RELATIVE PRICES AND THE INTERNATIONAL COMPARISON OF REAL AGRICULTURAL OUTPUT AND PRODUCTIVITY

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Abstract

This article reviews the different methods of constructing multilateral output and productivity indices for agriculture in cross-country panel studies. We show that various multilateral output indices used by different researchers can have considerable disparities, thus rendering the comparison of the final results problematic. The production indices produced by the Food and Agricultural Organization of the United Nations (FAO) are increasingly used by researchers as a unique source of data for cross-country panel studies. The paper examines the properties of the FAO index, and finds them deficient in paying attention to the problem of loss of characteristicity in a highly heterogeneous panel. It is shown that the FAO production indices lead to unacceptably large deviations from domestically based production indices in the case of low-income countries. It is argued further that the use of the FAO production index can lead to spurious results in econometric studies of the links between productivity growth, per capita income, and price levels.

1. Introduction

The use of large cross-country panel data in research on agricultural productivity in developing countries has proliferated in the past two decades. The internationally comparable real output and productivity measures used in this literature have had various sources. The first important source of data has been the wheat equivalent output measures by Hayami and Ruttan (1985), or new estimates based on Hayami and Ruttan methodology (see, e.g., Kawagoe, et.al, 1985, Kawagoe and Hayami, 1985, Block, 1994, and Lau and Yotopoulos, 1989). A second measure of real agricultural output used in this literature has been based on the conversion of national real output measures by official exchange rates or PPP exchange rates provided in Penn World Tables (see, e.g., Antle, 1983, Shuh and Norton, 1991). Others have used their own data series on internationally comparable output, which do not seem to be in public domain or in publication with wide circulation (see, e.g., Binswanger, *et.al*, 1987). In recent years the real output measures produced by FAO have been increasingly used in cross-country studies (see, e.g., Fulgeniti *et.al*, 1993, 1997, and Craig, Pardey and Roseboom, 1991). In these studies, hardly any serious discussion of the comparative properties of the different real output measures has been conducted.

This poses serious questions, not only with regard to the comparability of the results of the different studies on agricultural productivity, but also with regard to the accuracy of the results of each study *per se*. For example, it is not clear to what extent the results of the study by Lau and Yotopoulos (1989), which they claim to be 'strikingly different from those of Kawagoe, Hayami and Ruttan', are due to their different treatment of data, and to what extent are they due to the use of better econometric techniques as they claim.[1] In order to avoid sterile controversies and for the work of various researchers to generate complementary and cumulative generation of knowledge, it is important that at least matters related to data are sorted out first. In this paper we compare the properties of the various estimates of agricultural output and productivity, and investigate some of the implications of the use of different output measures for the results of international productivity growth comparison. In particular we would consider the properties of the FAO output index, which is increasingly used by researchers in cross-country productivity analysis. We show that some of the findings of econometric work on the determinants of productivity, e.g., the role of prices in productivity growth or the link between the stage of development and productivity growth, is likely to be the result of data construction rather than genuine economic relationships.

In the next section we start by discussing some of the methodological issues involved in measuring internationally comparable real agricultural output. In Section 3 we make a comparison of empirical results using different conversion factors in the measurement of real agricultural output. This section also makes a comparison of relative agricultural prices across the different countries and brings into clear relief the degree of agricultural protection in various industrialized countries. Section 4 makes a comparison between agricultural output measures using purchasing power parity exchange rates and those obtained by using Hayami and Ruttan methodology. Section 5 provides a critique of the FAO methodology in constructing production indices, and examines the likely effects of using FAO indices in some of the recent cross-country econometric studies of agricultural productivity. Concluding remarks are presented in Section 6.

2. Some Methodological Issues

One of the earliest studies of internationally comparable real agricultural output for a large set of countries is the work by Hayami and Ruttan (1985), which provides wheat equivalent output measures for 43 countries in 1971 base year prices. International wheat equivalent prices are measured for 71 items by a simple geometric average of relative prices in India, Japan and the United States. The international wheat equivalent prices are then used as weights to aggregate real output in different countries to arrive at comparable wheat equivalent measures of real output. The same price

[1] An important difference in the treatment of data between the two studies is that while Hayami and Ruttan (1985) adjust their output data to remedy for the inclusion of forestry and fishing in the employment data, Lau and Yotopoulos (1989) do not make such an adjustment. This points to another source of problems ignored by cross-country studies, namely, that while the real output measures used in most of these studies refer to agriculture, the available employment data for most countries refers to agriculture plus forestry and fishing.

weights are used by Block (1994), which measure wheat equivalent output estimates for African countries following the same methodology as Hayami and Ruttan. As pointed out by Hayami and Ruttan (1985, p.449), their choice of the three countries for calculating price weights has been dictated more by the availability of data rather than on theoretical grounds. The choice is further justified by pointing out that by representing countries in three stages of development, it provides a fair representation of international average weights given the data constraints.

The main problem with the Hayami and Ruttan methodology, however, is not the number or choice of countries in measuring the international price weights. There are more fundamental problems arising from their choice of the numeraire in calculating the wheat equivalent measure of output. To see these problems more clearly, let us replicate Hayami and Ruttan's method by assuming that data for agricultural prices and quantities for all individual items in all the countries exist. If we denote the price of item i in country c by p_{ci}, and the respective quantity by q_{ci}, then a general version of Hayami and Ruttan method would measure international price weights, P_i, as a weighted average of individual country relative prices for n countries and m commodities as:

$$p_i = \prod_{c=1}^{n} \left(\frac{p_{c,i}}{p_{c,1}} \right)^{w_{c,i}} \quad ; \quad w_{c,i} = \frac{q_{c,i}}{\sum_{i=1,m} q_{c,i}} \qquad \text{(Eq.1)}$$

Or in terms of weighted arithmetic means as:

$$p_i = \sum_{c=1}^{n} \frac{p_{c,i}}{p_{c,1}} w_{c,i} \quad ; \quad w_{c,i} = \frac{q_{c,i}}{\sum_{i=1,m} q_{c,i}} \qquad \text{(Eq.2)}$$

Where $P_{c,1}$ is the price of wheat in country c. This is a general version of Hayami and Ruttan formula in the sense that if we set w_{ci} equal to 1/3 for India, Japan, and the United States, and 0 for other countries we arrive at international price weights as calculated by them. Using these international price weights one can measure wheat equivalent output for individual countries as:

$$Q_c = \sum_{i=1,m} P_i q_{c,i} \qquad c = 1, n$$

Of course, in order to prevent double counting, the value of seed and feed and other agricultural intermediate products used in the sector itself should be subtracted from this output measure. The main problem with this index of real output is that it is sensitive to the choice of the base commodity. In other words, if we change the base commodity from wheat to another commodity, say maize, the maize equivalent outputs would differ from the wheat equivalent measure not only in terms of scale (which is expected), but also in terms of the relative distance between the countries. Such a change in the base commodity can even affect the ranking of country outputs. Denoting the wheat and maize relative price weights by P_i and P^*_i, the condition for the neutrality of the base commodity can be written as:

$$\frac{\sum_i P_i q_{ki}}{\sum_i P^*_i q_{ki}} = \frac{\sum_i P_i q_{li}}{\sum_i P^*_i q_{li}} \qquad \text{(Eq.3)}$$

for any two countries k and *l*. This condition would only hold in general if P^*_i is a scaler product of P_i for all commodities; a condition which is clearly not satisfied by the Hayami and Ruttan method, even in its general form depicted above. Different commodity bases therefore give rise to different indices in this method, and the use of any particular base commodity would in effect imply the use of that commodity's purchasing power parity exchange rate in converting domestic currency prices into internationally comparable price indices.[2] Thus, contrary to what is sometimes asserted, the measurement of wheat equivalent output indices does not dispense with the need to use some kind of exchange rate conversion factor.[3]

Considering that there are over 150 agricultural commodities, each with its own purchasing power parity exchange rate, the wheat equivalent indices

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[2] The PPP exchange rates in this sense are measured in terms of international commodity (e.g., wheat) equivalent units rather than any particular currency units.

[3] See for example, Block (1994, p.620) where he claims that, 'Aggregation into wheat units provides the best practical approach to creating a physical output aggregate free of the above problems [associated with exchange rate conversions]'.

suggested by Haymi and Ruttan can only be legitimately considered as preferred indices, compared to other commodity bases, if we assume that relative wheat prices, in some sense, reflect the purchasing power parity exchange rates of the agricultural sector in general across different countries. Such an assumption is obviously implausible. The next question, therefore, is the aggregation method whereby agricultural PPP exchange rates can be constructed on the basis of individual commodity PPP rates, in such a way that each commodity receives an appropriate weighting reflecting its importance in the aggregate output of the country concerned. For the real output index to be neutral to the commodity base one needs to first convert domestic prices into comparable international prices at such agricultural purchasing power parity exchange rates. This would allow the measurement of internationally comparable real outputs, either in terms of a base country currency or in terms of a base commodity unit. In either case, the resulting index would be neutral to the choice of base commodity or currency, apart from a scale factor, which results from the change of the numeraire.

A number of methods have been suggested in the literature for the aggregation of individual commodity purchasing power parity exchange rates.[4] In order for our estimates to be compatible with the GDP-PPP exchange rate estimates in the International Comparison Project (ICP), and also with the FAO method, we have adopted the Geary-Khamis methodology as described in Kravis, Heston, and Summers (1975, 1982).[5] This would allow a comparison of the agricultural ppp exchange rates with the GDP purchasing power parity measures as reported in the Penn World Tables. Denoting the agricultural ppp exchange rate for country c as PPP_c, we can use Equation 2 above to measure international average prices as:

[4] For a review of the different methods see, Kravis et.al, 1975, ch.5, pp.54-80, and FAO (1993).

[5] The FAO (1993) publication was brought to my attention after our measurements were completed. The agricultural purchasing power parity exchange rates estimated here are however in conformity with the FAO results.

$$\pi_i = \sum_{c=1}^{n} \frac{p_{c,i}}{ppp_c} w_{c,i} \quad ; \quad w_{c,i} = \frac{q_{c,i}}{\sum_{i=1,m} q_{c,i}} \qquad i = 1, m \quad \text{(Eq.4)}$$

Taking US dollar as the numeraire, the agricultural PPP exchange rate for country c can be defined as:

$$ppp_c = \frac{\sum_{i=1,m} P_{ci} q_{ci}}{\sum_{i=1,m} \pi_i q_{ci}} \qquad c = 1, n \qquad \text{(Eq.5)}$$

where π_i is the international price of agricultural commodity i, and p and q represent the domestic currency price and the output of that commodity. International prices are in US dollars and ppp is measured in domestic currency units per US dollars.

The Geary-Khamis method, used for the measurement of PPP exchange rates in the International Comparison project (ICP) by Kravis, et.al, consists of a simultaneous estimation of n-1 PPP exchange rates (The US exchange rate is used as numeraire) and m international commodity prices, by solving the m+n-1 linearly independent simultaneous equation system in Eq.4 and Eq.5 above. International prices can then be used to calculate comparable real output measures for individual countries in 1980 US dollar prices, or in terms of a commodity numeraire, e.g., wheat or maize equivalent units. With this method, the choice of commodity or currency base does not affect the relative position of real output indices for different countries.

A useful property of Geary-Khamis system is that the real output index measured at international prices is equivalent to deflating the domestic currency value of output by agricultural PPP index rates. In other words for any two countries, k and l, the following identity always holds:

$$\frac{\sum_i \pi_i q_{ki}}{\sum_i \pi_i q_{li}} = \frac{ppp_l \sum_i P_{ki} q_{ki}}{ppp_k \sum_i P_{li} q_{li}} \qquad \text{(Eq.6)}$$

This means that, once agricultural PPP exchange rates are calculated, comparable real output measures can be also obtained by deflating domestic currency measures of agricultural output by the PPP exchange rates. As we noted above, this method has been adopted by various authors, using as deflators either the official exchange rates or GDP purchasing power parity rates. However, to the extent that the value of these other notions of exchange rate diverges from the agricultural PPP exchange rate, the resulting index would be biased. A comparison of these different exchange rates is made in the next section.

3. Agricultural Purchasing Power Parity Exchange Rates

We have used the quantity and price data provided in the FAO databank to measure the agricultural PPP exchange rates for the years 1970, 1980 and 1990. In each year, price and quantity data on 185 agricultural commodities for 123 countries have been used to measure average world commodity prices and country PPP exchange rates on the basis of equations 4 and 5 above, which in this context form a system of 308 simultaneous equations. A more detailed discussion of the data and the international price and output estimates is provided in the following sections. In this section we shall examine the relationship between the estimated agricultural PPP exchange rates, the official exchange rates, and the PPP exchange rates based on GDP aggregates.

The estimated agricultural PPP exchange rates, along with the official exchange rates and the GDP PPP exchange rates for 1980 are shown in Appendix, Table A1. Exchange rates are expressed in terms of domestic currency per US dollar. Countries are listed in alphabetical order in the Table. Given the large number of countries, we have tried to highlight some of the systematic relationships between the three exchange rates with the help of graphs with countries ranked according to their per capita GDP levels. Figure 1 shows the exchange rate deviation index for the PPP exchange rates for agriculture and GDP aggregates, plotted against an index of real per capita GDP for the years 1970, 1980, and 1990. Exchange rate deviation index is defined as in Kravis *et.al*, (1982) as the ratio of output measured in one exchange rate (GDP PPP rate in this case) to the value of output measured in another exchange rate (agricultural PPP rate in this case).[6] Per capita GDP is in current international dollars, and the source of the data, as with the GDP PPP rate, is the Penn World Tables.

As can be seen from Figure 1, the deviation index between the two PPP exchange rates shows a wide dispersion across countries, with a clear negative relationship between the deviation indices and per capita incomes in all the three years. The negative relationship between the deviation index and per capita GDP is not an unexpected phenomenon, as an important component of the GDP-PPP exchange rate consists of services which are relatively cheaper in low wage / low income countries. The conversion of agricultural output at GDP-PPP rate would therefore lead to a serious overestimation for poor countries relative to rich ones. The high degree of dispersion of the deviation index around the negative trend lines suggests that even for countries within a narrow range of per capita income, the GDP-PPP exchange rates are not appropriate conversion factors for the agricultural output.

We next examine the relationship between the agricultural PPP exchange rates and the official exchange rates. Figure 2 shows the exchange rate deviation index for these two rates (that is, the value of agricultural output converted at official exchange rate over output converted at the agricultural PPP exchange rate) against per capita income for the years, 1970, 1980 and 1990. As can be seen the dispersion of the deviation index for official exchange rate in all the three years is much less than the index for the GDP-PPP rate shown in Figure 1. This is particularly the case for the low-income countries, where the official exchange rate deviation indices cluster around 1 in all the three years. It appears, therefore, that for low-income countries the official exchange rates are more appropriate conversion factors than the GDP-PPP rates, while for more industrialized countries the GDP-PPP exchange rates are closer approximations to the true agricultural purchasing power parity rates. Another notable aspect of behavior of the exchange rate deviation index in Figure 2, is the positive relationship between this index

[6] Note that domestic currency output is divided by the exchange rates as defined here to arrive at the value of output measured in international dollars. The exchange rate deviation index is hence equal to the reciprocal of the ratio of the two exchange rates, with the index for the US set equal to 1.

and per capita income, as shown by the upward sloping trend lines shown in the Figure. These upward trends are in fact totally due to the relatively high deviation indices in Europe and Japan. As can be seen from Figures 3 and 4, once we drop Japan and Europe from the sample, the upward trend between the exchange rate deviation index and per capita GDP vanishes. In the case of Japan and the European economies, under the conditions of free currency convertibility and relatively low restrictions on trade in non-agricultural commodities, such high exchange rate deviation indices clearly reflect the high degree of protection of the agricultural sector. As can be seen from Table 1, the exchange rate deviation index in the case of Japan in 1990 was 4.27, and in European countries varied between 1.5 and 3. As the Table also shows, the degree of protection of the agricultural sector in Japan and in all the European countries, as indicated by their exchange rate deviation indices seems to have been increasing relative to the US agriculture during the 1970-90 period.

Despite the fact that the exchange rate deviation indices for the developing countries suggest that the official exchange rates are better conversion factors for agricultural output than the GDP-PPP rates, the error involved in using official exchange rates is still considerable, as a quick glance at Table 1 would indicate. For example, measured at the official exchange rates, agricultural output in Saudi Arabia would be more than three times higher, and in Pakistan about 50 per cent lower, than when measured at the agricultural PPP exchange rates. This clearly vindicates the considerable effort made in the literature to devise internationally comparable output measures that are not based on official exchange rates. In the next section we shall compare the properties of wheat equivalent and purchasing power parity based measures of agricultural output.

4. Wheat Equivalent and Purchasing Power Parity Based Output Measures

The solution of the equation systems 4 and 5, in addition to providing estimates of agricultural PPP exchange rates, also provides us with average world prices for various primary agricultural commodities which can be used as price weights for measuring real country outputs at international prices. Table A2 in the Appendix reports the estimated international prices

for crops and livestock products, both in dollars and in international wheat equivalent units, for 1980.[7] All the data on quantities and producer prices are based on the FAO database. Livestock products do not include additions to the stock of animals, and as can be seen from the list in Table A2, they refer to the final products of animal husbandry.

A large part of agricultural output in most countries is used as intermediate input in agriculture itself. In order to avoid double counting, such intermediate input is subtracted from gross output to arrive at net agricultural output. One issue to be addressed is whether the quantities used in the systems of equations 4 and 5 should be net or gross output quantities. Gross outputs are arguably better weights in calculating world average prices. Consider a country which is a major producer of grains, but a large part of its grain output is used as intermediate input in animal husbandry. The use of net output in measuring world average prices can give a much lower weight to such a country, as compared to another country that is a smaller grain producer but its grain output is sold to other sectors or is exported. For this reason we have used gross output weights in calculating world average prices.

The estimated international prices are used to calculate internationally comparable output measures for different countries at world prices. The output estimates for the year 1980 are shown in million US dollars in Table A1. The Table also reports wheat equivalent output measures at world prices. These are similar to the measures reported in the Table at US dollars, with the difference that the numeraire instead of US dollar is the international price of wheat. In order to compare these with the wheat equivalent measures estimated along the lines of Hayami and Ruttan, the Table also reports wheat equivalent measures using a variant of Hayami and Ruttan's method. These are referred to in the Table as weighted average wheat equivalent measures, and are estimated on the basis of equation 2 above. As can be seen, the differences between these two measures for

[7] For brevity the prices are shown in Table A2 for only 95 products out of 185 commodities used in the estimates of real output (66 crops out of 157 and 28 livestock products). The 66 crops reported in the Table constitute more than 95 per cent of total world output, but the livestock list is exhaustive.

some countries are quite large. To examine whether the error involved shows any systematic patterns, we have plotted the ratio of the two output measures against per capita GDP in Figure 5. As can be seen, the Hayami and Ruttan method systematically over-estimates agricultural output for high income countries. Even for the least developed countries the range of discrepancy between the two measures can be as much as 30 per cent.

5. Characteristicity and the FAO Production Index

The real output measures based on the agricultural PPP exchange rates discussed in the previous section have various desirable properties as well as certain shortcomings. Most of the desirable properties of index numbers are based on criteria discussed in the 1920s literature (see, e.g., Fisher, 1927). The properties of the Geary-Khamis method in constructing multilateral index numbers have been discussed extensively in relation to GDP comparisons in the ICP literature (see, e.g., Kravis *et.al*, 1975, 1978 and 1982). As discussed above, for example, the Geary-Khamis procedure for calculating agricultural output index numbers has the advantage over the Hayami-Ruttan method of being neutral to the commodity base or country base adopted. In addition the Geary-Khamis method also clearly fulfills the transitivity criterion, or what is known as Fisher's circular test.[8] This method also fulfills the 'additive consistency' test discussed in Kravis, *et.al*, (1975, p.54), in the sense that the aggregate agricultural production index is equal to the sum of the indices for sub-categories of agricultural output.

The Geary-Khamis method, however, has an important shortcoming in that the price vector used in calculating multilateral agricultural output indices can substantially deviate from domestic relative prices for some countries. This is, of course, to some extent the inevitable price one has to pay in order to achieve country base neutrality and transitivity. Even in binary comparisons between two countries the price weights used to measure

[8] Transitivity or circularity test basically means that multilateral price or quantity indices should be such that pairwise comparisons of any group of countries (say country j, k, and l) should be such that $I_{j/k} = I_{j/l} \div I_{k/l}$. This clearly holds for the Geary-Khamis method used above, where the same price vector is used in weighting quantities for individual countries.

quantity indices would be different from individual country relative prices, if one is to achieve country base neutrality. However, in such binary comparisons it is plausible that the price weight adopted should be optimal for the two countries, in the sense that it should be as close as possible to the relative prices in both countries. Dreschler (1973) has referred to this criterion as 'characteristicity'. The problem of lack of characteristicity becomes compounded in multilateral comparisons when one also needs to preserve the circularity or transitivity condition. Even when binary comparisons between country pairs conform to the characteristicity criterion, the construction of multilateral indices that obey transitivity would inevitably lead to a deviation from the optimal binary indices. The practical approach adopted in the literature to resolve this problem has been to suggest multilateral indices that attain transitivity while having least distance from a set of bilateral indices that are deemed appropriate for binary comparisons between country pairs.[9]

Caves, Christensen and Diewert (1982) have criticized the use of Geary-Khamis method in the international comparison project by Kravis *et.al*, both on the grounds of lack of characteristicity, as well as lack of adequate theoretical foundations. They propose a 'superlative' multilateral index number based on Tornqvist-Theil index.[10] The multilateral translog index number proposed by Caves, *et.al* (1982) is transitive and has least distance from a set of bilateral Tornqvist-Theil indices. They advocate the use of the new multilateral index, not only in multi-country cross-section comparisons, but also in panel data of the type used in agricultural productivity literature discussed above. There are, however, a number of

[9] Dreschler (1973) for example discusses the EKS method (proposed by Hungarian and Polish statisticians Elteo, Koves and Szule), producing multilateral indices which are transitive and their deviation from a set of Fisher Ideal bilateral indices is minimized.

[10] The term 'superlative' is due to Diewert (1976), and is defined as an index number which is consistent with a 'flexible' aggregator function. A flexible aggregator function is defined as one that can provide a second order approximation to an arbitrary twice differentiable linearly homogeneous function. For example, Tornqvist-Theil binary index number is consistent with the translog aggregator function, which is a flexible function.

reasons to suggest that the use of the proposed index in constructing multilateral panel data series may be problematic. The first reason, as indicated by Caves and associates themselves, is that with the passage of time and the availability of new observations the entire historical data series in the panel will have to be continuously updated, which creates problems for historical comparisons. The second reason, more closely related to the literature on panel studies of agricultural productivity, is that the input data used in such studies is usually in physical units such as horsepower for tractors, labor hours, and tons of fertilizers and other inputs. Unless a similar method of multilateral index number construction is used on the input side as well, the adoption of the proposed method by Caves and associates only on the output side introduces distortions in the time-series behavior of productivity in panel studies. Finally, though the proposed method is an improvement on other methods in taking account of the problem of loss of characteristicity, the price weights used in measuring quantity indices can in some cases still substantially diverge from individual country weights. This would be particularly the case for developing countries that carry a small weight in multilateral index construction and where relative prices are likely to substantially diverge from international prices. The application of the proposed method to the panel data is likely to introduce serious distortions to the growth rates in the case of such countries. Under these circumstances, it is perhaps more appropriate to apply the proposed multilateral translog index, or the Geary-Khamis index, to the cross section of countries in some base year, and extrapolate the time series component of the panel data on the basis of index numbers measured at domestic prices.[11]

The problem of loss of characteristicity in panel data assumes two dimensions – one is the spatial dimension arising from the attempt to attain comparable index numbers across heterogeneous units, and the other arising from changing relative price structures over time. Given the considerable relative price differences in the agricultural sectors between developing and

[11] The results would of course vary depending on the base year adopted. But such variation would be confined only to individual country effects that can be picked up by individual country dummies in panel analysis, without distorting the time series properties of the data.

industrialized countries, whatever method is adopted in dealing with cross-country comparisons at a point in time, it is advisable to measure the growth component of the panel data at domestic prices. It may be argued that given price 'distortions' in individual developing countries, the use of international price weights in measuring output indices might be a better option than the use of domestic price weights. However, as we observed in Section 3, the most prominent examples of price distortions at the international level arose from protective policies of industrialized countries. As these countries exert a substantial weight in the measurement of international prices, the price distortion argument in fact strengthens the case for the use of domestic prices in the measurement of output indices.

The agricultural production index published by the FAO provides an example of the degree to which country heterogeneity can distort the time series component of panel data. The FAO production index, which provides data for some 170 countries covering the period from 1963 to the present, is available in FAO data bank (AGROSTAT) and is increasingly used by researchers in panel studies of agricultural productivity. The agricultural production indices for individual countries are measured by using international base year prices calculated by Geary-Khamis method. The question here is not the use of the Geary-Khamis method as such, but the use of international prices for time series index number construction in a highly heterogeneous panel, no matter what the method of derivation of international prices is. We may refer to this as loss of characteristicity in the time series component of panel data, due to the use of international price weights in a highly heterogeneous sample.[12] Since the FAO data is published in index form we shall concentrate on the loss of characteristicity on the growth component, or the time series component, resulting from the use of world prices in measuring the index. For this purpose we have compared the FAO index with two alternative indices that by definition satisfy the condition of characteristicity more closely than the FAO index.

[12] There is of course also the loss of characteristicity in the time series component due to the changing relative prices over time, with which we are not concerned here.

The first index is measured in the same way as the FAO production index, using Geary-Khamis method, but with the difference that instead of using base year international prices we have used base year regional prices. For this purpose countries have been grouped into five regions, namely, the Industrial Block, the Centrally Planned, and developing countries in Asia, Latin America and Sub-Saharan Africa. Relative prices in the base year for countries in each region are measured by applying the Geary-Khamis method discussed in the previous section to the group of countries in that region only. Considering that the weight of industrial countries overshadows many smaller developing countries whose economic structures and relative prices are likely to sharply diverge from the former group, this method clearly satisfies the characteristicity condition more closely than the FAO method, particularly in the case of developing countries. Of course, with this method, individual country outputs across different regions are not comparable, but since here we are only interested in the time series or growth component of the production indices, this should not pose a problem. The results of this regionally based method are shown in Figure 6, relative to the FAO production index.

Figure 6a shows the regional based production index relative to the FAO index in 1990, with both indices having a base value of 100 in 1970. Figures 6b and 6c depict the same relative index for the 1970s and the 1980s decades respectively. As can be seen, the two indices show relatively similar growth performance for the industrialized countries, but they considerably diverge in the case of developing countries. The dispersion of the relative growth rates between the two indices increases as we move towards lower per capita income countries, but in general the FAO index seems to underestimate the growth of agricultural output in least developed countries – in some countries by up to 20 per cent during the 1970-90 period. During the 1970s and the 1980s sub-periods the dispersion of relative growth rates of the two indices is less pronounced than the entire 1970-90 period, but the same relationship between per capita income and output deviations is exhibited (Figures 6b and 6c).

The second output index that we have compared with the FAO index is measured by using domestic base year prices rather than international prices. Similar to the above exercise, we have plotted the domestic based

index relative to the FAO index in Figures 7a, 7b, and 7c. Figure 7a shows the ratio of the domestic based index to the FAO index in 1990, both having 1970 as the base year, against per capita income. Figures 7b and 7c depict the same indicators for two sub-period of the 1970s and the 1980s decades respectively. As expected, the deviation of the domestic based index from the FAO index is much larger than the deviation between the regional based and FAO index shown in Figure 6. The deviation of the FAO index from the domestic based index, even in the case of high-income countries, is noticeable, though as in the regional based index, the dispersion of points declines with the level of per capita income. Although in the case of a large number of developing countries the FAO index seems to overestimate growth, in general there seems to be a tendency towards underestimation of output growth for the lower income countries. What is particularly a cause of concern, however, is the relatively high deviation of growth rates between the FAO index and the domestically based index in the case of developing countries. During the 1970-90 period, for example, the deviation between the two indices was as large as 40 percentage points between the two countries that showed the largest negative and positive deviations (Figure 7a).

The systematic relation between FAO production index deviation and per capita GDP, shown in Figure 7, can have important ramifications for empirical results of modeling agricultural productivity using FAO production indices. For instance, this phenomenon, combined with our earlier finding in Section 3 that agricultural relative prices vary systematically with per capita income, may create a spurious correlation between productivity growth and price levels. One example is the work by Fugeniti and Perrin (1993, 1997), who find that there is a systematic positive correlation between the level of agricultural price protection and productivity growth for a selected number of developing countries, using FAO production index for their econometric modeling of agricultural productivity. The question that arises is to what extent this result is due to the underestimation of output growth in low income (low relative price) countries by FAO index, and to what extent it reflects a genuine relationship between the two variables. To investigate this, we have plotted the estimates of price protection used by Fulginiti and Perrin against the FAO production index deviation for their sample countries in Figure 8. As can be seen, there is a clear negative relationship between the FAO production index deviation and the rate of price protection. The underestimation of the output growth in low-income countries by the FAO index is thus likely to have exerted an important influence on the results of Fulginit and Perrin studies. It is not clear whether such results would be maintained with more appropriate production indices that obey the characteristicity condition more closely.

6. Concluding Remarks

The recent literature, using large cross-country panel data in the study of agricultural productivity, has paid much attention to perfecting the econometric techniques for dealing with large panel data with a long time series component. The treatment of the data on agricultural output and productivity, however, has been less satisfactory. As shown in this paper, the various multilateral output indices that have been used by different researchers can have considerable discrepancies, rendering the comparison of the final results problematic. With the availability of the FAO electronic data set, it is likely that future researchers would increasingly use the FAO data, which is a considerable improvement over past practice as it ends the problem of data incompatibility and the diversity of sources and methods. However as we have argued in this paper the, FAO production indices considerably diverge from domestic based indices in the case of developing countries. The main problem is not the use of Geary-Khamis method by the FAO in calculating comparable cross-country output indices. For the sake of comparability with the ICP project, it may be desirable for the FAO to adopt the Geary-Khamis method. However, the FAO's use of international prices in calculating the time series component of agricultural output is extremely problematic. As we have argued, this can lead to misleading results with respect to the links between productivity growth and the level of development, the level of prices and possibly other variables.

A further problem with the cross-country agricultural productivity indices, as pointed out in the introduction, is the differential treatment of the sectoral coverage of labor force and output. The available data on labor force for most countries, at least until very recently, has included employment in fishery and forestry, while output sources exclusively cover crops and

animal husbandry. The available disaggregated output series for fishery and forestry in the FAO data set can allow the construction of multilateral output indices for these sectors.[13] Such an attempt would be worthwhile in at least giving some indication of the relative magnitude of the error involved in excluding the fishery and forestry output when comparing agricultural labor productivity across different countries.

[13] The main problem appears to be the lack of price data for fishery and forestry products. The United States price weights, or unit values of international trade data available in the FAO data set can be possible sources of relative prices.

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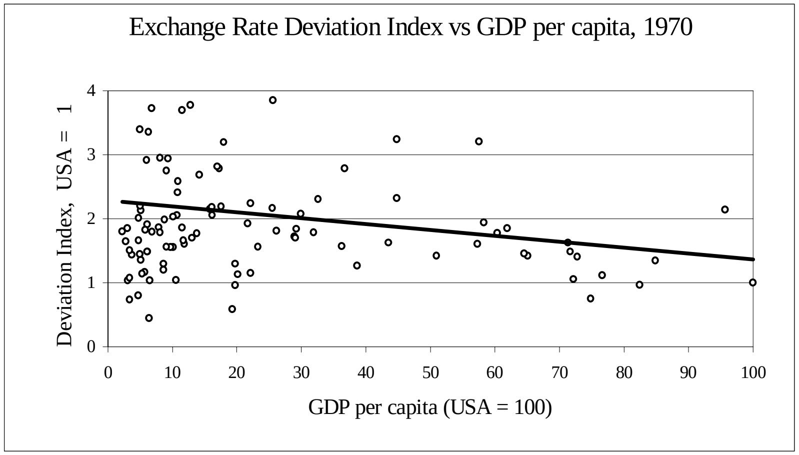
Figure 1: Exchange Rate Deviation Index of Agricultural PPP and GDP PPP Rates, in Relation to per capita GDP, 1970, 1980 and 1990



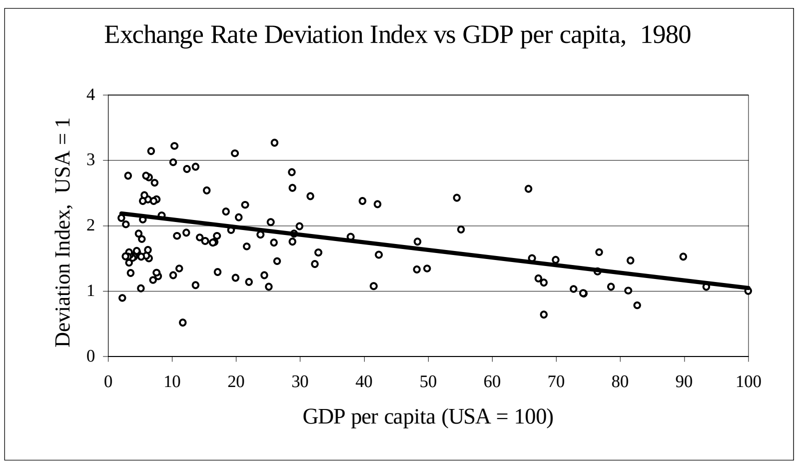


Figure 1: cont'd

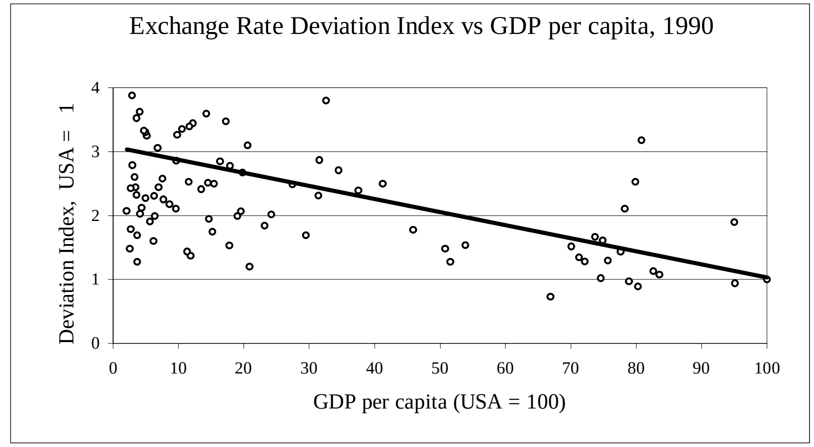
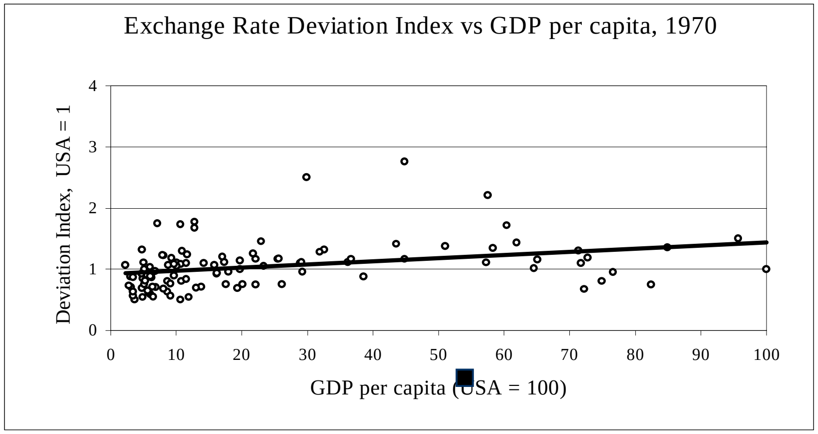


Figure 2: Exchange Rate Deviation Index of Agricultural PPP and the Official Rates, in Relation to per capita GDP, 1970, 1980 and 1990



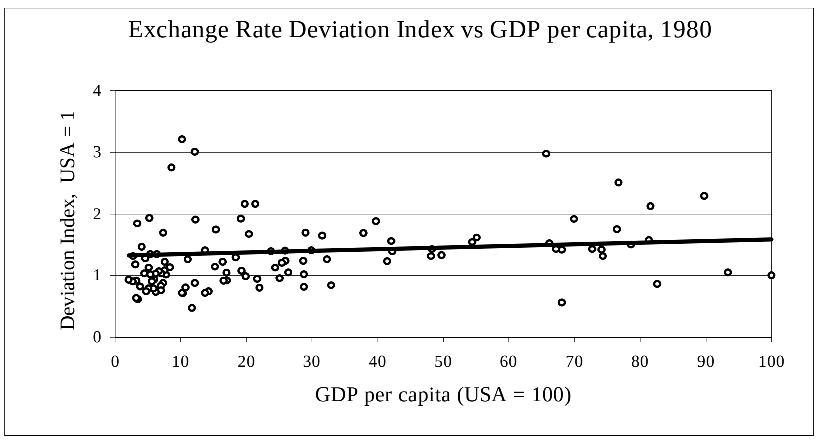


Figure 2: cont'd

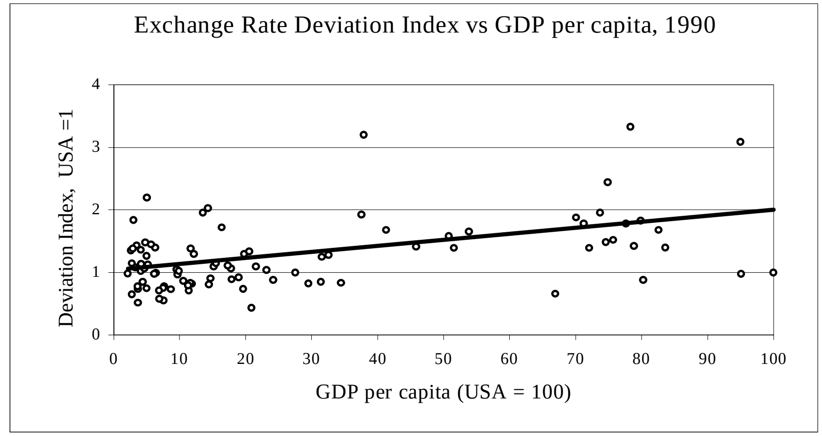


Figure 3: Exchange Rate Deviation Index of Agricultural PPP and the Official Rates, in Relation to per capita GDP in Different Regions, 1990

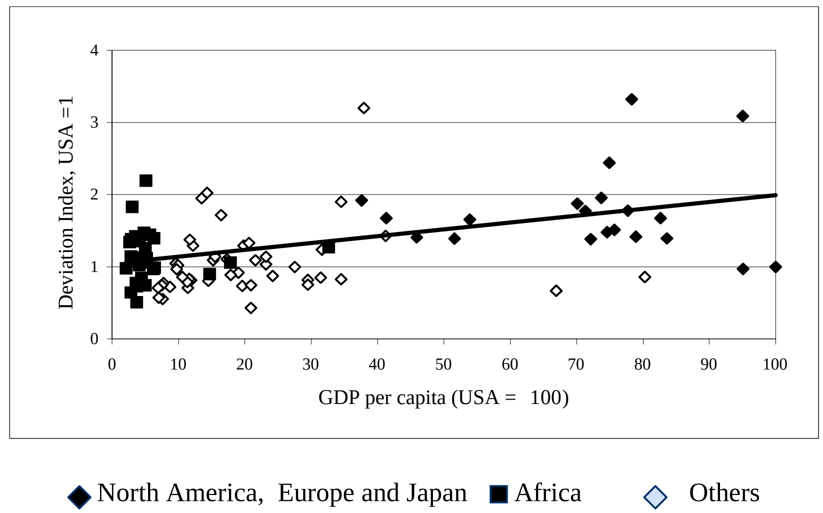


Figure 4: Exchange Rate Deviation Index of Agricultural PPP and the Official Rates, in Relation to per capita GDP, Excluding North America, Europe & Japan, 1990

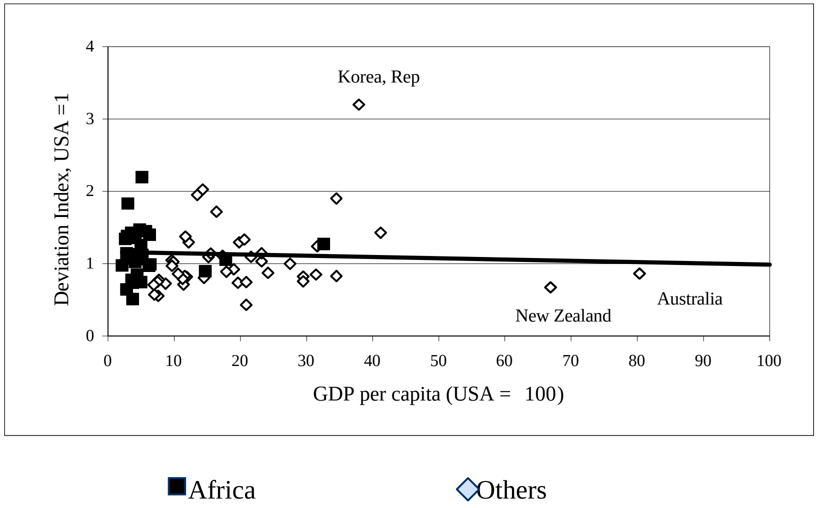


Figure 5: The Relation between Output Measured at Wheat PPP Exchange Rates and Output Measured at Agricultural PPP Exchange Rates, 1980

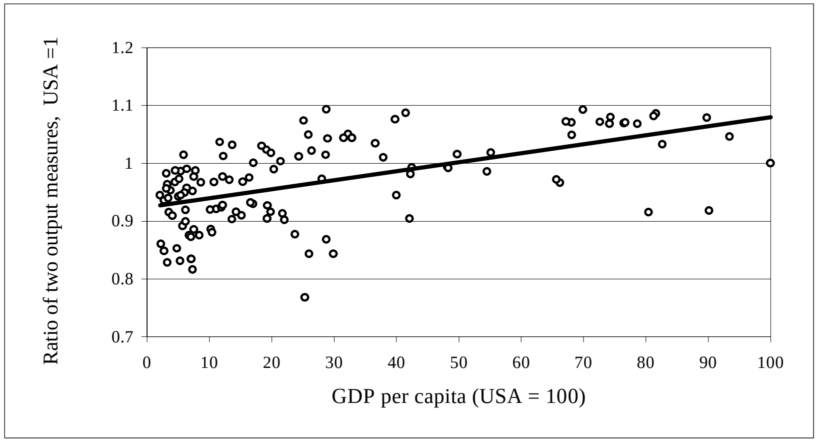
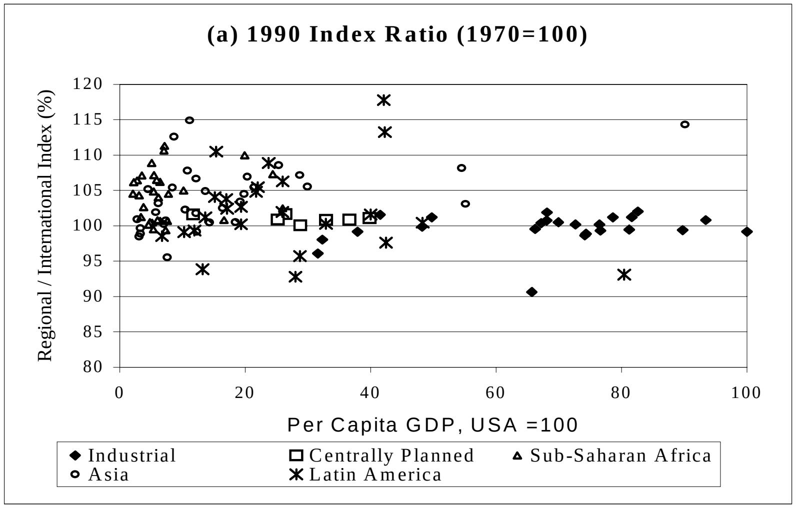


Figure 6:Production Index Deviation due to Loss Characterisity, in Relation to Per Capita GDP, 1970- 90



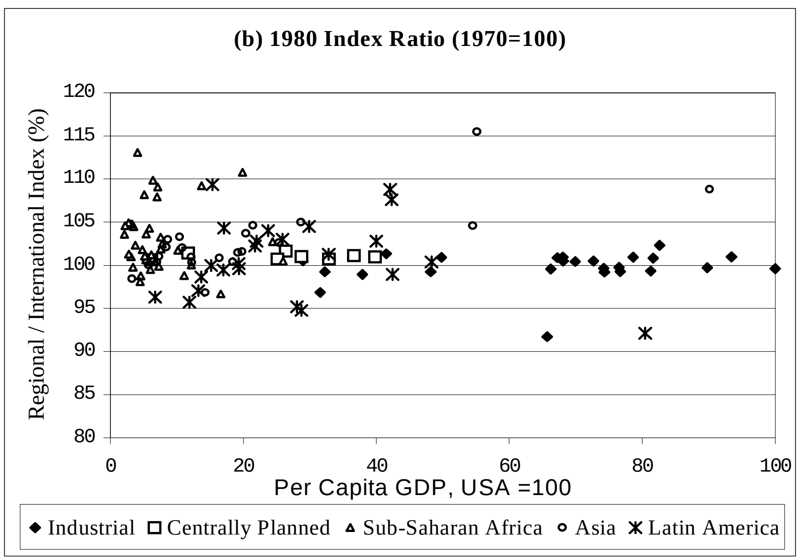


Figure 6: cont'd

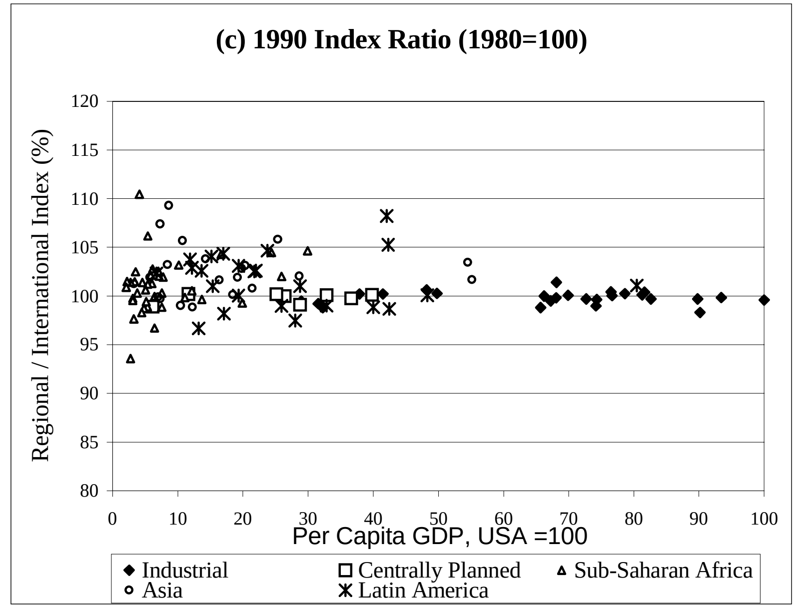
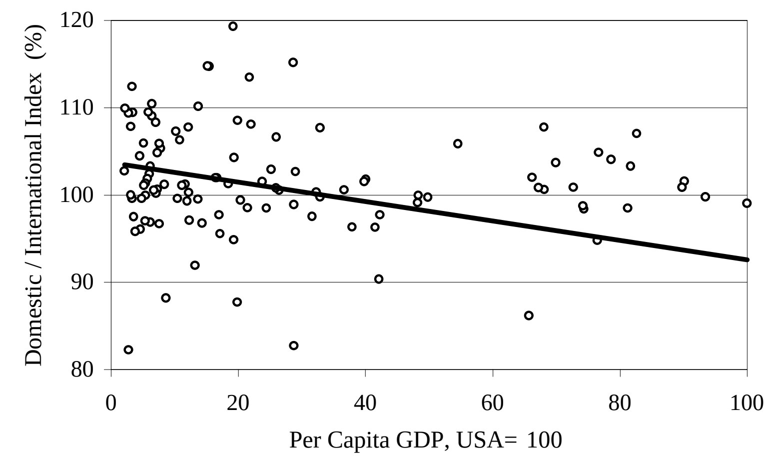


Figure 7: Production Index Deviation due to Loss of Characterisity, in Relation to Per Capita GDP, 1970-90

(a) 1990 Index Ratios , (1970=100)



(b) 1980 Index Ratio (1970=100)

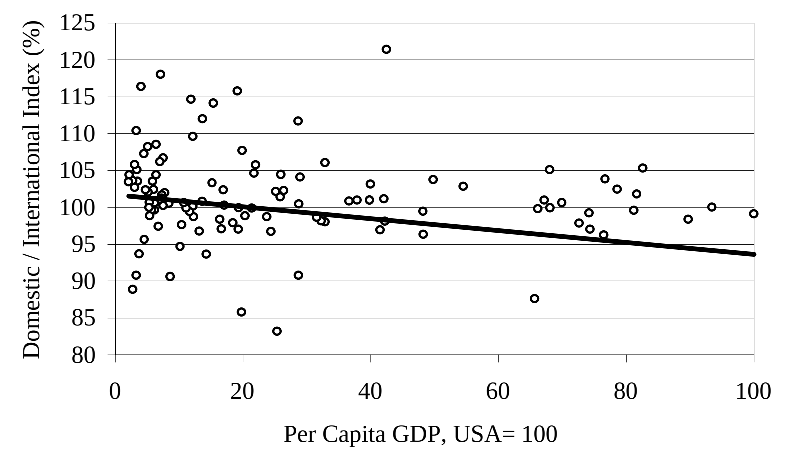


Figure 7: cont'd

© 1990 Index Ratio (1980=100)

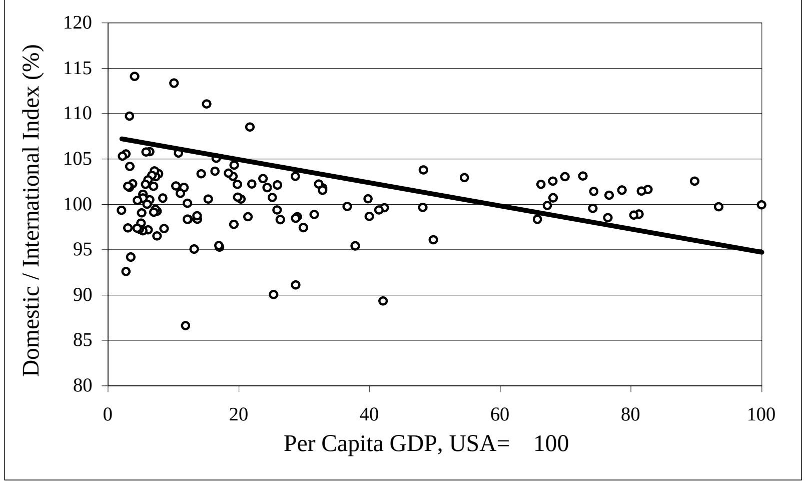
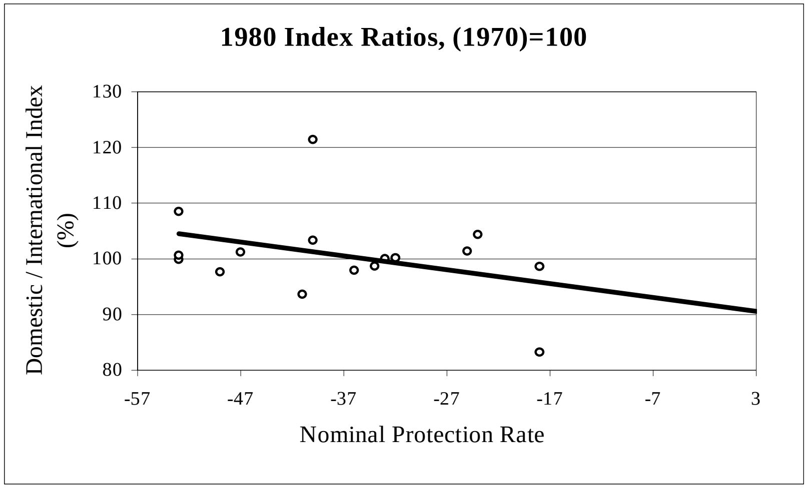


Figure 8: FAO Production Index Deviation in Relation to the Level of Agricultural Protection.



Notes: Nominal protection rate = (domestic price/border price)- 1, adjusted for exchange rate misalignment, average early 1960s to mid-1980s.Source: Nominal protection rate, World Bank estimates as reported in Fulginiti and Perrin (1993).

Table 1: Exchange Rate Deviation Index Between Official Exchange Rates and Agricultural Purchasing Power Parity Rates, 1970, 1980, and 1990 *(USA=1*

North America, Europe & Japan	***Exchange Rate Deviation Index* 1970**	**1980**	**1990**	***Per Capita GDP 1980***
USA	1.00	1.00	1.00	*100*
CANADA	0.81	1.05	0.97	*93.4*
SWITZERLAND	1.50	2.29	3.09	*89.8*
NORWAY	1.72	2.13	2.44	*81.6*
SWEDEN	1.35	1.57	1.68	*81.3*
GERMANY	1.19	1.50	1.39	*78.6*
FRANCE	1.31	1.75	1.78	*76.5*
NETHERLANDS	1.10	1.31	1.96	*74.3*
DENMARK	0.95	1.42	1.42	*74.2*
BEL-LUX	1.16	1.42	1.51	*72.7*
FINLAND	1.43	1.91	3.32	*69.9*
AUSTRIA	1.11	1.42	1.77	*68.1*
UK	1.01	1.42	1.38	*67.2*
ITALY	1.35	1.52	1.87	*66.2*
JAPAN	2.21	2.97	4.27	*65.7*
SPAIN	1.17	1.31	1.65	*48.2*
GREECE	1.28	1.69	1.92	*37.9*
PORTUGAL	1.17	1.65	1.67	*31.6*
Latin America				
VENEZUELA	1.12	1.42	0.85	*48.3*
PUERTO RICO	1.41	1.39	na	*42.3*
MEXICO	na	na	1.24	*40*
CHILE	1.12	1.40	0.87	*25.9*
COSTA RICA	1.17	1.39	0.92	*23.8*
PANAMA	0.76	0.80	1.09	*22*
ECUADOR	0.71	0.94	0.80	*21.7*
COLOMBIA	0.93	1.07	0.89	*19.3*
PERU	na	na	0.81	*19.3*
PARAGUAY	0.50	0.92	0.71	*17.1*
GUATEMALA	0.93	1.04	0.83	*17*
EL SALVADOR	1.10	1.41	1.05	*13.7*
HONDURAS	0.89	0.71	0.77	*10.2*

Table 1: cont'd

Middle East and North Africa	Exchange Rate Deviation Index 1970	1980	1990	Per Capita GDP 1980
SAUDI ARABIA	1.57	2.08	3.34	*90.1*
SYRIA	1.12	1.24	1.09	*28.7*
IRAN	1.18	2.16	1.72	*21.4*
JORDAN	1.30	1.67	1.11	*20.4*
ALGERIA	1.11	1.92	1.95	*19.2*
TURKEY	1.21	1.29	1.33	*18.4*
TUNISIA	1.09	1.22	1.14	*16.4*
MOROCCO	1.06	1.91	1.37	*12.3*
EGYPT	1.06	0.81	1.02	*10.8*
Eastern Europe	**1970**	**1980**	**1990**	***1980***
USSR	2.51	1.88	na	*39.8*
HUNGARY	0.75	0.84	0.82	*32.9*
POLAND	0.74	0.82	0.43	*28.8*
BULGARIA	1.90	1.05	0.83	*26.4*
CZECHOSLOVAKIA	1.14	0.95	1.03	*25.1*
ROMANIA	0.71	0.47	0.94	*11.7*
Asia				
MALAYSIA	1.07	1.21	1.00	*25.4*
KOREA, REP.	1.67	2.16	3.20	*19.8*
THAILAND	0.54	0.74	0.73	*14.3*
PHILIPPINES	0.81	0.88	0.97	*12.2*
SRI LANKA	1.18	0.71	0.79	*10.4*
INDONESIA	0.69	1.13	0.86	*8.4*
PAKISTAN	1.22	0.88	0.55	*7.3*
BANGLADESH	1.09	0.83	0.75	*7*
CHINA	1.00	0.73	0.57	*6.2*
INDIA	1.03	0.90	0.71	*5.7*

Table 1: cont'd

Africa	Exchange Rate Deviation Index 1970	1980	1990	Per Capita GDP 1980
MAURITIUS	0.96	1.24	1.27	*26*
SOUTH AFRICA	1.05	1.12	1.06	*24.4*
BOTSWANA	0.70	0.72	0.94	*13.7*
COTE DEVOIR	0.70	1.26	1.40	*11.1*
NIGERIA	1.32	3.21	2.19	*10.2*
ZIMBABWE	0.81	1.01	0.99	*7.8*
BENIN	0.77	1.09	1.12	*7.6*
CAMEROON	0.86	1.22	1.44	*7.6*
SIERRA LEONE	1.73	1.70	1.47	*7.3*
GAMBIA	0.59	1.03	0.84	*7.1*
SENEGAL	0.63	0.76	0.97	*7*
GHANA	1.24	5.20	1.26	*6.4*
KENYA	0.76	0.94	0.74	*6*
MOZAMBIQUE	0.83	0.79	1.02	*5.9*
SUDAN	0.89	1.35	4.35	*5.4*
LESOTHO	0.88	1.01	1.06	*5.4*
MAURITANIA	0.55	1.13	1.13	*5.2*
ANGOLA	0.68	0.79	2.56	*5.1*
CENTRAL AFR.R.	0.61	1.03	1.83	*4.5*
NIGER	0.65	1.46	1.98	*4.1*
MALI	0.50	0.83	1.07	*3.8*
MALAWI	0.57	0.61	0.64	*3.5*
CHAD	0.54	0.91	0.98	*3.3*
TANZANIA	0.63	1.18	0.61	*3.1*
BURKINA FASO	0.73	1.31	1.14	*2.8*
UGANDA	0.93	6.90	1.38	*2.2*
ETHIOPIA	1.07	0.93	1.42	*2.1*

Notes: Exchange Rate Deviation Index is defined as the value of agricultural output converted at the official Exchange Rate divided by the value of output measured at agricultural PPP rate.

Table A1: Purchasing Power Parities and Agricultural Output at PPP and Wheat Equivalent Rates, 1980

	Local Currency per US $				Agricultural Output	
	Official Exchange Rate	Purchasing Power Parities		at Agr. PPP Rate	Wheat Equivalent	
		GDP	Agriculture	Mn US$	PPP Mn tons	Weighted Avr [(1)] Mn tons
AFGHANISTAN	44.10	na	53.37	1888	12.67	12.49
ALGERIA	3.84	3.82	7.37	1524	10.23	10.17
ANGOLA	29.62	22.61	23.45	662	4.44	4.08
ARGENTINA	1.80E-08	2.65E-0	na	19551	131.25	127.11
AUSTRALIA	0.88	0.97	0.76	13340	89.55	90.09
AUSTRIA	12.94	16.27	18.39	2621	17.59	18.35
BANGLADESH	15.48	2.76	12.89	7013	47.08	38.19
BARBADOS	2.01	1.35	3.13	49	0.33	0.29
BELIZ	2.00	0.79	2.04	51	0.34	0.29
BEL-LUX	29.24	40.57	41.66	3104	20.84	21.68
BENIN	211.30	95.63	229.57	438	2.94	2.74
BOLIVIA	2.50E-05	1.43E-0	2.43E-0	1042	7.00	6.59
BOTSWANA	0.79	0.53	0.57	124	0.83	0.84
BRAZIL	5.30E-08	3.08E-0	na	35653	239.34	225.60
BULGARIA	1.29	0.93	1.35	3936	26.42	26.33
BURKINA FASO	211.30	137.35	277.77	486	3.26	2.98
CAMEROON	209.20	200.37	256.18	1522	10.22	8.80
CANADA	1.17	1.15	1.23	11631	78.08	79.85
CENT AFR REP	211.30	136.12	218.59	398	2.67	2.53
CHAD	211.30	120.40	192.13	518	3.48	3.28
CHILE	39.00	31.32	54.52	2118	14.22	14.57
CHINA	2.24	0.69	1.64	112585	755.79	676.98
COLOMBIA	47.28	25.90	50.69	6213	41.71	37.56
CONGO, DEM R	2.80	4.05	11.20	2884	19.36	18.59
CONGO, REP	211.30	152.88	635.76	162	1.09	1.04
COSTA RICA	8.57	6.42	11.93	821	5.51	4.72
COTE DIVOIRE	211.30	198.41	266.92	2398	16.10	14.34
CYPRUS	0.35	0.31	0.44	182	1.22	1.26
CZECHOSLOVAK	14.26	12.86	13.61	4781	32.10	33.64
DENMARK	5.64	8.27	8.00	3276	21.99	22.69
DOMINICAN RP	1.00	0.65	1.14	1175	7.89	7.00
ECUADOR	25.00	13.97	23.54	1730	11.62	10.30
EGYPT	0.72	0.31	0.58	6418	43.08	40.56
EL SALVADOR	2.50	1.21	3.52	961	6.45	5.68
ETHIOPIA PDR	2.07	0.91	1.92	3487	23.41	21.54

Table A1: cont'd

	Local Currency per US $				Agricultural Output	
	Official Exchange Rate	Purchasing Power Parities		at Agr. PPP Rate	Wheat Equivalent	
		GDP	Agriculture	Mn US $	PPP Mn tons	Weighted Average [(1)] Mn tons
FINLAND	3.73	4.85	7.13	1459	9.79	10.35
FRANCE	4.23	5.73	7.40	26770	179.71	187.59
GAMBIA	1.75	0.76	1.81	64	0.43	0.35
GERMANY	1.82	2.56	2.72	22507	151.09	155.91
GHANA	2.75	5.22	14.30	1443	9.69	9.05
GREECE	42.62	39.39	71.87	5085	34.14	33.63
GUATEMALA	1.00	0.56	1.04	1645	11.04	10.01
GUINEA	18.97	20.46	36.69	606	4.07	3.29
GUINEABISSAU	33.81	19.88	30.46	91	0.61	0.51
HAITI	5.00	1.70	5.34	678	4.55	3.89
HONDURAS	2.00	1.15	1.43	762	5.12	4.43
HONG KONG	4.98	4.14	8.03	404	2.71	2.69
HUNGARY	32.53	17.22	27.31	5059	33.96	34.85
ICELAND	4.80	7.55	12.05	76	0.51	0.53
INDIA	7.89	2.90	7.14	68178	457.68	396.87
INDONESIA	627.00	329.99	710.79	15945	107.04	91.39
IRAN	71.58	66.52	154.27	5718	38.39	37.33
IRAQ	0.30	0.19	0.46	1418	9.52	9.10
IRELAND	0.49	0.56	0.60	2649	17.78	18.84
ISRAEL	5.10E-03	5.04E-03	6.77E-03	1190	7.99	7.98
ITALY	856.40	872.33	1303.72	27646	185.59	173.90
JAMAICA	1.78	1.22	3.11	289	1.94	1.82
JAPAN	226.70	263.33	673.37	13785	92.54	87.55
JORDAN	0.30	0.23	0.50	224	1.51	1.45
KENYA	7.42	4.53	6.96	2008	13.48	12.46
KOREA REP	607.40	423.11	1312.98	4455	29.90	26.55
LESOTHO	0.78	0.33	0.79	97	0.65	0.63
MADAGASCAR	211.30	133.67	217.47	1634	10.97	9.65
MALAWI	0.81	0.39	0.50	738	4.95	4.42
MALAYSIA	2.18	1.28	2.63	5375	36.09	26.88
MALI	211.30	116.09	174.65	814	5.46	5.09
MALTA	0.35	0.31	0.59	32	0.22	0.22
MAURITANIA	45.91	34.00	51.71	186	1.25	1.19
MAURITIUS	7.68	2.92	9.54	143	0.96	0.78
MEXICO	2.30E-02	1.40E-02	2.32E-02	17139	115.05	106.28

Table A1: cont'd

	Local Currency per US $				Agricultural Output	
	Official Exchange	Purchasing Power Parities		at Agr. PPP Rate	Wheat Equivalent	
					PPP	Weighted Average (1)
	Rate	GDP	Agriculture	Mn US $	Mn tons	Mn tons
MOROCCO	3.94	2.62	7.51	2307	15.48	15.25
MOZAMBIQUE	32.40	9.25	25.53	1030	6.92	6.87
MYANMAR	6.61	2.95	4.21	4473	30.03	24.31
NAMIBIA	0.78	0.64	0.77	234	1.57	1.56
NETHERLANDS	1.99	2.74	2.61	5480	36.79	38.27
NEW ZEALAND	1.03	0.92	0.58	5604	37.62	38.43
NICARAGUA	3.00E-09	1.07E-09	na	592	3.98	3.58
NIGER	211.30	202.95	309.07	644	4.33	3.86
NIGERIA	0.55	0.59	1.76	8304	55.75	49.18
NORWAY	4.94	7.18	10.52	891	5.98	6.39
PAKISTAN	9.90	3.28	8.71	11570	77.67	71.99
PANAMA	1.00	0.70	0.80	438	2.94	2.60
PARAGUAY	126.00	90.19	116.12	1352	9.07	8.74
PERU	2.89E-07	1.51E-07	na	3114	20.91	18.35
PHILIPPINES	7.51	3.49	6.60	7588	50.94	46.19
POLAND	44.22	20.63	36.15	10779	72.36	76.62
PORTUGAL	50.06	33.69	82.40	1878	12.61	13.01
PUERTO RICO	1.00	0.90	1.39	355	2.38	2.28
REUNION	4.23	13.40	9.58	84	0.57	0.48
ROMANIA	21.92	20.02	10.29	7430	49.88	50.58
RWANDA	92.84	36.63	68.83	713	4.79	3.97
SAUDI ARABIA	3.33	3.84	6.91	583	3.92	3.38
SENEGAL	211.30	137.73	160.59	456	3.06	2.71
SIERRA LEONE	1.05	0.41	1.78	311	2.09	1.66
SOMALIA	6.30	7.48	11.60	970	6.51	5.97
SOUTH AFRICA	0.78	0.70	0.88	6637	44.55	44.06
SPAIN	71.70	70.83	94.10	17147	115.11	110.95
SRI LANKA	16.53	3.64	11.71	1851	12.42	10.66
SUDAN	0.50	0.32	0.67	3404	22.85	21.05
SURINAME	1.79	1.26	2.52	84	0.56	0.46
SWAZILAND	0.78	0.41	0.71	179	1.20	1.09
SWEDEN	4.23	6.62	6.64	2344	15.73	16.56
SWITZERLAND	1.68	2.53	3.84	1692	11.36	11.91
SYRIA	3.93	1.73	4.87	2532	17.00	16.75
TANZANIA	8.20	6.34	9.67	2642	17.73	16.55
THAILAND	20.48	8.31	15.11	10564	70.91	63.53
TOGO	211.30	169.15	270.08	326	2.19	2.11

Table A1: cont'd

	Local Currency per US $				Agricultural Output	
	Official Exchange	Purchasing Power Parities		at Agr. PPP Rate	Wheat Equivalent	
					PPP	Weighted Average (1)
	Rate	GDP	Agriculture	Mn US $	Mn tons	Mn tons
TRINIDAD	2.40	1.45	3.37	106	0.71	0.63
TUNISIA	0.41	0.28	0.50	1154	7.75	7.35
TURKEY	76.04	44.46	98.36	14294	95.96	97.67
UGANDA	0.07	0.57	0.51	1813	12.17	10.25
UK	0.43	0.51	0.61	12769	85.72	89.66
URUGUAY	9.10E-03	8.10E-03	na	1622	10.89	11.10
USA	1.00	1.00	1.00	132354	888.50	868.12
USSR	0.62	0.49	1.17	77584	520.83	546.33
VENEZUELA	4.29	3.49	6.11	2590	17.39	16.92
YEMEN	4.56	1.64	12.56	504	3.38	3.19
YUGOSLAV SFR	2.50E-03	1.88E-03	3.37E-03	6721	45.12	45.79
ZAMBIA	0.79	0.71	1.06	454	3.05	2.95
ZIMBABWE	0.64	0.53	0.65	1179	7.91	7.63

Notes: 1. PPP wheat equivalent units are measured at international prices, and the weighted average wheat eq. Units are based on a version of Hayami and Ruttan methodology as explained in the text.

Table A2: International Prices of Crops and Livestock Products, 1980

	International Prices		Cumulative World
	in US $	Wheat Eq.	Output
Crops			
RICE, PADDY	219.8	1.48	13.0
WHEAT	149.0	1.00	23.3
MAIZE	135.4	0.91	31.7
ALFALFA	172.2	1.16	36.5
POTATOES	123.7	0.83	41.2
SEED COTTON	616.6	4.14	45.1
SOYBEANS	282.4	1.90	48.7
COTTON LINT	1556.1	10.45	52.1
BARLEY	125.8	0.84	55.2
GRAPES	295.2	1.98	58.3
SUGAR CANE	23.6	0.16	60.8
VEGETABLES FRESH NES	162.4	1.09	62.9
CASSAVA	97.6	0.65	64.8
SWEET POTATOES	79.4	0.53	66.4
TOBACCO LEAVES	1870.1	12.55	67.9
SUGAR BEETS	35.1	0.24	69.4
TOMATOES	172.6	1.16	70.8
GROUNDNUTS IN SHELL	532.8	3.58	72.3
SORGHUM	141.6	0.95	73.5
ORANGES	178.4	1.20	74.6
APPLES	209.4	1.41	75.7
COFFEE, GREEN	1474.1	9.90	76.8
BEANS, DRY	440.9	2.96	77.7
OLIVES	437.8	2.94	78.5
OATS	115.6	0.78	79.2
ONIONS, DRY	217.4	1.46	79.9
BANANAS	134.7	0.90	80.7
OIL PALM FRUIT	113.7	0.76	81.3
COTTONSEED	151.3	1.02	81.9
COCONUTS	130.1	0.87	82.5

Table A2: cont'd

	International Prices		Cumulative World
	in US $	Wheat Eq.	Output
Crops			
RAPESEED	348.8	2.34	83.1
CABBAGES	101.7	0.68	83.7
RYE	139.1	0.93	84.2
SUNFLOWER SEED	242.2	1.63	84.7
MILLET	130.3	0.87	85.3
MANGOES	220.4	1.48	85.7
PLANTAINS	137.2	0.92	86.2
NATURAL RUBBER	837.9	5.63	86.7
GARLIC	721.8	4.85	87.2
WATERMELONS	114.3	0.77	87.7
CUCUMBERS ETC.	226.1	1.52	88.1
TEA	1453.8	9.76	88.5
YAMS	210.6	1.41	88.9
PEACHES ETC.	308.5	2.07	89.3
PEAS, DRY	226.1	1.52	89.6
CHICK-PEAS	426.0	2.86	89.9
PALM OIL	406.2	2.73	90.2
LETTUCE	231.4	1.55	90.6
CHILLIES ETC.	249.2	1.67	90.9
PLUMS	314.9	2.11	91.1
FRUIT FRESH NES	240.3	1.61	91.4
MELONS ETC.	204.6	1.37	91.7
PEARS	207.0	1.39	92.0
TANGERINES ETC.	202.8	1.36	92.3
ASPARAGUS	1289.8	8.66	92.5
COCOA BEANS	1020.9	6.85	92.8
PIMENTO, ALLSPICE	1047.3	7.03	93.0
STRAWBERRIES	880.6	5.91	93.3
PINEAPPLES	148.4	1.00	93.5
MUSHROOMS	1354.8	9.09	93.8
BANANAS	134.7	0.90	80.7
OIL PALM FRUIT	113.7	0.76	81.3
COTTONSEED	151.3	1.02	81.9

Table A2: cont'd

	International Prices		Cumulative World
	in US $	Wheat Eq.	Output
Crops			
COCONUTS	130.1	0.87	82.5
CARROTS	141.0	0.95	94.0
FRUIT TROPICAL NES	175.6	1.18	94.2
ALMONDS	1518.1	10.19	94.4
EGGPLANTS	163.7	1.10	94.6
LEMONS AND LIMES	254.5	1.71	94.8
PUMPKINS, ETC.	165.2	1.11	95.0
Livestock Products			
CATTLE MEAT	2315.4	15.54	27.3
COW MILK, FRESH	231.7	1.56	52.7
PIGMEAT	1355.2	9.10	71.2
CHICKEN MEAT	1280.0	8.59	78.7
HEN EGGS	1111.6	7.46	86.2
SHEEP MEAT	2204.9	14.80	89.3
WOOL, GREASY	3598.9	24.16	91.9
BUFFALO MILK	319.9	2.15	94.2
GOAT MEAT	1995.7	13.40	95.0
TURKEY MEAT	1221.1	8.20	95.7
SHEEP MILK	308.5	2.07	96.2
GOAT MILK	267.0	1.79	96.8
EGGS EXCL HEN	1477.4	9.92	97.2
BUFFALO MEAT	1165.0	7.82	97.7
HONEY	1415.5	9.50	98.0
RABBIT MEAT	1739.5	11.68	98.3
GAME MEAT	1398.4	9.39	98.7
MEAT NES	1279.5	8.59	99.0
COCOONS, REELABLE	2801.2	18.80	99.2
HORSE MEAT	1865.6	12.52	99.5
DUCK MEAT	1229.7	8.26	99.7
GEESE MEAT	1955.1	13.12	99.8
CAMEL MILK	281.6	1.89	99.9
CAMEL MEAT	1512.5	10.15	100.0
BEESWAX	2144.4	14.40	100.0

Table A2: cont'd

	International Prices		Cumulative World
	in US $	Wheat Eq.	Output
Livestock Products			
ASS MEAT	1588.1	10.66	100.0
MULE MEAT	1639.0	11.00	100.0
OTHER POULTRY	1609.1	10.80	100.0

Notes: Selected Crops shown in the table constitute ninety five percent of world output