818435	0.961785
1982	0.887711	0.706445	0.869745	1	0.795116	0.890175	0.828487	0.693689
1983	1	0.796835	0.980083	0.739368	0.745146	0.817823	0.968336	0.904044
1984	0.941459	0.707820	0.781367	0.810941	0.973802	1	0.873191	0.846622
1985	0.884714	0.657156	0.788810	0.789147	0.610264	0.735861	0.783192	1
1986	0.769191	0.848241	0.812106	0.776942	1	0.724466	0.752620	0.781382

quantities of inputs used in producing the commodities, by years, along with their respective prices.[5] Assembling the data for these T-T estimates required four man-months of intensive effort and considerable travel cost so they are more demanding of research

[5] These Törnqvist-Theil indexes for the agricultural sectors of Jamaica and Trinidad and Tobago were developed as a component of a broader project entitled "Agriculture, Trade, and the Environment in the Caribbean Basin: Sustainable Development Imperatives" which is being carried out under an even broader umbrella provided by a cooperative agreement (CA) among the University of Florida (UF), The University of the West Indies (UWI), and The Caribbean Research and Development Institute (CARDI). Professors Langham, Carlton Davis and Carlisle Pemberton are leading this productivity work.

The estimated T-T and Malmquist indexes being compared for Jamaica and Trinidad and Tobago are presented in Table 5. The reader is cautioned to keep in mind that this comparison is a bit like comparing apples and oranges. The T-T estimates for a country show movements in productivity relative to a base year in that country. The base year was chosen as 1992 in both countries. In contrast, Malmquist estimates for any year are relative to that of the country, or countries, that define the production frontier in that year. Our chief interest in making the comparison of the empirical results was to see if the measures from the two approaches exhibited similar patterns of movement within each of the two countrys. If so, the Malmquist indexes may be of some use for productivity analysis in a particular country to support its policies in addition to using them to make comparisons across countries.

The averages rates of growth of the Malmquist indexes for Jamaica and Trinidad and Tobago were 0.00055 and -0.00718, respectively. The average rate of growth over the same years in our Törnqvist-Theil indexes were -0.01035 and -0.00485, respectively[6]. The results show essentially the same answer for Trinidad and Tobago. However, the Törnqvist-Theil estimates suggest that Jamaica looks stronger when compared to neighboring countries over time than it does when compared to its own history over time. Although the differences would not be statistically significant, the numbers suggest just the opposite is true in Trinidad and Tobago.

[6] The rate of growth in the T-T estimates was estimated by regressing the natural logarithm of MFP on time and adjusting the coefficient for discrete time.

Table 5
Tornqvist-Theil and Malmqvist Indexes of Multifactor Productivity for Jamaica and Trinidad and Tobago, 1960-90

	Tornqvist-Theil		Malmquist	
Year	Jamaica	Trinidad and Tobago	Jamaica	Trinidad and Tobago
1960	1.045	-----	-----	-----
1961	1.048	-----	0.988	0.892
1962	1.063	-----	0.995	1.043
1963	1.118	1.189	0.917	0.920
1964	1.152	1.152	1.090	0.917
1965	1.250	1.189	1.005	0.997
1966	1.383	1.110	1.074	1.065
1967	1.408	1.077	0.994	1.020
1968	1.319	1.200	0.897	0.978
1969	1.214	1.097	1.045	1.011
1970	1.263	1.226	1.058	0.920
1971	1.373	1.232	0.978	1.029
1972	1.392	1.390	1.385	0.827
1973	1.314	1.412	0.642	1.055
1974	1.152	1.330	1.052	1.124
1975	1.213	1.393	1.115	1.173
1976	1.189	1.384	0.973	1.008
1977	1.183	1.334	1.052	0.802
1978	1.187	1.218	0.995	1.018
1979	1.154	1.077	0.877	0.983
1980	0.990	1.071	0.925	0.930
1981	0.921	0.886	1.124	1.179
1982	0.854	1.157	1.002	0.781
1983	0.981	1.125	0.906	1.001
1984	1.084	1.147	1.147	0.971
1985	0.940	1.055	0.890	1.210
1986	1.004	1.030	0.891	0.961
1987	0.951	1.046		
1988	0.810	1.022		
1989	0.885	1.011		
1990	1.000	1.000		
Avg. growth rate, 1961-86	-0.01035	-0.00485	0.00055	-0.00718

Concluding Remarks

We argued in the introduction that the most successful way for a region to increase its economic rents to support its 'competitiveness', which we prefer to call its economic development, was to increase its output per unit of the inputs it uses -- its productivity. Research on changes in productivity indicates that this is a long term investment process, largely in human capital, in the forms of the education of farmers and agribusiness leaders, and agricultural research and extension support. Large investments in physical infrastructure are also needed. Research in Florida by Langham, Tangka, and Roberts suggests that increased specialization and larger scale of enterprises also occurs along with increased productivity. Each of the ways to improve productivity suggest a move toward a more science based agricultural system with modern management.

There is no free lunch and the investments are only a part of the costs of increasing productivity. The human adjustment costs are paramount simply because a modern science-based agricultural system cannot support large numbers of workers at acceptable wages and hence these human adjustment costs will fall most heavily on the poorest in the countryside.

These human adjustment costs are not easy to absorb economically or politically, and they often lead to policies that aggravate the situation by decreasing productivity. For example, Sub-Saharan Africa has taxed agriculture heavily through government parastatals and over-valued currencies mainly it seems to attempt to avoid the human problems of adjustment away from a system of semi-subsistent farms. The policies have been to the relative benefit of urban elites and productivity in the agricultural sectors has declined to the point where this agriculturally-based continent is a net food importer.[7]

We enjoy the benefits as consumers of a reasonably well-developed international market for food that is supplying our daily bread at reasonable prices. Even so the number of poor who spend 40 percent or more of their incomes on food continues to increase, and within the next decade and for the first time, more of these poor will live in urban rather than in rural areas. With this growing world population increasingly living in congested areas in dire need of low-cost nutritious food, a focus on trade and 'competitiveness' is essential for stable real food prices and will require policies sensitive to what is happening with productivity in the agricultural sectors of all our economies.

[7] A study by Langham and Kamajou (Chapter 12) Cameroon found that Arabica coffee growers were being taxed at an implicit rate of nearly 76 percent of the farmers' economic rents, and this rate did not include the implicit tax in the Country's overvalued exchange rate which at the time was equivalent to at least another 6 percent tax. Rather than lowering these taxes and letting more rents pass through to the growers, the policy responses to the farmers' loss of interest in coffee production was a law to make it illegal for farmers to remove coffee trees and a program of diversification to find profitable alternatives to Arabica. The farmers' response was not to take care of the coffee trees and to do more subsistence farming.

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