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HOW MUCH STRUCTURAL CHANGE IS "REAL"?: SYSTEMATIC DEVIATIONS BETWEEN MEASURES OF REAL AND NOMINAL VALUE-ADDED SHARES OF GDP

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I. INTRODUCTION

In this paper, we examine the extent to which measures of change in nominal value-added sectoral shares of GDP represent real changes in sectoral activity as opposed to systematic changes in the structure of relative prices. Although the prospect of systematic changes in relative prices was considered by Kuznets in his original "quantitative aspects" articles [19, pp. 135–41, 334–35], the topic received limited attention in subsequent analyses of development patterns until the International Comparison Project (ICP) derived repriced estimates of per capita national product for a number of countries.[1]

As a result of the ICP findings, certain stylized facts are now widely accepted concerning the nature of changes in output prices with increases in per capita income, and alternative theories have been proposed to explain these "facts." Both the "facts" and theories have implications with respect to the sectoral price indexes for value added implicit in the national accounts data, and these implications have not been systematically analyzed or empirically tested. To do so is the purpose of this paper.

A. *Evidence of Price Changes with Development*

It is now widely accepted for instance that the real output price level, measured in purchasing-power-parity terms, increases significantly with per capita income. Simultaneously, there is an increase in the output price of services relative to that of commodities, and in the ratio of productivity in traded industrial goods to productivity in non-traded services (see [15]). In another context, Ram [21], taking into account the adjustment of per capita income derived from the ICP, has pointed out significant differences between the elasticities of factor shares derived using "real" (ICP) measures of per capita income and those derived using conventional (dollar) measures of per capita income. Chenery, Robinson, and Syrquin [3] note the importance of prices but do not introduce them explicitly except in the chapter using a Walrasian computable general equilibrium model as the basis of analysis. Syrquin and Chenery [26] take the issue of the effect of systematic changes in relative prices as important but unresolved.[2]

One indication of the potential magnitude of the changes in relative prices inherent in the process of moving from low to high per capita income is given by Theodore Schultz who reports a two-hundred fold increase in the wage of unskilled labor (measured in bushels of wheat) between England in Ricardo's time and the United States in 1970 [23, p. 107] and argues that such changes in relative prices play a fundamental role in effecting long-run growth [23, p. 118]. Jorgenson presents further evidence that appropriate models of growth must explicitly include relative prices, arguing that in the United States changes in relative prices appear to have played important roles in differential rates of technical change among sectors [9].

B. *Theories Consistent with the Stylized Facts*

Theories advanced to explain the differentials in price structures across countries date at least to Harrod's introduction of the subject in his 1933 text on international trade.[3] Harrod drew the now-familiar distinction between tradables and non-tradables (together with an intermediate kind of differentiated tradable) and related comparative price levels for commodities and factors to factor endowments and productivity differentials in production of tradables and non-tradables, leading to the expectation that non-tradables were likely to be "more expensive in the more efficient countries" [7, p. 80].

Productivity differentials across countries in producing traded and non-traded goods remain a leading element in models explaining systematic differences in relative prices. The most common models assume high productivity differentials between rich and poor countries in the production of tradable goods, and lower differentials in the production of non-tradable services. The high differentials set factor returns (most notably to labor) which impart higher relative prices to the labor-intensive non-tradable services in high income countries (for examples, see [1] [22] [2]). A second approach relies on differing factor endowments rather

2 "At a point in time, the internal structure of relative prices varies across countries. Since there are reasons to expect an association of the price structures with the level of development, the estimates of cross country patterns incorporate both real and price effects" (Syrquin and Chenery [26, pp. 75–76]). Syrquin and Chenery's analysis of relative price effects involves different estimation procedures and a different focus than those in this paper. They employ a two-stage estimation procedure, first estimating time rates of change then using those estimated rates in a cross-section regression on per capita income. The part of their analysis devoted to value-added measures is limited.

3 [7, chapter 4]. This appears to be the first discussion dealing with comparative price differentials across countries, though Kravis and Lipsey note a precursor to the idea that national price levels vary with levels of income is Ricardo [17, p. 4].

than productivity differentials to lead to relative price differentials (see [2] [4]) and in a third approach economies of scale in the production of industrial goods lead to the relative price differentials.[4]

The models seeking to explain price variations across countries at different levels of development differ not only in the mechanisms they propose, but also in the types of price variation for which explanation is sought. Kravis and Lipsey in their extensive review of the subject focus on the strong link between price *levels* and real per capita income.[5] Kravis, Heston, and Summers focus on goods prices (prices of commodities and services in final consumption) [15] while Panagariya's model is cast in terms of prices in producing sectors [20, especially pp. 514–19]. While prices of commodities employed in final use (consumption, investment, etc.) are related to value-added prices, they are not the same, and it is to this distinction, which is important to our analysis of the "real" and nominal patterns of sectoral change with development, that we now turn.

II. PRICE STRUCTURES AND MEASURES OF VALUE ADDED

The interpretation of relative price movements as they affect measures of the structure of production is by no means unambiguous. If we find, for instance, that the share of sector j in total product is lower at current prices in year t than it is at the constant prices of some base year, we are tempted to say that the relative "price" in sector j has fallen. But what does that mean? When we say the relative price of a single commodity—say corn—has fallen, we mean that a standard unit of that commodity (a bushel) costs less in relation to other commodity prices than it did in some "base" period. But the value added in the corn sector of the economy does not refer to bushels, instead it represents the value of some combination of primary factors used to produce corn or, alternatively, the price of a bushel of corn less the value of a vector of intermediate inputs used to produce corn.

A. R_j—*The Relative Factor Price Deflator for Sector j*

To keep this point clear, it is convenient to define R_{jt} as the relative factor price deflator for sector j in year t, or

$$R_{jt} = \pi_{jt}/\pi_t,$$

where π_{jt} is the implicit price deflator for sector j's primary inputs (factors or "value-added inputs") and π_t is the GDP implicit price deflator, that is,

$$\pi_{jt} = V_{jt}/C_{jt}, \text{ and}$$
$$\pi_t = V_t/C_t,$$

[4] [20]. Kravis and Lipsey provide a useful review of the literature on relative price differentials [17, pp. 2–20], and Panagariya provides the classification of models into those relying on productivity differentials, resource endowment differences, and scale economies [20, pp. 509–13].

[5] Kravis and Lipsey [17] define national price levels as purchasing-power-parity price deflators divided by the exchange rate.

where $V_{jt}=\sum_k p^v_{kt}u_{kjt}$,

letting

p^v_{kt}=kth primary factor (value added) price for year t,

$u_{kjt}=a^v_{kjt}x_{jt}$,

a^v_{kjt}=kth primary factor (value added) input-output coefficient for sector j in year t,

x_{jt}=gross output in sector j for year t, and

$C_{jt}=\sum_k p^v_{k0}u_{kjt}$.

GDP at current prices is given by $V_t=\sum_j V_{jt}$, and GDP at constant (base year) prices by $C_t=\sum_j C_{jt}$.

From these definitions the relative factor price deflator for sector j in year t is easily calculated as sector j's value-added share in current price terms divided by its share in constant price terms. That is,

$$R_{jt}=v_{jt}/c_{jt}$$

where

$v_{jt}=V_{jt}/V_t$, the current-price value-added share, and
$c_{jt}=C_{jt}/C_t$, the constant-price value-added share.

In the base year ($t=0$):

$$V_{jt}=C_{jt},\ V_t=C_t,\ v_{jt}=c_{jt},\ \text{and}\ \pi_{jt}=\pi_t=R_{jt}=1.$$

Thus for $t>0$, an R_{jt} greater (less) than one implies each of the following equivalent statements:

(1) The jth sector's factor price index is greater (less) than the overall GDP price index.
(2) The growth rate of R_j was positive (negative) between the base period and t, and thus the growth rate of the jth sector's factor price index was greater (less) than that of the overall GDP price index.
(3) The jth sector's value-added share in current price terms is greater (less) than its share in constant price terms.
(4) The growth rate of R_j was positive (negative) between the base period and t, and thus the growth rate of the jth sector's value-added share in current price terms was greater (less) than that of the overall GDP price index.

The focus of this paper is the relation between the level of per capita income and the relative factor price deflators (R_{jt}'s) for agriculture, manufacturing, non-manufacturing industry, and services. We employ a convenient and equivalent approach by estimating the relative rates of growth as represented by the elasticity (α_j) of the relative factor price deflator of sector j with respect to per capita income. That is,

$$\alpha_j=\frac{\Delta R_j/R_j}{\Delta y/y},$$

where y = constant price GDP, C, divided by population.

It follows that as per capita income increases, the sector with a positive (negative) α_j experiences rising (falling) relative factor prices.

Before presenting hypotheses concerning the expected signs for α_j by sector, we note that:

$$\alpha_j \gtreqless 0 \text{ if } V_{jt}-C_{jt} \gtreqless v_{j0}(V_t-C_t) \text{ and } \Delta y>0, \quad (1)$$

i.e., the sign of α_j will be positive or negative depending upon whether the deviation between current and constant price value added for sector j exceeds or is less than the deviation between current and constant price GDP weighted by sector j's base year value-added share, when per capita income is increasing.[6]

Next, we consider the determinants of $(V_{jt}-C_{jt})$. This result forms a convenient link between economic theory, stylized facts, and hypotheses concerning the expected sign of α_j for each sector.

B. *The Deviation between Value Added at Current and Constant Prices*

To examine the components of the deviation between V_{jt} and C_{jt} for value added in sector j, consider the following input-output relation which exists for sector j between the prices of gross output, intermediate inputs, and primary inputs.

$$p_{jt}=\sum_i p_{it}a_{ijt}+\sum_k p^v_{kt}a^v_{kjt},$$

where

p_{jt} = price of gross output of sector j in t, and
a_{ijt} = ith intermediate input-output coefficient.

It follows from the accounting framework that the value added for sector j for year t in current prices may be written either as:

$$V_{jt}=\sum_k p^v_{kt}u_{kjt}-\sum_k p^v_{kt}a^v_{kjt}x_{jt},$$

or alternatively as

$$V_{jt}=p_{jt}x_{jt}-\sum_i p_{it}a_{ijt}x_{jt}.$$

The value added in constant prices may be written similarly by replacing t with 0 for the price variables only.

[6] Proof of equation (1) is straightforward. The elasticity α_j is the ratio of two ratios, and by repeated use of the fact that the proportional rate of change of a ratio is the rate of change of the numerator minus the rate of change of the denominator, it follows that:

$$\alpha_j=\frac{\Delta R_j/R_j}{\Delta y/y}=\frac{(\Delta V_j/V_j)-(\Delta C_j/C_j)-[(\Delta V/V)-(\Delta C/C)]}{\Delta y/y}.$$

Since $V_{jt}=C_{jt}$ for base year $t=0$, the above expression can be written as:

$$\frac{\{[(V_{jt}-V_{j0})-(C_{jt}-C_{j0})]/V_{j0}\}-\{[(V_t-V_0)-(C_t-C_0)]/V_0\}}{\Delta y/y}$$

$$=\frac{[(V_{jt}-C_{jt})/V_{j0}]-[(V_t-C_t)/V_0]}{\Delta y/y}.$$

Since $v_{j0}=V_{j0}/V_0$, it follows that:

$$\alpha_j \gtreqless 0 \text{ if } V_{jt}-C_{jt} \gtreqless v_{j0}(V_t-C_t) \text{ and } \Delta y>0,$$

which is the result shown in equation (1).

Now, consider the difference between the current price and constant price value added in sector j at time t. This deviation will be equal to what may be called the primary input price effect (PIPE) where

$$\text{PIPE} = \sum_k \Delta p^v_{kt} a^v_{kjt} x_{jt} = V_{jt} - C_{jt}, \tag{2}$$

where $\Delta p^v_{kt} = p^v_{kt} - p^v_{k0}$.

Alternatively, $V_{jt} - C_{jt}$ is equal to the sum of a gross output price effect (GOPE) plus an intermediate input price effect (IIPE), where

$$\text{GOPE} + \text{IIPE} = (\Delta p_{jt} x_{jt}) + (-\sum_i \Delta p_{it} a_{ijt} x_{jt}), \tag{3}$$

given that $\Delta p_{jt} = p_{jt} - p_{j0}$.

It follows from the above results that while structural change in current value terms is the net result of a combination of demand, price, and input technique effects, the deviation between value added at current and constant prices does not depend on gross output effects or technical effects, but only on price effects. It is the deviation between value added in current and constant prices that is the prime link between economic theory, stylized facts, and hypotheses concerning the expected signs of sectoral elasticities in the analysis which follows.

III. HYPOTHESES: RELATIVE FACTOR PRICE DEFLATORS AND INCOME GROWTH

If the relative output and factor price structure of low income countries become more like that of high income countries as the low income countries experience growth in per capita income, then this has implications for the value-added structure of production in economies and especially for the deviation between current and constant value added on a sectoral basis. We will use stylized facts about relative price structure in conjunction with the relations in equations (1), (2), and (3) to form hypotheses about the nature of deviations between current and constant value added on a sector by sector basis.

We first note that in equation (1), $(V_t - C_t)$ can be expected to be positive for $\Delta y > 0$ since total GDP measured in current price value added, V_t, can be expected to grow more rapidly than GDP at constant prices, C_t, as per capita income increases. Evidence for this comes from the ICP finding that the price index for total GDP in the lowest income group of economies is only 41 per cent of that of the United States [17, Table 1] and from Chenery, Robinson, and Syrquin, who estimate that 68 per cent of growth in income across countries converted at exchange rates at all income levels is "real" growth, while the remaining 32 per cent represents systematic price effects.[7]

From equation (1), it is clear that the sign of the elasticity (α_j) of the relative factor price deflator of sector j with respect to per capita income will depend upon

[7] Chenery, Robinson, and Syrquin estimate the following relation between YR ("real" or purchasing-power-parity income conversions) and YE (exchange-rate income conversions) [3, p. 82]:

$$\ln YR = \underset{(16.7)}{2.81} + \underset{(28.9)}{0.68} \ln YE, \quad R^2 = 0.97.$$

whether $(V_{jt}-C_{jt})$, the jth sector's current-constant price value-added deviation, is larger or smaller than sector j's share of the current-constant price deviation for total GDP, (V_t-C_t).

A. *Services*

We consider first the services sector. The primary input price effect, $(\sum_k \Delta p^v_{kt} a^v_{kjt} x_{jt})$, is likely to be positive as per capita income increases because prices for labor services will rise more rapidly than prices of capital services, and services output tends to be labor intensive, so the weight of rising relative wages will have a relatively large weight in the primary input-output coefficients. This positive effect can be expected to be much larger for the services sector than for total GDP, and thus from equation (1) we expect $\alpha_j>0$ since $(V_{jt}-C_{jt})$ will exceed $v_{j0}(V_t-C_t)$. This implies that the services-sector current-price value-added share will overstate real increases in the services share.

The same conclusion may be reached by considering the size of $(V_{jt}-C_{jt})$ in terms of the gross output price effect, $(\Delta p_{jt}x_{jt})$, plus the intermediate input price ffect, $(-\sum_i \Delta p_{it} a_{ijt} x_{jt})$. Again, a positive net effect is expected since the rather dramatic potential for increases in services prices observed by Kravis, Heston, and Summers [15] can be expected to dominate the intermediate input price effect. The observed increase in the relative prices of services is consistent with the assumption that services have high income demand elasticities and are largely non-tradable.[8]

B. *Industry*

The data on industry are disaggregated into manufacturing and nonmanufacturing industry, the latter consisting of construction, utilities, and mining and quarrying. We will consider these sub-industry classifications in turn.

1. *Manufacturing*

The elasticity of the relative factor price deflator for manufacturing should be negative. The combined gross-output and intermediate-input price effects can be expected to be small, relative to the price effect for total GDP because of the stylized fact of relatively high commodities prices for low income countries due to tradability and given that intermediate inputs for manufacturing include purchases of services with rising relative prices.

If we consider the primary input price effect for manufacturing, we again come to the conclusion that a negative elasticity can be expected. Under the assumption that manufacturing is relatively capital intensive and has relatively low factor substitution elasticities, the stylized fact of relatively high capital goods prices (and thus we assume capital services prices) in low income countries leads to the hypothesis that the primary input price effect will be relatively smaller than for total GDP. The combination of possible scale economies and increasing productivity in this sector make the case for a negative elasticity even stronger.

8 Kravis and Lipsey provide similar arguments with respect to aggregate price behavior [18, pp. 9–10].

2. *Nonmanufacturing industry*

This is a nonhomogeneous grouping which consists of construction, utilities, and mining and quarrying. Since construction sector gross output is largely non-tradable, the gross output price effect may be relatively more positive than for manufacturing; furthermore, the primary input price effect is likely to be relatively large because of relatively high labor intensity.

For the utilities sector, the assumption of high capital intensity, a low substitution elasticity and scale economies may be made even more strongly than for manufacturing, thus leading to the conjecture that the sectoral relative factor price deflator will be negatively related to growth in per capita income. Considering the utilities sector from the point of view of gross output price effect plus intermediate input price effect, it appears, however, that one might reach the opposite view. Since the utilities sector output is largely non-tradable, and since the income elasticity of demand for output from this sector can be expected to be greater than one, it would not be surprising to find gross output prices positively related to per capita income growth, causing one to expect a positive elasticity for the relative factor price deflator. This is opposite to the conclusion reached by considering the primary input price effect. The fact that utilities are usually highly regulated and often publicly owned makes it even more difficult to predict a pattern for this sector.

For mining and quarrying, one would not expect a consistent pattern across countries with respect to per capita income levels due to the overriding importance of natural resource endowments for this sector. However a negative α_j might still be expected. Mining output is largely tradable, and (at least for petroleum and open pit mining) capital intensive, thus a negative elasticity may be expected for reasons similar to those stated above with respect to manufacturing.

To summarize, we would expect the elasticity to be positive for construction, negative for mining and quarrying, and inconclusive for utilities. Thus, it is not possible to form a clear hypothesis about relative price movements for the aggregation of these three sub-sectors which we are calling nonmanufacturing industry.

C. *Agriculture*

For the agricultural sector, we expect the elasticity of the relative factor price deflator to be negative and the negative effect to accelerate for the highest levels of per capita income. This expectation of an increasing elasticity with respect to the level of per capita income is based on the assumption that the vector of input-output coefficients for both primary and intermediate inputs will be dramatically different at different levels of development, thus changing the relative weights of the various price changes.

First, let us examine the primary input price effect. The long-run elasticity of factor substitution is relatively large in agriculture, leading to very labor-intensive production in low-wage, low-income countries, and to relatively capital-intensive production in countries with higher relative wage rates. Thus, the increment to the price of labor remains important in the primary input price effect,

($\sum_k \Delta p^v_{kt} a^v_{kjt} x_{jt}$), in the lower per capita income countries but has a much smaller weight in higher per capita income countries. Agriculture is a sector in which a specific factor, arable land, plays an essential role. Since land is essentially fixed and non-reproducible, basic micro theory would lead one to expect significant increases in its rental rate, and thus to have a large positive effect on primary input prices. This has not been the case, however, largely due to technical change, much of which is embodied in intermediate inputs.

Next consider agriculture from the gross output, intermediate input point of view. Agricultural output is highly tradable and tends to have a relatively low income elasticity of demand; therefore, the gross output price effect will be relatively small. A widely observed fact about the process of development in the agricultural sector is the increasing use of "green revolution" inputs such as fertilizers, pesticides, and hybrid seeds. In the input-output framework, this transformation will be observed in smaller values for the a^v_{kj} coefficients and larger values for the a_{ij} coefficients. Thus, at higher levels of per capita income, the intermediate input price effect becomes more important. This can be expected to result in a more negative elasticity for the relative factor price deflator for higher per capita income levels.

IV. EMPIRICAL TESTS

Our examination of the empirical evidence involves two stages. First we wish to ascertain whether a relationship exists between movements in sectorl relative factor price deflators and per capita incomes. Next we wish to determine more precisely the nature of this relationship through econometric analysis. Because of the nature of our data base, which involves data for eighty-five countries over a period of up to twenty-six years but with considerable amounts of missing data, each of these steps involves a different approach.

We start by discussing our strategy in approaching the problems of estimation, then turn to the data base, to our tests for the existence of a relationship, and to our econometric estimates.

A. *The Model to Be Estimated*

Our approach to estimation utilizes the fact that the relative factor price deflator for a given sector in a given year can be formed by dividing the nominal share of output arising in that sector by the constant price share of output of the same sector, i.e., as we have shown previously,

$$R_{jtK} = v_{jtK}/c_{jtK}, \tag{4}$$

where

R_{jtK} = the relative factor price deflator of sector j in country K at time t in relation to some base year,

v_{jtK} = the share of GDP of sector j in nominal terms for country K at time t,

c_{jtK} = the share of GDP of sector j in constant price terms for country K at time t.

Because we also want to partition our sample into subsets of countries corresponding to the World Bank's division between low-income, middle-income, and industrialized market economies (LIC, MIC, and IME) we specify the following estimating equations for v_{jtK} and c_{jtK}:

$$\log v_{jtK} = \log g_{jK} + b_{1j}\delta_1 \log (y_{tK}/y_K{}^*) + b_{2j}\delta_2 \log (y_{tK}/y_K{}^*) + b_{3j}\delta_3 \log (y_{tK}/y_K{}^*), \tag{5}$$

$$\log c_{jtK} = \log h_{jK} + d_{1j}\delta_1 \log (y_{tK}/y_K{}^*) + d_{2j}\delta_2 \log (y_{tK}/y_K{}^*) + d_{3j}\delta_3 \log (y_{tK}/y_K{}^*), \tag{6}$$

where

y_{tK} = per capita income in constant prices of country K at time t,

$y_K{}^* = y_{1980,K}$,[9]

$\delta_1 = 1$ if $K \in$ LIC group, 0 otherwise,

$\delta_2 = 1$ if $K \in$ MIC group, 0 otherwise, and

$\delta_3 = 1$ if $K \in$ IME group, 0 otherwise.

The b_{ij} and d_{ij} $(i = 1, 2, 3)$ are the elasticities of the nominal and constant shares respectively with respect to income, and i $(= 1, 2, 3)$ refers to the three income subgroups of countries, respectively LIC, MIC, and IME.

For $t = 1980$, by construction, $v_{jtK} = c_{jtK} = g_{jK} = h_{jK}$, $\forall j$ and K. This formulation allows individual country intercepts, and different slopes for the three country groups. The slopes within groups, however, are assumed to be the same. The individual country intercepts are of fundamental importance in the formulation since they normalize for each country's per capita income in the base year when current and constant price measures of the dependent variable are equal.

Given the above formulation, R_{jtK}, the sectoral relative factor price deflator for sector j of country K at time t, can be derived as:

$$\log R_{jtK} = \log v_{jtK} - \log c_{jtK}$$
$$= (b_{1j} - d_{1j})\delta_1 \log (y_{tK}/y_K{}^*) + (b_{2j} - d_{2j})\delta_2 \log (y_{tK}/y_K{}^*) + (b_{3j} - d_{3j})\delta_3 \log (y_{tK}/y_K{}^*), \text{ or}$$

$$\log R_{jtK} = \alpha_{1j}\delta_1 \log (y_{tK}/y_K{}^*) + \alpha_{2j}\delta_2 \log (y_{tK}/y_K{}^*) + \alpha_{3j}\delta_3 \log (y_{tK}/y_K{}^*), \tag{7}$$

where $\alpha_{ij} = b_{ij} - d_{ij}$, and i $(= 1, 2, 3)$ again refers to the three subgroups of countries.[10]

The α_{ij}'s are elasticities in country group i of the relative factor price deflator of sector j with respect to income.[11] Estimates of these parameters determine the nature of the relationship of R_{jtK}'s with respect to income and thus provide a basis

[9] This has been chosen because 1980 is the base year in the World Bank's World Tables data set.

[10] This formulation also incorporates the fact that $R_{jtK} = 1$ in the base year 1980.

[11] To see that α_{ij} in equation (7) is indeed the elasticity defined previously, consider the case in which $i = 1$. Then, equation (7) can be written as:

$$\log R_{jtK} = \alpha_{1j} \log y_{tK} - \alpha_{1j} \log y_K{}^*.$$

for a direct test of the hypotheses set forth in Section III. Note that the income term is normalized with respect to each country's 1980 income so that cross-country differences in units of measurement cancel out in terms of the level of income and are important only as they affect growth rates. This formulation should not be affected by whether income among countries has been converted at purchasing-power-parity prices or at official or market exchange rates because of the apparent linear relation between the exchange rate converted measure of income used here and purchasing-power-parity measures of income.[12]

B. *The Data*

The data are obtained from the World Bank's World Tables Tape for 1987. Data on per capita income, per capita income growth, and on nominal and constant-price shares of value added (and hence R_j's) are drawn for eighty-five countries covering the period 1965–86 (see Appendix Table III). The countries are classified into four per capita income groups, which correspond to the World Bank's current division between low-income countries (LIC), low and upper middle income countries (LMIC and UMIC), and industrialized market economies (IME).[13] The sectors considered are agriculture, services, and industry, in turn subdivided into manufacturing and nonmanufacturing.[14] In all, our sample provides data on v_{ij}'s and c_{ij}'s for at least some years for eighty-five countries: thirty-five LIC, seventeen LMIC, fourteen UMIC, and nineteen IME (see Appendix Table III). We conduct a series of chi-square and nonparametric tests to test the relationship between the various sectoral relative factor price deflators and income class in the eight-five–country sample.[15]

Data are not available for all of the eighty-five countries for the entire block of years between 1965 and 1985, so the requirements of our procedure for eco-

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Differentiating with respect to y_{tK} yields:

$$\frac{1}{R_{jtK}}\,\frac{dR_{jtK}}{dy_{tK}}=\alpha_{1j}\frac{1}{y_{tK}},\ \text{or}$$

$$\alpha_{1j}=\frac{dR_{jtK}/R_{jtK}}{dy_{tK}/y_{tK}}.$$

12 Chenery, Robinson, and Syrquin report a very good fit for a linear relation between exchange rate and purchasing-power-parity converted measures of income [3, p. 82]. Based on this, the derivative of the former with respect to the latter would be a constant. If the equation in the previous footnote were differentiated with respect to the purchasing-power-parity measure of income and the chain rule were used in the differentiation, there would be a constant on each side of the equal sign which would cancel. It follows that the elasticity measure would be unaffected.

13 We grouped countries on the basis of their 1970 per capita incomes expressed in ICP dollars (see Appendix Table III). We experimented with alternative groupings, including that used in World Bank [28], and although these resulted in assignment of some countries to different groups, they did not affect the nature of our basic findings. Estimates of the nonparametric and econometric tests employing the alternative grouping are available from the authors.

14 As noted above, the "nonmanufacturing" sector includes construction, mining and quarrying, public utilities, etc.

15 See Table I and Appendix Table IV for these results.

nometric estimation of the elasticities of sectoral relative factor price deflators and value-added shares with respect to income restrict the size of the sample to considerably fewer than eighty-five countries.

C. *The Sample and Procedures for Estimating Elasticities*

To estimate equations (5)–(7), we introduce an additive disturbance term to each of the equations. In view of the nature of the data used, i.e., a time series of cross sections, the disturbances are assumed to be cross-sectionally heteroskedastic and timewise autoregressive. Using SHAZAM, a general computer program for econometric methods [27], the equations are estimated separately for each sector. The estimation technique is a generalized least squares procedure, described in Kmenta [10]. This procedure has a number of advantages, but requires a full set of data for each year for each country included.

Complete data on sectoral relative factor price deflators, economic openness, and per capita GDP for the period 1965–84 are available for forty-one countries. Excluding the small countries (those with populations less than 5 million in 1970), the sample size is reduced to twenty-eight countries, including eleven LIC, nine LMIC, two UMIC, and six IME.[16] In view of the small number of UMIC, the two middle income country groups are merged to yield a single middle income country (MIC) group. We, thus, have a time series of cross-section data on twenty-eight countries and a time period of twenty years.

We do not think it appropriate to estimate elasticities from the combined sample of our country set as our hypothesis discriminates between what happens for low, middle, and high income countries.[17]

V. RESULTS

We will organize the main discussion of the results on a sector by sector basis. For each sector, the results of three related but different types of analyses are considered. First, nonparametric tests are employed to analyze the relation between the sectoral mean annual growth rates of the relative factor price deflators and the levels of per capita income. Second, estimates of α_j's, the elasticities of the relative factor price deflators with respect to per capita income, are presented. Third, we present estimates of the elasticities of the nominal and constant price shares of GDP with respect to per capita income. A brief discussion of the results from each of these three different analytic approaches will precede the discussion for specific sectors.

A. *Nonparametric Tests on the Large (Eight-Five–Country) Sample*

To examine the potential association between the rise and fall in R_{jt} values and the level of per capita income, a cross classification of R_j^* (the mean annual

[16] These countries are indicated in Appendix Table III.

[17] Following Jameson [8], we conducted a test of homogeneity of slopes of the equations (i.e., the homogeneity of elasticities of the sectoral price relatives) across income groups using a combined sample of all three income groups. The hypothesis of equality of elasticities was rejected for all sectors.

TABLE I

MEAN ANNUAL GROWTH RATES OF SECTORAL RELATIVE FACTOR PRICE DEFLATORS BY INCOME CLASS

(Number of countries=85, 75 for mfg. and nonmfg.)

Sector	Mean Annual Growth Rate (R_j*)[a]	Country Groups[b]				Chi-square Significance
		LIC	LMIC	UMIC	IME	
Agriculture	<0	12	9	8	18	0.000
	≥0	23	8	6	1	
Services	<0	22	11	9	3	0.004
	≥0	13	6	5	16	
Manufacturing	<0	18	9	7	15	0.314
	≥0	11	7	5	3	
Nonmanufacturing industry	<0	16	5	1	6	0.035
	≥0	13	11	11	12	

a For years between 1965 and 1986 which are available.
b Income ranges for countries (per capita income in 1970 ICP dollars; see [14]):
LIC (low income countries)=below 950,
LMIC (lower middle income countries)=950–1,800,
UMIC (upper middle income countries)=1,801–3,200,
IME (industrial market economies)=over 3,200.

growth rate of R_{jt}) with the level of income is used (Table I).[18] A chi-square test of association, performed for each sector, shows we cannot reject the existence of significant relationships in the agriculture, services, and nonmanufacturing sectors. Furthermore, to test the equality of mean R_j*'s across country groups, a one-way analysis of variance procedure is used (Appendix Table IV). The hypothesis of equal means is rejected for agriculture and services sectors. Since we cannot accept independence between sectoral shares and the level of development, we do not run any tests of significance of differences in factor shares with our four income groups.

B. *Elasticity Estimates*

Table II reports our main results, which are the estimates of α_j's, the elasticities of the relative factor price deflators with respect to per capita income. As discussed below, with minor exceptions in services, the hypotheses we put forth in Section III are supported. Table III shows the estimated values of the elasticities[19] of the nominal and constant price shares of GDP with respect to per capita income. Here, the results for nominal shares generally conform to the stylized facts of

18 Given the fact that R_{jt} values are index numbers, and that the value of R_{j0} is 1 for every country in its base year regardless of the country's level of per capita income, the comparisons have been made in terms of the growth rates of R_{jt}'s.

19 Recall that b_j is the growth elasticity of the nominal value-added share of sector j (equation 5) and, similarly, d_j is the growth elasticity of the "real" value-added share of sector j (equation 6).

TABLE II

ESTIMATED ELASTICITIES OF SECTORAL RELATIVE FACTOR PRICE DEFLATORS WITH RESPECT TO PER CAPITA INCOME

Sector	Income Class	Estimated Elasticity α_j
Agriculture	LIC	0.02772 (0.660)
	MIC	−0.00078 (−0.026)
	IME	−0.62109 (−12.143)
Services	LIC	−0.05328 (−1.958)
	MIC	−0.08776 (−4.405)
	IME	0.18834 (5.708)
Manufacturing	LIC	−0.33959 (−7.473)
	MIC	−0.32169 (−8.758)
	IME	−0.43594 (−6.519)
Nonmanufacturing industry	LIC	0.43352 (7.045)
	MIC	0.39632 (8.156)
	IME	0.35255 (4.052)

Note: Figures in parentheses are *t*-values.

the Kuznets-Chenery-Syrquin "patterns" in both sign and level of significance. Only the negative but very small elasticity estimates (one marginally significant, one marginally not) for the services share in low income countries deviate from traditionally expected patterns. These results suggest that the relative growth of services' share in both nominal as well as constant price value added is a phenomenon accompanying the middle and later stages of development.

C. *Manufacturing*

Table II shows that the α_j for manufacturing is, as expected, significantly negative for each income group. In industrialized market economies the reason for this result is that the elasticity of nominal shares is more negative than that of constant price shares (see Table III); however, in the middle and lower income countries the negative α_j follows from the fact that the elasticity of nominal shares is less positive than that for the constant price shares. It follows that changes in

TABLE III

ESTIMATED ELASTICITIES OF THE NOMINAL AND CONSTANT PRICE SHARES OF GDP WITH RESPECT TO PER CAPITA INCOME, 1965–84

Sector	Income Class	Nominal Shares b_j	Constant Price Shares d_j
Agriculture	LIC	−0.68390	−0.60735
		(−12.743)	(−15.933)
	MIC	−0.77553	−0.70863
		(−19.524)	(−24.573)
	IME	−1.3104	−0.57207
		(−18.759)	(−11.281)
Services	LIC	−0.05905	−0.00473
		(−2.114)	(−0.194)
	MIC	0.02299	0.10682
		(1.073)	(5.240)
	IME	0.34089	0.09508
		(9.141)	(2.589)
Manufacturing	LIC	0.04521	0.36383
		(0.849)	(6.524)
	MIC	0.16045	0.40048
		(3.844)	(9.343)
	IME	−0.38137	−0.01103
		(−5.286)	(−0.144)
Nonmanufacturing industry	LIC	1.60340	1.13450
		(23.682)	(22.039)
	MIC	0.72271	0.35280
		(12.375)	(8.586)
	IME	−0.03915	−0.38548
		(−0.372)	(−5.313)

Note: Figures in parentheses are t-values.

nominal shares overstate the rate of real (constant price) decline in manufacturing's share for the industrial market economies. Similarly, the rate of real growth in manufacturing's share is understated by changes in nominal shares for lower income countries. Given all the discussion about loss of manufacturing in industrial countries it is remarkable that this study shows no evidence of such a phenomenon; the elasticity of constant price manufacturing share is only −0.01 and statistically not different from zero.

Table I provides additional evidence in support of negative α_j's for manufacturing. Two-thirds of all countries studied had declining relative factor price deflators for manufacturing over the period studied, and for the industrial market economies fifteen out of eighteen countries experienced this trend. These numbers confirm the importance of the incidence of declining relative factor price deflators for manufacturing.

D. *Nonmanufacturing*

Despite the fact that nonmanufacturing constitutes a nonhomogeneous grouping of construction, utilities, and mining and quarrying, all but one of the nine elasticities reported in Tables II and III are highly statistically significant. Note especially the high elasticities in the LIC group for both nominal and constant price shares. These are the only elasticity estimates greater than one[20] and imply that the growth of the nonmanufacturing industry constitutes the most dramatic structural change in low income countries. This result is consistent with the stylized impression that low income countries are primarily involved with building infrastructure (construction and utilities) and in some countries in expanding extractive primary products (mining and quarrying). The implications of the estimates in Table III for low income countries are that changes in the structure of nominal shares primarily represent movement out of agriculture and into the nonmanufacturing industry. A similar statement holds for constant price shares except that there is growth in manufacturing as well as nonmanufacturing shares.

For the nonmanufacturing components of industry, the α_j is significantly positive for each income group, a result that is somewhat surprising in the light of the characteristics that make predictions about the sign of the α_j for this group ambiguous. Table I shows that nearly two-thirds of the countries in the sample experienced increasing relative factor price deflators for this sector over the period. Because mining and quarrying is included in this sector, we ran subsidiary tests excluding the years of the world boom in oil prices. The results for the nonmanufacturing α_j's remain the same in all sub-periods examined.[21]

E. *Services*

For the high income economies the relatively large α_j elasticity estimate of 0.19 for services has the expected sign and is significant. The growth in services share in these economies is primarily a relative price effect; the estimate for the constant price share elasticity is significant but less than 0.1 as shown in Table III. These results provide evidence that the growth in services share in real terms is relatively slow and the growth in nominal services shares in high income countries significantly overstates constant-price structural change in value added.

For the low and middle income groups all the elasticity estimates for services are quite small, only one of six has an absolute value as large as 0.1. Table III provides evidence of very little structural change in the services share in either nominal or real terms for these countries, only for constant price shares in the MIC group is the elasticity as large as 0.1. The α_j's are unexpectedly negative and statistically significant; however, their small absolute value must be interpreted as evidence that per capita income growth has little effect on the relative factor price deflator for services in low and middle income countries.

[20] The industrial market countries have an elasticity for agricultural share in nominal terms which is negative but greater than one in absolute value.

[21] Subsidiary tests, run on sub-periods before and during the world petroleum boom (1973–81) show results similar to those when all years are included.

This lack of evidence for significant positive α_j's for services in low and middle income countries is, perhaps, the most unexpected result we have to report. We are measuring the value-added price deflator, and not the final-use price of services which increases significantly with development according to the ICP data. Despite this difference, based on our discussion in Section III, we expected to find the service's sector relative factor price deflators with respect to per capita income to be positive for lower as well as high income countries. One possible explanation rests on the widely held assumption that services sector activities, especially informal activities, are more underestimated in national income statistics the lower the per capita income.[22] While changes in the degree of underestimation will affect both nominal and constant price measures, some bias may enter because of different weights implicit in the aggregation. If at the sub-services aggregation level the most undercounted types of services, e.g., personal services or retail trade, were also the most labor intensive or those with the most rapid rates of price increase, estimated increases in the service's sector value-added price deflator would be biased downward for lower income economies.

F. *Agriculture*

For agriculture, α_j is insignificant for the LIC and MIC, but negative and strongly significant for the high income economies. Table I shows that eighteen of nineteen of the IME experienced declining relative factor price deflators in agriculture for the period. Although we expected significant negative elasticities for the relative factor price deflators with respect to income for the LIC and MIC samples as well, the results are consistent with our hypothesis in Section III that the elasticity would be more negative for higher income groups.

Table III shows that elasticities for both nominal and constant price agricultural shares are negative, relatively large in absolute value, and highly statistically significant for all country groups. This provides clear evidence of a very general and significant shift out of agriculture in both nominal and real terms.

VI. CONCLUSIONS

We find that, indeed, a significant amount of structural change in the value-added components of GDP is "real." We also find evidence that relative factor prices as well as relative real shares of value added change systematically during development in expected ways. The fact that a systematic relation exists between per capita income and sectoral relative factor price deflators and that this relation is implicit in the current and constant price national product account data has not been demonstrated previously. Previous studies have focused on relative output prices and/or have used data sources other than the standard national accounts data.

Our results imply that the evolution of nominal shares sometimes overstates the degree of real structural change. For example, we find evidence of little or

[22] We are indebted to an anonymous referee for this suggestion.

no real structural change in either manufacturing or services in industrial market economies. Movements of nominal shares may also mute the degree of real structural change where relative price and factor movements are in opposite directions. We find evidence of this in both the services and manufacturing sectors in middle income countries and in manufacturing for low income countries.

Our results on nominal shares are generally consistent with previous general findings of the "patterns of development" literature. Furthermore, even though quite different data and methods are used, our results are consistent with some of the more recent findings of the International Comparison Project about shifts in relative prices as development proceeds. Our analysis suggests that the factors underlying the evolution of relative prices with development are more complex and varied than is typically conceded, and that models designed to describe the process of growth and development must incorporate the effects of relative price changes.

REFERENCES

1. Balassa, B. "The Purchasing Power Parity Doctrine: A Reappraisal," *Journal of Political Economy*, Vol. 72, No. 6 (December 1964).
2. Bhagwati, J. N. "Why Are Services Cheaper in the Poor Countries?" *Economic Journal*, Vol. 94 (June 1984).
3. Chenery, H.B.; Robinson, S.; and Syrquin, M. *Industrialization and Growth: A Comparative Study* (New York: Oxford University Press for the World Bank, 1986).
4. Clague, C.K. "A Model of Real National Price Levels," *Southern Economic Journal*, Vol. 51, No. 4 (April 1985).
5. ————. "Short-cut Estimates of Real Income," *Review of Income and Wealth*, Vol. 32, No. 3 (September 1986).
6. ————. "Explanations of National Price Levels," in *World Comparison of Incomes, Prices, and Product*, ed. J. Salazar-Carrilo and D. S. Prasada Rao (New York: North-Holland, 1988).
7. Harrod, R. F. *International Economics*, Cambridge Economic Handbooks No. 8 (New York: Harcourt, Brace and Co., 1933).
8. Jameson, K. P. "A Critical Examination of 'The Patterns of Development,'" *Journal of Development Studies*, Vol. 18, No. 4 (July 1982).
9. Jorgenson, D. W. "Productivity and Post-War U.S. Economic Growth," *Journal of Economic Perspectives*, Vol. 2, No. 4 (Fall 1988).
10. Kmenta, J. *Elements of Econometrics*, 2nd ed. (New York: Macmillan, 1986).
11. Kravis, I. B.; Heston, A. W.; and Summers, R. F. "Real GDP Per Capita for More Than One Hundred Countries," *Economic Journal*, Vol. 88 (June 1978).
12. ————. *International Comparisons of Real Product and Purchasing Power*, United Nations International Comparison Project: Phase II, produced by the Statistical Office of the United Nations and the World Bank (Baltimore: Johns Hopkins University Press for the World Bank, 1978).
13. ————. "New Insights into the Structure of the World Economy," *Review of Income and Wealth*, Vol. 27, No. 4 (December 1981).
14. ————. *World Product and Income: International Comparisons of Real Gross Product*, United Nations International Comparison Project: Phase III, produced by the Statistical Office of the United Nations and the World Bank (Baltimore: Johns Hopkins University Press for the World Bank, 1982).

15. ————. "The Share of Services in Economic Growth," in *Global Econometrics: Essays in Honor of Lawrence R. Klein*, ed. F. G. Adams and B. G. Hickman (Cambridge, Mass.: MIT Press, 1983).
16. Kravis, I. B.; Kenessey, Z.; Heston, A. W.; and Summers, R. *A System of International Comparisons of Gross Product and Purchasing Power*, United Nations International Comparison Project: Phase I, produced by the Statistical Office of the United Nations, the World Bank, and the International Comparison Unit of the University of Pennsylvania (Baltimore: Johns Hopkins University Press for the World Bank, 1975).
17. Kravis, I. B., and Lipsey, R. E. "Towards an Explanation of National Price Levels," Special Studies in International Finance No. 52 (International Finance Section, Department of Economics, Princeton University, 1983).
18. ————. "National Price Levels and the Prices of Tradables and Nontradables," NBER Working Paper No. 2536 (Cambridge, Mass.: National Bureau of Economic Research, 1988).
19. Kuznets, S. *Economic Growth of Nations: Total Output and Production* (Cambridge, Mass.: Belnap Press of Harvard University Press, 1971).
20. Panagariya, A. "A Theoretical Explanation of Some Stylized Facts of Economic Growth," *Quarterly Journal of Economics*, Vol. 103, No. 3 (August 1988).
21. Ram, R. "Conventional and 'Real' GDP Per Capita in Cross-Country Studies of Production Structure," *Journal of Development Economics*, Vol. 18, Nos. 2–3 (August 1985).
22. Samuelson, P. A. "Theoretical Notes on Trade Problems," *Review of Economics and Statistics*, Vol. 46, No. 2 (May 1964).
23. Schultz, T. W. "On the Economics of the Increases in the Value of Human Time over Time," in *Economic Growth and Resources: Proceedings of the Fifth World Congress of the International Congress of the International Economic Association*, Vol. 2, *Trends and Factors*, ed. R. C. O. Matthews (New York: St. Martin's Press, 1980).
24. Summers, R., and Heston, A. W. "Improved International Comparisons of Real Product and Its Composition," *Review of Income and Wealth*, Vol. 30, No. 2 (June 1984).
25. ————. "A New Set of International Comparisons of Real Product and Prices: Estimates for 130 Countries, 1950–85," *Review of Income and Wealth*, Vol. 34, No. 1 (March 1988) plus three floppy disks.
26. Syrquin, M., and Chenery, H. B. *Patterns of Development, 1950–1983*, World Bank Discussion Paper 41 (Washington, D.C., 1989).
27. White, K. J. "A General Computer Program for Econometric Methods—SHAZAM," *Econometrica*, Vol. 46, No. 1 (January 1978).
28. World Bank. *World Development Report 1986* (New York: Oxford University Press for the World Bank, 1986).

APPENDIX

THE IMPACT OF ECONOMIC OPENNESS

Another potential element to be considered in the evolution of relative factor price deflators and sectoral shares of output as development proceeds is the degree of openness of the economy to world markets. The structures of more open economies may diverge from those characteristic of given levels of development, and the impact of international prices may also affect the degree to which sectoral relative factor price deflators change with development. Although we form no hypotheses about the impact of openness on specific sectors, openness has often been identified as a characteristic which may modify the evolution of sectoral shares and relative sectoral prices with income growth,[a] and thus we adapt our measures to take into account the openness of economies in its impact on structural change.

1. *The model with economic openness*

In this formulation, we introduce a measure of economic openness into the estimation equations. The measure of openness used is one-half the ratio of total exports plus total imports to total GDP. The equations corresponding to equations (5–7) become:

$$\log v_{jtK}=\log a_{jK}+(g_{1j}e_{tK})\delta_1 \log(y_{tK}/y_K{}^*)+(g_{2j}e_{tK})\delta_2 \log(y_{tK}/y_K{}^*) + (g_{3j}e_{tK})\delta_3 \log(y_{tK}/y_K{}^*), \quad \text{(A.1)}$$

$$\log c_{jtK}=\log a_{jK}+(f_{1j}e_{tK})\delta_1 \log(y_{tK}/y_K{}^*)+(f_{2j}e_{tK})\delta_2 \log(y_{tK}/y_K{}^*) + (f_{3j}e_{tK})\delta_3 \log(y_{tK}/y_K{}^*), \quad \text{(A.2)}$$

$$\log R_{jtK}=(\beta_{1j}e_{tK})\delta_1 \log(y_{tK}/y_K{}^*)+(\beta_{2j}e_{tK})\delta_2 \log(y_{tK}/y_K{}^*) + (\beta_{3j}e_{tK})\delta_3 \log(y_{tK}/y_K{}^*), \quad \text{(A.3)}$$

where

$e_{tK}=\dfrac{(M_{tK}+E_{tK})/2}{y_K{}^*}$ is economic openness of country K at time t,

$\beta_{ij}=g_{ij}-f_{ij}$, and i (=1, 2, 3) refers to each country group.

Here $\beta_{ij}e_{tK}$ provides an alternative measure of the growth elasticities of the R_{jtK} modified to incorporate openness, and $g_{ij}e_{tK}$ and $f_{ij}e_{tK}$ provide similar measures of the growth elasticities of sectoral shares (nominal and real, respectively) adjusted for openness.

To see this more explicitly, let $j=1$ and drop the subscripts so equation (A.3) becomes

$$\log R = \beta e(\log y - \log y^*).$$

Now, differentiate with respect to time to obtain,

$$\frac{\dot{R}}{R}=\beta e\frac{\dot{y}}{y}+\left(\beta \log\frac{y}{y^*}\right)\dot{e}.$$

Consider two cases: case 1, when openness is unchanged,

$$\dot{e}=0 \Rightarrow \beta e=\frac{\dot{R}/R}{\dot{y}/y},$$

and case 2, when per capita income is unchanged,

$$\dot{y}=0 \Rightarrow \frac{\dot{R}}{R}=\left(\beta \log\frac{y}{y^*}\right)\dot{e}.$$

[a] For discussions of the effect of openness in determining prices, see [3] [11] [12] [14] [17] [24]. Clague [5] [6] has criticized the use of the foreign trade ratio in this context, arguing that a satisfactory theoretical basis for its inclusion is not evident.

APPENDIX TABLE I

ESTIMATED ELASTICITIES OF SECTORAL RELATIVE FACTOR PRICE DEFLATORS WITH RESPECT TO PER CAPITA INCOME WITH ECONOMIC OPENNESS

Sector	Income Class	Coefficient Estimate β_j	Elasticity Estimate for Mean Openness $\beta_j e$ (Mean)
Agriculture	LIC	0.33639 (2.378)	0.08260
	MIC	−0.17614 (−1.455)	−0.04411
	IME	−2.66710 (−12.639)	−0.66810
Services	LIC	−0.28370 (−2.873)	−0.06966
	MIC	−0.61713 (−7.385)	−0.15456
	IME	0.91440 (6.563)	0.22906
Manufacturing	LIC	−1.1502 (−7.648)	−0.28244
	MIC	−1.5553 (−11.523)	−0.38952
	IME	−1.8503 (−8.061)	−0.46350
		(5.606)	
Nonmanufacturing industry	LIC	1.17930	0.28959
	MIC	1.85510 (10.597)	0.46461
	IME	1.25570 (3.813)	0.31455

Note: Figures in parentheses are *t*-values.

Case 1 shows that the specification in equation (A.3) allows for changes in R due to changes in openness independent of any change in per capita income. Case 2 shows that βe equals the growth elasticity of R adjusted for openness. Following a similar approach it is clear that,

$$\dot{e}=0 \Rightarrow ge=\frac{\dot{v}/v}{\dot{y}/y}, \text{ and}$$

$$\dot{e}=0 \Rightarrow fe=\frac{\dot{c}/c}{\dot{y}/y}.$$

That is, ge and fe represent the growth elasticities of nominal and real sectoral shares, respectively, each adjusted for openness.

APPENDIX TABLE II

ESTIMATED ELASTICITIES OF NOMINAL AND CONSTANT PRICE SECTOR SHARES WITH RESPECT TO INCOME PER CAPITA WITH ECONOMIC OPENNESS

Sector	Income Class	Nominal Shares: Estimated Coefficient	Nominal Shares: Estimated Elasticity for Mean Openness	Constant Price Shares: Estimated Coefficient	Constant Price Shares: Estimated Elasticity for Means Openness
		f_j	$f_j e$ (Mean)	g_j	$g_j e$ (Mean)
Agriculture	LIC	−1.46560 (−6.824)	−0.35989	−1.69670 (−10.430)	−0.41664
	MIC	−2.62940 (−14.806)	−0.65853	−2.20560 (−16.010)	−0.55239
	IME	−5.02060 (−15.677)	−1.25766	−1.71960 (−6.959)	−0.43075
Services	LIC	−0.31316 (−3.173)	−0.07689	−0.01313 (−0.148)	−0.00322
	MIC	−0.15870 (−1.862)	−0.03974	0.45519 (6.120)	0.11400
	IME	1.31950 (8.750)	0.33053	0.24369 (1.687)	0.06104
Manufacturing	LIC	−0.13804 (−0.734)	−0.03389	0.68992 (3.682)	0.16942
	MIC	0.16257 (0.977)	0.16257	1.53110 (9.748)	0.38346
	IME	−1.84690 (−6.176)	−0.46264	−0.20792 (−0.742)	−0.05201
Nonmanufacturing Industry	LIC	5.20970 (19.776)	1.27929	3.81670 (19.374)	0.93723
	MIC	2.83710 (12.268)	0.71055	1.06790 (6.141)	0.26746
	IME	0.16109 (0.36819)	0.04035	−0.82751 (−2.561)	−0.20729

Note: Figures in parentheses are t-values.

2. *The effects of economic openness*

The results reported in Appendix Table I show how the elasticity estimates are affected when the model incorporates economic openness (measured for each country by one-half the ratio of imports plus exports to GDP at current prices). The β_j's are estimated using equation (A.3) and the right-hand column of Appendix Table I, the product of β_j and the mean level of openness in each subsample, e (mean). This provides an alternative estimate of the growth elasticities of relative factor price deflators adjusted for openness.

Comparing the estimates of the growth elasticities incorporating and not incorporating openness shows the qualitative nature of the changes in sectoral rela-

APPENDIX TABLE III

LIST OF COUNTRIES USED IN NONPARAMETRIC TESTS AND IN POOLED REGRESSIONS

Group 1: LIC			
Bangladesh*	El Salvador	Liberia	Sierra Leone
Benin	Ethiopia*	Malawi†	Sri Lanka*
Bolivia	Gambia†	Mali†	Tanzania*
Botswana	Honduras	Mauretania†	Thailand*
Burkina Faso†	India*	Mauritius	Togo
Burma†	Indonesia	Nigeria*	Uganda
Cameroun*	Jordan	Pakistan*	Zaire
Central Afr. Rep.	Kenya*	Philippines*	Zambia
Egypt†	Lesotho	Rwanda	
Group 2: LMIC			
Algeria*	Ecuador*	Korea*	Turkey*
Brazil*	Fiji	Malaysia	Zimbabwe
Colombia*	Ghana	Paraguay	
Costa Rica†	Guyana	Peru*	
Dominican Rep.	Ivory Coast*	Tunisia*	
Group 3: UMIC			
Argentina*	Greece*	Portugal†	Trinidad & Tobago
Barbados	Jamaica	Singapore	Uruguay†
Chile	Mexico	South Africa	
Cyprus	Panama	Surinam	
Group 4: IME			
Australia	Denmark	Italy*	Norway
Austria*	Finland	Japan	Spain
Belgium*	France*	Luxemburg	Sweden
Britain	Germany*	Netherlands†	U.S.A.*
Canada	Israel	New Zealand	

Notes: 1. * designates a country used in the pooled regressions, and a (†) indicates missing data for the manufacturing and nonmanufacturing sectors.

2. Grouping is on the basis of ICP per capita incomes for 1970 (Kravis, Heston, and Summers [14]). An alternative grouping of countries, based on the *1986 World Development Report*'s classification [28] reassigned some countries to different groups but resulted in no significant differences in the regression or nonparametric tests' results.

tive factor price deflators to be relatively unaltered. Due to the presence of a high multicollinearity between the independent variables used in equations (7) and (A.3) we are reluctant to put much confidence in the degree to which our measured elasticities distinguish between the effect of openness and the effect of growth. We conclude that including openness in the model does not change the fundamental nature of our results with respect to growth elasticities, but we are unable to separate, with confidence, the effect of openness on the elasticities of the R_j's with respect to per capita income growth.

Appendix Table II reports alternative measures of the nominal and real shares incorporating openness into the model, but these results are subject to the same

APPENDIX TABLE IV

ONE-WAY ANALYSIS OF VARIANCE FOR TESTING EQUALITY OF THE MEAN OF SECTORAL "MEAN ANNUAL GROWTH RATES" ACROSS COUNTRY GROUPS

(Number of countries=85, 75 for mfg. and nonmfg.)

Country Group	Number of Countries	Mean of Sectoral Mean Annual Growth Rates			
		Agriculture	Services	Mfg.	Nonmfg.
LIC	35	0.0080	−0.0052	−0.0097	−0.0038
LMIC	17	−0.0013	−0.0053	−0.0082	0.0100
UMIC	14	−0.0064	−0.0037	−0.0027	0.0121
IME	19	−0.0183	0.0042	−0.0084	0.0080
$F_{3,81}$		13.43*	3.49*		
$F_{3,71}$				0.334	1.38
Significance of Cochran's test of homogeneity of variance		0.037	0.000	0.001	0.000

* Significance at 5 per cent level.

strictures as our result with respect to openness and the R_j's. However, again the qualitative nature of the results has not been altered.

Appendix Table III reports the countries in our two samples, and Appendix Table IV reports the one-way analysis of variance used to test the equality of means of R_j's across country groupings.