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INDUSTRIALISATION, CATCHING UP AND ECONOMIC GROWTH

A Comparative Study Across the World's Capitalist Countries

Steve Dowrick and Norman Gemmell

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INDUSTRIALISATION, CATCHING UP AND ECONOMIC GROWTH

A Comparative Study Across The World's Capitalist Economies

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EXECUTIVE SUMMARY

This paper examines hypotheses concerning the convergence and divergence of income levels between rich, middle-income and poor countries. We develop a model of disequilibrium medium-term growth with sector-specific technological progress and technological spillover both between sectors and between countries. The model is estimated first on a sample of 52 'rich' and 'middle-income' capitalist economies for the periods 1960-73 and 1973-85, then on an extended sample containing an additional 26 'poor' (mainly sub-Saharan Africa) countries.

We find that growth is significantly affected by the degree of intersectoral resource allocation to the extent that the average product of labour differs across sectors. We confirm William Baumol's findings of three 'growth clubs' but find important differences in the nature and extent of technological spillovers both by levels of development and between industrial and agricultural sectors. There is strong evidence of technological catch-up in the industrial sectors of the rich and middle-income countries. Whilst the poorest countries have seen relatively rapid technical progress in agriculture since 1973, these beneficial effects have been offset by a falling-behind in technical progress in industry and in investment per head of population. The poorest countries are caught in a poverty trap, unable to generate the capital accumulation which might raise living standards, technical progress and the surplus required for further accumulation.

INTRODUCTION

William Baumol (1986) examines the growth performance of some 60 capitalist economies for the period 1950-80 and concludes that there were three 'clubs': the relatively rich industrialized economies experienced average rates of growth of per capita GDP of 3.1 percent per annum; the middle-income market economies grew at about 3 percent per annum; but growth averaged only 1.5 percent per annum for the poorest group of countries. Within the richest group he observes convergence of per capita GDP levels over the thirty year period; within the middle-income group he observes only a small decrease in the degree of dispersion of income levels; within the poorest group he observes divergence. Overall, the slow rate of growth of the poorest countries has led to a widening of the aggregate degree of dispersion.

Similar trends can be observed for a wider group of non-oil capitalist economies over the period 1960-85. Using the latest data set provided by Robert Summers and Alan Heston (1988) we can, however, add some qualifications: when the richest group is defined by *ex-ante* income criteria, there appears to be intra-group divergence of per capita GDP; and the average annual rate of growth in the poorest group has slumped since 1973 to levels around zero or even negative depending on the sampling criteria. The poorest countries, almost all of them in sub-Saharan Africa, are not only falling behind in relative terms, they are struggling even to maintain real income levels.

Both Baumol and Moses Abramovitz (1986) suggest a range of technological and demand-side explanations for the observed pattern of growth, particularly for convergence of income levels amongst some of the richer countries and divergence at the bottom of the income scale. We focus here on a stylized version of the Baumol-Abramovitz hypotheses. Technological spillover gives less developed countries the opportunity to catch-up; but their capacity to benefit from the 'advantages of backwardness' may depend on the existence of a threshold level of infrastructural development and patterns of consumption. Those economies below this threshold, with inadequate stocks of physical and human capital and with little domestic demand for the areas of production where technological advance is concentrated, are unable to follow let alone catch-up on technical progress and therefore languish in the wake of the progress of the high and middle-productivity economies.

The primary evidence which has been adduced in support of the technological spillover thesis has been subject to important criticism by Bradford de Long (1988). He argues that the group of sixteen leading countries which has frequently been cited as a clear demonstration of income convergence is a biased sample chosen on the basis of *ex-post* economic success. If we select groups of countries on the basis of *ex-ante* income levels, any negative correlation between development and subsequent growth performance depends on arbitrary selection criteria.

Steve Dowrick and Duc-Tho Nguyen (1989) find, nevertheless, a strong tendency for levels of total factor productivity to converge amongst the richer countries even where per capita income levels have diverged. Technological catch-up has been masked in the data on per capita GDP by the tendency for the relatively poor countries to have lower rates of growth of per capita capital stock.

We are still left with the question why per capita GDP growth in the least developed countries has lagged behind so drastically. Is it because they lack the infrastructural capacity to enjoy the benefits of technological catch-up? Or is it because of slow growth of capital stock per head of population?

A third set of explanations for the falling behind of the poorest countries is suggested by the literature on structural change in developing countries. Norman Gemmell (1982) has charted the tendency for economic development from an intermediate base to lead to a shift of resources from agriculture to industry. Hollis Chenery (1986) and Gershon Feder (1986) have argued for a model of disequilibrium growth whereby such a transfer of resources can raise average productivity levels if marginal productivities of factors of production are lower in agriculture than in industry. Such models predict faster growth for those economies which move resources more quickly out of low productivity agriculture. Dowrick (1989) finds evidence that labor reallocation has indeed been a significant source of growth in OECD countries since 1950. It might be the case that the poorest countries are failing to transfer resources out of agriculture. A further possibility is that there might be a systematic tendency for productivity growth in agriculture to lag behind that in industry, catching the poorest countries who tend to have the largest agricultural sectors in a trap of sluggish productivity growth, low income levels, low savings and investment and an inability to industrialize.

In this paper we develop a model of disequilibrium growth supplemented by sector-specific technological progress and catch-up. In contrast to previous models we allow for the possibility that the degree of sectoral disequilibrium, hence the potential to raise growth by reallocation of resources, may vary according to the level of development; moreover, we allow for rates of technological advance to differ both between sectors and by levels of development. Our first task is to construct a model which can combine, or test between, the various theories which seek to explain systematic differences in rates of growth; then to estimate the model in relation to available data on economic growth and sectoral composition; then to re-evaluate the explanations put forward by Baumol and others for the performances within and between the three 'growth clubs'.

1. MODELLING STRUCTURAL CHANGE AND CATCH-UP

To examine the growth process we integrate and adapt the models of Feder (1986) and Dowrick and Nguyen (1989). We consider first a simple equilibrium growth model and then allow for disequilibrium in factor markets and for differences in technological progress.

Consider an economy composed of two sectors which may be labelled 'Agriculture', a, and 'Industry', i,[1] having production functions given by

$$A = A(K_a, L_a, t) \quad ; \quad I = I(K_i, L_i, t) \qquad (1)$$

where A,I represents output from each sector, K_j and L_j are respectively capital and labor in sector j (j = a,i), and t is technology. Total output, capital and labor are Y, K and L respectively.

intersectoral equilibrium

If there are no barriers to flows of capital and labor between sectors, competitive equilibrium requires the equalisation of sectoral marginal products. We take this as a characterisation of the null hypothesis of inter-sectoral equilibrium growth: $A_K = I_K$; $A_L = I_L$ (where the subscript denotes the marginal product). We assume a uniform rate of growth, τ, of total factor productivity. The growth rate of output ($\dot{Y}$) is:

$$\dot{Y} = I_K \frac{dK}{Y} + I_L (L/Y)\, \dot{L} + \tau \qquad (2)$$

Further, we assume a fixed ratio, β, of the marginal product of labor to the average product (as implied by Cobb-Douglas technology) :

$$A_L = I_L = \beta(Y/L) \qquad (3a)$$

and we assume that international capital mobility equalizes marginal returns to capital, at least across countries at similar levels of development:

$$A_K = I_K = \alpha + \alpha_1 \cdot y \qquad (4a)$$

where y is a variable capturing stages of development. We can treat y either as a continuous function of some measure of development, e.g. labor productivity:

[1] We refer throughout this paper to the non-agricultural part of the economy as the 'industrial sector'.

$$y \quad = \quad \ln(Y/L) \qquad (5)$$

or else we can treat y as a dichotomous variable distinguishing country groups:

$$y \quad = \quad 1 \quad \text{if } (Y/L) > (Y/L)^* \; ; \qquad y = 0 \quad \text{otherwise} \qquad (5')$$

These assumptions lead to the standard inter-sectoral equilibrium growth model[2]:

$$\dot{Y} \quad = \quad \alpha \frac{dK}{Y} \quad + \quad \alpha_1 \left(y \frac{dK}{Y}\right) \quad + \quad \beta \dot{L} \quad + \quad \tau \qquad (6a)$$

The hypothesis that marginal returns to capital are equalized across countries is : $H_0 : \alpha_1 = 0$. $\alpha_1 < 0$ implies the marginal productivity of capital is higher in low productivity countries. This may be expected if the cost of capital is higher in low income countries, e.g. if capital goods are imported by poorer countries who face transport costs and the costs of additional risk premia on finance.

intersectoral disequilibrium

We want to test the hypothesis that barriers to the transfer of labor between sectors and countries drive a wedge between sectoral marginal products. As Jeffrey Williamson (1986) has recognized, the process of inter-sectoral labor transfer which this productivity differential is likely to stimulate raises aggregate labour productivity and moves sectoral marginal products towards equality. Indeed our data confirm that the ratio of *average* labor productivity in agriculture to that in industry rises with the level of development (see Tables 1 and 5). We suggest the hypothesis that sectoral *marginal* products of labor follow a similar pattern. Specifically we assume that

$$A_L \quad = \quad \mu A/L_a$$
$$I_L \quad = \quad \beta I/L_i \qquad (3b)$$

This can be compared with the assumption made by Feder that the ratio of sectoral marginal products is the same in all countries:

[2]This is, implicitly, the type of model assumed by Kormendi and Meguire (1985), Dowrick and Nguyen (1989), and others who have ignored the possibility of intersectoral disequilibrium.

$$A_L = \mu' Y/L$$

$$I_L = \beta' Y/L \qquad (3c)$$

We find (3c) implausible when applied to a sample of countries with a wide range of levels of development and prefer specification (3b) which implies that sectoral marginal productivities may be equal where average productivities are equal, but may be widely differing in less developed economies. Moreover, we note that (3b) is a necessary condition if production is quasi-Cobb-Douglas - i.e. if

$A = f^a (K_a, t_a) . (L_a)^{\mu}$ and $I = f^i (K_i, t_i) . (L_i)^{\beta}$.

Substitution of assumptions (3b) or (3c) for (3a), gives alternative expressions for the growth rate of total output:

$$\dot{Y} = \alpha \frac{dK}{Y} + \alpha_1 (y \frac{dK}{Y}) + \beta \frac{I}{Y} \dot{L}_i + \mu \frac{A}{Y} \dot{L}_a + \tau \qquad (6b)$$

$$\dot{Y} = \alpha \frac{dK}{Y} + \alpha_1 (y \frac{dK}{Y}) + \beta' \frac{L_i}{L} \dot{L}_i + \mu' \frac{L_a}{L} \dot{L}_a + \tau \qquad (6c)$$

Equations 6a, 6b and 6c embody three alternative assumptions concerning sectoral labour productivity. If marginal products are equalized across sectors, disaggregation of labor inputs is not required - see 6a. If marginal products are proportional to average products, sectoral labor growth is weighted by sectoral output share as in 6b. If the ratio of marginal products is constant, sectoral labor growth is weighted by employment share as in 6c. We can test between these hypotheses noting that 6c reduces to 6a if $\beta' = \mu'$, but we require a non-nested test between 6b and the other two specifications.

If capital is immobile between sectors we may expect that marginal products of capital are not necessarily equal. In principle, we could model this marginal productivity gap in the same ways as we have done for labor; but we lack the necessary data on sectoral capital stocks. Feder's solution to this problem is to assume a fixed marginal productivity gap for capital such that

$$A_K = \delta I_K \qquad (5d)$$

and then to use the production function definition (1) to substitute out the sectoral distribution of capital growth. This procedure implies that a further term is added to the growth model of the form $\alpha_2 \, dA/Y$ where $\alpha_2 = (\delta - 1)/\delta$.[3] We expect α_2 to be negative if the marginal product of capital is lower in agriculture, or positive if the marginal product is lower in industry. If $\alpha_2 = 0$, we accept the null hypothesis that intersectoral capital flows have equalized marginal returns to capital.[4]

technological progress

The recent literature on technological progress suggests that rates of technological progress may differ systematically across countries according to their stage of development. Dowrick and Nguyen, for example, model technological catch-up as a function of the ratio of a country's overall labor productivity to that of a 'leading' country. The productivity level of a country captures the supply side of the technological spillover effect: the bigger the productivity gap, the greater the potential for copying, buying or transfering the technological advances of the leading economies. This suggests a negative relationship between productivity levels and economic growth. At the same time, we note the arguments put forward by both Abramovitz and Baumol that some poorer countries may have less capacity to take advantage of technological spillover, implying a positive relationship between economic growth and productivity levels. The net result of the supply-side spillover effect and the capacity effect may imply either a negative or a positive relationship between growth and productivity levels . In consequence we may expect to find structural breaks or non-linearities in the relationship between productivity growth and levels of development.

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[3] δ also enters the other terms in the equation in a multiplicative fashion, so if δ does not equal unity we have to change our interpretation of the other coefficients.

[4]We have, however, serious doubts about the usual OLS estimation of α_2 due to the distinct possibility of simultaneous equation bias. The equation is derived as a supply-side growth model, but we must expect that economic growth has a simultaneous demand-side influence on the growth of agricultural output. Rao (1989), for instance, finds significant evidence of simultaneous causation between economic growth and the growth of government output.

One further hypothesis which we put forward here is that the rate of technological progress in agriculture, t_a, may differ from that in industry, t_i, implying that we should substitute $\tau = t_i + (A/Y)(t_a - t_i)$ into equation 6 . We disaggregate catch-up to allow for sector specific effects both in terms of the productivity gap and the strength of catch-up. We might also expect some technological spillover to occur *within* a country if its industrial sector is relatively advanced and is supplying capital goods to the agricultural sector. If this 'internal' catch-up operates, countries with lower agricultural (labor) productivity relative to that in industry should experience faster growth, industrial development acting as a 'magnet', pulling up agricultural productivity. Thus we assume:

$$t_a = \lambda_a^1 + \lambda_a^2 \ln(\pi_a / \pi_a^*) + \lambda_a^3 \ln(\pi_a / \pi_i) \tag{7}$$

$$t_i = \lambda_i^1 + \lambda_i^2 \ln(\pi_i / \pi_i^*) \tag{8}$$

where π is labor productivity[5] and * denotes the leading country (eg USA). The parameters λ_a^1 and λ_i^1 measure different exogenous rates of sectoral productivity growth, the λ^2 terms capture the effect of <u>international</u> catch-up <u>within sectors</u>, while λ_a^3 measures any catch-up effects induced by differences in sectoral productivity rates <u>within countries</u>.[6]

a combined model of disequilibrium growth and differential technological progress

Combining (7) and (8) with (6b) gives:

$$\dot{Y} = \alpha\frac{dK}{Y} + \alpha_1 y\frac{dK}{Y} + \beta\frac{I}{Y}\dot{L}_i + \mu\frac{A}{Y}\dot{L}_a + (\lambda_a^1 - \lambda_i^1)\frac{A}{Y} + \lambda_a^2\frac{A}{Y}\ln\left(\frac{\pi_a}{\pi_a^*}\right)$$

$$+ \lambda_i^2\frac{I}{Y}\ln\left(\frac{\pi_i}{\pi_i^*}\right) + \lambda_a^3\frac{A}{Y}\ln\left(\frac{\pi_a}{\pi_i}\right) + \lambda_i \tag{9b}$$

Substitution of (6a) or (6c) for (6b) gives alternative specifications (9a) and (9c); the addition of assumption (5d) - inter-sectoral differences in the marginal product of capital - implies the addition of the term $\alpha_2\, dA/Y$ to give

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[5]Ideally, we would measure the technological gap by the ratio of total factor productivities; lacking data on capital stocks, we proxy this gap by comparing labour productivity levels.

[6]Though (7) and (8) assume linear relationships we also test for non-linearities by allowing dummy variables at different levels of development and also by testing quadratic terms.

specification (9d). These equations provide the basis for regression analysis on a sample of developed and developing countries, allowing us to test and compare the various hypotheses about the process of growth. Clearly it will be important to test for parameter stability across levels of development. Also, since our data cover 1960-85, we test for stability across periods on either side of the critical 'shock' to the world economy in 1973.

At this point we should note some of the deficiencies of our model. We have not taken account of differences in sectoral productivity levels of the service sector, the government sector or the export sector - although previous authors have suggested that such sectoral differentials may affect growth rates.[7] In part we are limited by data availability, but even where data are available we are not convinced that the apparently significant impact of sectoral growth rates which some of these authors have found is not an artefact of the simultaneous equation bias to which we have referred in footnote 3. Without adequate instruments for estimation of a simultaneous equation system, we have chosen to omit these variables. This choice is guided by a prior belief that if sectoral imbalance is an important part of the growth process, it is likely to be located most strongly in the imbalance between the agricultural sector and the rest of the economy.

We do not take account of changes in capital and labor utilisation rates. Whilst the analysis of fluctuations in these rates, or fluctuations in the 'shadow price of capital' in the temporary equilibrium framework of Ernst Berndt and Melvin Fuss (1986), is clearly important for short-term cross-sectional comparison or time-series analysis we feel that omission of such fluctuations should not induce significant bias into our estimates of trend productivity growth over the medium-term. The evidence from Catherine Morrison's (1986) analysis of temporary equilibrium in the US supports this position.

[7]See Feder (1982, 1986), Ram (1986).; Dowrick (1989), however, finds no significant evidence of differential productivity growth between the industrial and service sectors in the OECD.

More important missing variables are likely to be political factors, especially wars, and natural phenomena such as droughts. To the extent that these are short-lived events, and that economies are able to recover fairly quickly, our use of medium-term trend data should minimize the effect of their omission.

Finally, we note our omission of human capital. Insofar as human capital acts as a stock of inputs into the production process, we would want to include the growth in this stock as an additional, and potentially important, explanatory variable - controlling, of course, for simultaneous reverse causation. This would constitute a major undertaking, well beyond the scope of this study. On the other hand, insofar as human capital acts on a country's capacity to initiate and imitate technological progress, we might expect growth to be influenced by the level (rather than the rate of growth) of educational and skill levels. We are able to test this latter hypothesis on one of our samples with some basic data on educational enrolments.

2. DATA AND MODEL ESTIMATION FOR SAMPLE 1

Since our interest is in medium-term growth we use data which has been averaged or trended over two periods: 1960-73 and 1974-85. The data is discussed in detail in the Appendix. It is based on the international data set of Summers and Heston (S-H, 1988) supplemented by World Bank and ILO sources. While each of these sources provides data on relevant variables for sizeable sub-samples of the 114 S-H countries, these are only partially overlapping giving us a final sample of usable data for 95 observations: 43 countries 1960-73 and 52 countries 1973-85. The countries (observations) are composed as follows: 20 (31) OECD; 8 (11) African; 8 (14) Asian; and 21 (39) Central and South American.

Since this sample excludes almost all of the poorest countries in the Summers and Heston data set we are constrained to test our full model of disequilibrium growth on the rich and middle-income groups. We are, however, able to assemble from World Bank (1988) a much wider though less reliable sample of 78 countries for 1973-85. We refer to the pooled sample with data from 1960-85 as 'sample 1' and to the extended but less reliable sample for 1973-85 as 'sample 2'. The second sample includes 27 of the poorest countries (mainly sub-Saharan Africa) and enables us to test hypotheses concerning technological catch-up at the bottom end of the world income scale. Moreover, information on educational enrolments for sample 2 allows some preliminary testing of the hypothesis that educational levels affect the capacity of countries to initiate or copy technical advances.

We have estimated equations (9a-9d) on the pooled sample of 95 observations., labelling the variables V1 - V11. Descriptive statistics for the main components of these variables are given in Table 1 and the principal regression results are presented in Table 2.

parameter stability

We have tested the models for parameter stability between the two periods and by level of development. The stability test which we use is the standard F-test (or Chow test) applied to all variables and to subsets of variables. Our null hypothesis is that parameters are stable. Where we find evidence of instability which is significant at the conventional 95% confidence level we estimate separate period and/or development level coefficients for the appropriate variables.

The stability tests are described in detail in the notes to Table 2. We find a significant structural break by level of development at 41% of US labor productivity dividing the sample into a high productivity group with 41

Table 1
Descriptive Statistics for Sample 1

Variable means and standard deviations (in brackets) are given for the principal components of the regression variables. Each variable is disaggregated by period and by level of development. The 'rich' countries are those with labor productivity at least 41% of that in the USA; the 'middle-income' countries are those with lower productivity. All variables are measured as averages over periods 1960-73 and 1973-85. GDP and population growth are estimated as logarithmic trends. All growth rates are annual averages.

countries		'middle-income'		'rich'	
period		'60-73	'73-85	'60-73	'73-85
n		28	26	15	26
GDP growth	$\dot{Y}$	.063 (.018)	.047 (.024)	.043 (.012)	.024 (.018)
population growth	$\dot{P}$	.025 (.010)	.024 (.010)	.013 (.010)	.009 (.009)
labor force growth	$\dot{L}$	.019 (.015)	.031 (.017)	.012 (.011)	.015 (.012)
investment ratio	dK/Y	.180 (.067)	.191 (.070)	.240 (.087)	.255 (.054)
agricultural output share	A/Y	.244 (.097)	.196 (.075)	.072 (.034)	.055 (.033)
agricultural labor force share	L_a/L	.505 (.169)	.428 (.161)	.189 (.102)	.113 (.081)
agricultural labor force growth	$\dot{L}_a$	-.006 (.023)	.004 (.036)	-.030 (.022)	-.018 (.020)
industrial labor force growth	$\dot{L}_i$	.044 (.026)	.048 (.022)	.022 (.012)	.021 (.019)
ag. productivity / ind. productivity	π_a/π_i	.332 (.170)	.383 (.295)	.373 (.175)	.539 (.224)
ag. productivity / US ag. productivity	π_a/π_a^*	.176 (.094)	.170 (.150)	.373 (.200)	.547 (.259)
ind. productivity / US ind.productivity	π_i/π_i^*	.296 (.102)	.332 (.106)	.707 (.203)	.758 (.152)

Table 2
Estimation of the impact of sectoral composition and technological spillover on the growth rate of real GDP

The dependent variable is the annual trend rate of growth of real GDP. Estimation is by Ordinary Least Squares (OLS) or by Two-Stage Least Squares (2SLS). t-statistics are shown in brackets; for OLS estimation, the White heteroscedasticity-consistent statistics are reported. The model numbers refer to the equations in the text. the variables V1-V11 are defined in the Appendix. dX/X indicates an annual average rate of growth. n=95. Some diagnostic tests are reported: B-P-G is the Breusch-Pagan-Godfrey chi-square test for heteroscedasticity with k degrees of freedom(we report this because it is the most significant of a battery of heteroscedasticity tests); we also report the Reset test F statistics; significance at the 5% (1%) level is indicated for the diagnostic tests by * (**).

		9a OLS	9b OLS	9c OLS	9d 2SLS
capital stock growth					
V1 : dK/Y	1960-73	.038 (1.04).	**.039 (1.07)**	.042 (1.14)	.041 (1.28)
	1973-85	.230 (6.35)	**.217 (5.76)**	.217 (5.63)	.218 (6.33)
V3 : dA/Y					.656 (0.28)
labor force growth					
V4 : dL_i/L				.469 (3.05)	
V5 : $(I/Y)(dL_i/L_i)$			**.336 (3.58)**		.316 (2.67)
V6 : dL_a/L				.107 (0.48)	
V7 : $(A/Y)(dL_a/L_a)$			**.357 (0.79)**		.288 (0.59)
dL/L		.356 (2.76)			
total factor productivity growth					
V8 : A/Y		.031 (0.69)	**.042 (1.06)**	.032 (0.72)	.017 (0.17)
V9 : $(A/Y)\ln(\pi_a/\pi_i)$		-.094 (-2.24)	**-.061 (-1.41)**	-.087 (-2.07)	-.057 (-1.43)
V10 : $(A/Y)\ln(\pi_a/\pi_a^*)$					
middle	1960-73	.070 (1.97)	**.060 (1.82)**	.062 (1.73)	.058 (1.86)
	1973-85	.036 .(1.17)	**.025 (0.80)**	.028 (0.89)	.018 (0.50)
rich	1960-73	.113 (1.31)	**.106 (1.22)**	.106 (1.21)	.097 (1.29)
	1973-85	.188 (2.68)	**.183 (2.89)**	.193 (3.06)	.171 (2.25)
V11 : $(I/Y)\ln(\pi_i/\pi_i^*)$		-.027 (-4.45)	**-.024 (-3.46)**	-.023 (-3.45)	-.024 (-3.32)
constant	1960-73	.021 (2.36)	**.021 (2.47)**	.018 (2.01)	.022 (2.22)
	1973-85	-.044 (-4.82)	**-.041 (-4.36)**	-.043 (-4.42)	-.040 (-4.20)
$\overline{R}^2$		.5795	**.5933**	.5835	.6343
s.e. of estimate		.015	**.015**	.015	.014
B-P-G chi^2 test		25.3**	**22.3***	25.4*	
RESET 2		4.3*	**0.6**	2.4	
RESET 3		2.6	**1.9**	2.0	
RESET 4		2.5	**1.7**	1.8	

Notes to Table 2

Parameter stability tests have been carried out on all of the models, looking for instability across periods and across levels of development. We report here the results for the preferred model 9b, noting that the stability results for the other models are very similar. Testing for stability across the two periods, the hypothesis that V5, V7, V8-V11 are jointly stable is not rejected at the 5% level: $F(6,79) = 2.04 < 2.22$. We test for stability across levels of development by ranking the observations in order of aggregate labour productivity and conducting Chow tests at every observation in turn. The F-statistic reaches local maxima at the 16th lowest observation and at the 54th lowest observation (corresponding to 14 percent and 41 percent of US productivity). The breaks are individually, but not jointly, significant at the 5% level. We have used the upper break point which corresponds to the World Bank's classification of countries and gives two groups of comparable size. We cannot reject the joint hypotheses that V1 is stable across development groups and that V5, V7 and V11 are stable across periods and across development groups: $F(11,63) = 1.83 < 1.95$.

observations and a lower productivity group with 54 observations (see Appendix for a full listing). This division corresponds closely to the World Bank's distinction between lower middle-income countries and the upper middle-income plus the industrialized countries. We refer henceforth to the two groups as 'middle-income' and 'rich'.

We find that most of the parameters are stable both over time and by level of development. Parameter stability across periods is rejected only for V1, the gross investment rate. Stability across periods *and* by levels of development is rejected only for the group of variables capturing technological progress in the agricultural sector - V8, V9 and V10; here we find coefficient instability and poor identification which is almost certainly due to collinearity. The full set of estimated coefficients on V8-V10 are reported in the Appendix for the preferred model 9b. We report in Table 2 a restricted version allowing for instability in V10 but imposing stability on V8 and V9. This version gives plausible coefficients on all variables[8], but there is residual structural instability. We restrict our inferences from the results in Table 2 to those which are also supported by the full model.

marginal productivity of capital

We are unable to reject the hypotheses that the marginal product of capital is constant across sectors (α_2=0)[9] and across levels of development (α_1=0) - see 9d. This result holds for specifications 9a-c and also holds when we add

[8]F-tests indicate that instability is stronger for V10 than for V8 or V9. We would expect the coefficients on these variables to be of the order of several percent, representing differential annual rates of exogenous technological growth and catch-up. When dummies are introduced on all these variables, however, some coefficients take implausible values as high as ninety percent with standard errors up to twenty percentage points - see Appendix Table 2.

[9]When 9d is estimated by OLS α_2 is estimated to be over 2. This implies an implausible negative marginal product of capital in industry. We believe this result to be the result of simultaneous equation bias, since we expect GDP growth to stimulate agricultural output through demand side effects. We agree with Rao's (1989) criticism of single equation estimates of the supply side effects of sectoral growth. Comparison with our preferred 2SLS estimate confirms the suspicion of simultaneous equation bias.

development level dummy variables for the investment variable V1. Accordingly, we omit variables V2 and V3 from specifications 9a-c.

We find, however, the surprising result that the marginal product of capital is estimated to rise from 4% in the 1960s to over 20% for the period after 1973. (If we drop the observation for Mexico in the first period, which is the only significant outlier on the DFFITS test, the first period estimate rises to 6%, significant at the 10% level). This finding is robust across our different specifications 9a-c; it holds also for an unreported simplified model estimated on the full Summers and Heston sample.

We are unable to offer a convincing explanation for such marked differences in returns to investment between the two periods. A capital-shortage explanation is not supported by the evidence that investment rates are generally higher after 1973. We might conjecture that technological progress was 'disembodied' in the 1960s but was embodied in investment goods in the later period. We also note the evidence presented by J.R. Sargent (1982) that the real cost of capital in the industrialised economies fell in the 1960s, due to a combination of tax concessions and lowered risk premia, and rose again in the 1970s due to the oil shocks and increased uncertainty.

labor reallocation

We have three models of the effects of labor reallocation between agriculture and industry. 9a is a nested version of 9c: the hypothesis that the coefficients on V4 and V6 are equal is not rejected at even the 10% level (t=1.37), so we may tentatively prefer 9a to 9c. In Table 3 we report the Davidson-MacKinnon J test statistics to distinguish between the non-nested models . Model 9b is preferred unambiguously; it is superior at the 5% level to 9a, and at around the 10% level to 9c. This evidence implies support for the hypothesis that there is disequilibrium between sectors in those countries where the average productivity of labor is substantially lower in agriculture

Table 3

Non-nested tests of alternative specifications

We first compare models 9a, 9b and 9c by adding the predicted values of each model to each of the other models. T-statistics are reported. With 81 degrees of freedom, the 10% critical value on a two-tailed test is 1.67, the 5% critical value is 1.99. A significant t-statistic implies that the maintained model H_0 is rejected in favour of the alternative model H_1.

	Alternative model (H_1)		
Maintained model(H_0)	9a	9b	9c
9a	---	2.23	1.36
9b	-0.50	---	-0.13
9c	0.67	1.65	---

We next compare the preferred model 9b with models 10b, 11b and 12b which alternately replace the group of variables V8-11 with levels of per capita GDP, the logarithm of per capita GDP, or the logarithm of aggregate labor productivity (allowing separate sub-group coefficients on these variables, as for V10). The critical test-statistics are similar to those reported above.

	Alternative model (H_1)			
Maintained model(H_0)	9b	10b	11b	12b
9b	---	0.91	1.46	1.13
10b	4.40	---	4.42	4.48
11b	3.05	-2.35	---	2.52
12b	2.32	2.31	2.48	---

than in industry. Such countries are typically, but not entirely, the poorer (i.e. low productivity) countries.

Our preferred model predicts that the greatest gains from labor reallocation are to be found in those countries with a low productivity ratio. For illustrative purposes, we can predict from the coefficients on V5 and V7 in 9b the effects of an annual transfer of one percent of the total labor force from agriculture to industry. We take as a benchmark a hypothetical country where employment is divided evenly between the sectors and labor productivity in agriculture is one third of that in industry. (These figures correspond roughly to the variable means for the middle-income group of countries in the first period.) Thus, a two percent reduction in agricultural labor is matched by a two percent increase in industrial labor; we estimate that this causes GDP growth to increase by 0.3 percentage points. If the agricultural productivity level is as low as one tenth of that in industry (as in some of the poorest countries in the sample) GDP growth is increased by 0.5 percentage points, suggesting that the impact of labor transfers on aggregate growth can be quite substantial for those countries with a large productivity gap between sectors.

<u>total factor productivity growth in agriculture</u>

Agricultural TFP growth is captured in our model by three variables, V8-V10: the share of agriculture in total output; the ratio of agricultural to industrial productivity; and the ratio of agricultural productivity to that in the USA.[10] We find that the signs and sizes of the coefficient estimates are similar across specifications 9a-9d as reported in Table 2. V8 and V10 are consistently positive, while V9 is negative. (The same sign pattern holds for the full set of dummy variables reported in the Appendix except in the case of V8 which is negative for the rich countries).

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[10]The coefficients on these three variables, V8-V10, including the period and development dummies on V10, are individually not well determined in the preferred speficication 9b, due to collinearity. They are, however, jointly significant on an F-test: F(6,82) = 3.18, compared with the 1% critical value of 3.05.

The negative coefficients on V9 imply that where the agricultural sector is less-developed than the industrial sector, there is a tendency for *internal catch-up* to occur, i.e. productivity advances in the industrial sector feed through to the agricultural sector. We might expect this process to take place through the provision of farm machinery, equipment, fertilizers, etc.

The positive coefficients on V10 suggest that productivity levels in agriculture are tending towards *international divergence within each development group*. Technological advances in the leading agricultural producers (such as the USA, Canada and Australia) do not appear to feed through to lower productivity producers. This divergence of agricultural productivity levels is strongest within the group of relatively more developed countries, especially after 1973 when the coefficient estimate is 0.183; on the other hand, the divergence is small (0.025) and statistically insignificant for the middle-income group after 1973. This evidence suggests the possibility that such innovations as the 'green revolution' of the 1970s helped boost agricultural productivity growth in the middle-income group which is composed largely of Asian and the poorer South American countries. These countries may have benefitted from the development of new strains of crops such as rice and wheat- so that they have at least kept pace with rates of progress in the most advanced agricultural sectors, even if they have not narrowed the gap[11]. The agricultural laggards appear to be the low productivity agricultural producers amongst the richer group of countries.

total factor productivity growth in industry

Our results indicate that *industrial* productivity levels, on the other hand, exhibit a pattern of *international convergence*: the coefficient on V11 is significantly less than zero at the 1% level.[12] It appears, therefore, that direct

[11]Allen Kelley (1988: 1704)) suggests that the success of the "Green Revolution" may have depended in part on the scale economies made possible by population density as found in most Asian countries.

[12]When we estimate separate sub-group coefficients on V11 there is some indication that industrial catch-up is stronger within the middle-income group and also that the rate of catch-up has slackened since 1973; the differences between the coefficients are not, however,

technological spillover is confined to the industrial sector. We interpret the evidence on internal catch-up to imply that any agricultural catch-up tends to be indirect: if a middle-income country takes advantage of possibilities for technical progress in its industrial sector, it can expect some of the productivity gains to be passed on to the agricultural sector. These results tend to confirm the view that industrial development is at the heart of the development process for the middle-income countries.

comparison of aggregate and sectoral models of technological catch-up

Previous studies of technological catch-up have tested for systematic relationships between growth rates and starting levels of *aggregate* rather than *sectoral* productivity, or per capita GDP. It is of interest to compare our preferred model 9b, as reported in Table 2, with alternative models which replace the sectoral productivity variables V8-V11 by either labor productivity or per capita GDP. Table 3 presents the non-nested J-test statistics. We cannot distinguish between per capita GDP, its logarithm, or the logarithm of labor productivity in terms of their ability to predict GDP growth; but our sectoral model is significantly superior when measured against any of these alternatives.

implications for the growth of GDP and per capita income

The average rate of growth of GDP for the middle-income group exceeds the average growth rate for the developed economies by 2 percent per annum between 1960 and 1973, and by 2.3 percent per annum between 1973-85. In Table 4 we decompose these differentials into the components attributable to groups of variables using both the estimated coefficients from the regression 9b as reported in Table 2 and also the coefficient esitmates from the specification reported in the Appendix.

The lower rate of investment in the middle-income group predicts slower growth, especially in the second period when we estimate that the marginal

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statistically significant. Quadratic terms on the catch-up variables V10 and V11 are not statistically significant.

Table 4
Explaining differences in the average rates of growth of the developed and less developed countries

The predicted difference in annual percentage rates of growth of trend GDP between the middle-income countries average and the rich countries average is decomposed by groups of variables using the regression coefficients reported in Table 2 (figures in brackets are derived from the alternative results reported in the Appendix) and the sub-group means reported in Table 1. A positive number indicates that the value for the middle-income group exceeds that for the rich group.

differences in GDP growth due to	1960-73		1973-85	
investment rates (V1)	- 0.24	(-0.22)	- 1.40	(-1.59)
labor force growth and re-allocation (V5 & V7)	0.47	(0.13)	0.73	(0.54)
productivity growth in agriculture (V8, V9 & V10)	- 0.10	(-0.26)	1.50	(1.26)
productivity growth in industry (V11)	1.43	(2.05)	1.52	(2.18)
unexplained differential	0.44	(0.30)	- 0.05	(-0.09)
= observed difference in GDP trend growth	2.00		2.30	
less population growth differential	1.20		1.50	
= observed difference in growth of per capita GDP	0.80		0.50	

productivity of capital was high. This is offset to some extent by the faster rates of growth of the labor force in LDCs. The main source of differences in growth is, however, the faster rate of technological progress in the poorer countries - the catch-up effect. We have combined here the estimated effects of the three agricultural sector variables - V8, V9 and V10 - to give an estimate of the net effect of technical progress in agriculture. It is important to note that the estimation procedure using the full set of dummy variables, as reported in the Appendix, gives very similar results to the procedure based on the restricted regressions: in the first period, the large, slow-growing agricultural sectors in middle-income countries slowed annual GDP growth relative to that of the rich countries by 0.1 (0.3) percentage points . Since 1973, however, improved productivity growth in agriculture contributed to higher relative growth rates by as much as 1.5 (1.3) percentage points. Technological catch-up in the industrial sector has directly contributed around 1.5 (2.0) percentage points in both periods. (The indirect contribution of the industrial sector through internal catch-up is over 1 percentage point after 1973).

Given these estimated rates of technological catch-up, particularly after 1973, why have *per capita income* levels in the middle-income countries converged so slowly on those of the rich countries (catch-up has been less than one percent per annum) and why have we not observed intra-group convergence ? From the descriptive statistics given in Table 1, it appears that the answer is simple: capital investment has been lower in the poorer countries and their rates of population growth have been much higher. Rapid catch-up in total factor productivity has been largely offset by a rapid falling behind in capital per head of population. (This observation is also borne out in the full Summers and Heston data set, i.e. our results do not appear to reflect sample selection bias).

3. MODEL ESTIMATION INCLUDING THE 'POOR' COUNTRY GROUP

We turn next to Baumol's observation that there is a third 'growth club', comprising the world's poorest economies. When we estimate model 9b on our second sample of 78 countries for the period 1973-85 this observation is strongly confirmed. Tests for structural breaks by levels of labor productivity now reveal two jointly significant breaks at 41 percent and 13 percent of US levels. The upper break point between 'rich' and 'middle-income' countries matches almost exactly the break identified in sample 1; this break is straddled by Greece, Uruguay and Argentina. The lower break point corresponds to the very bottom of the middle-income group in sample 1, giving a group of 29 'poor' countries which are almost all African. The country groups are listed in the Appendix; sub-sample means of the principal variables are given in Table 5; summary regression results are given in Table 6.

We are able to include an additional variable which measures the proportion of the school-age population who were in secondary education in 1965. This variable attempts to capture the educational level of the workforce in the 1970s and early 1980s and it allows testing of Baumol's (1986: 1081) hypothesis that this educational level may influence a country's ability to initiate and copy technological advances. Given the poor quality of labor force growth data for this sample, we concentrate on the estimates of technological change which are reported in Table 6.

Estimating equation 9b, we cannot reject the hypothesis that variables V2, V8 and V9 are equal to zero for all country groups and that the educational variable equals zero for both the rich and middle-income groups. We find that the parameter break between the rich and middle-income country groups is located in the agricultural productivity variable, V10. On the other hand, almost all of the variables exhibit instability between the middle-income group and the poor group. The reported results impose the appropriate restrictions

Table 5
Descriptive statistics for sample 2

Mean values are given for the principal variables in sample 2, averaged over the period 1973-85. The sample division into 'rich', 'middle-income' and 'poor' country groups is explained in the text. Growth rates are annual percentage averages.

	All	Rich	Middle	Poor
sample size	78	22	27	29
log(per capita GDP)	7.44	8.86	7.56	6.26
growth of per capita GDP	1.1	1.5	2.1	-0.3
growth of population	2.1	1.0	2.4	2.8
investment as % of GDP	18.6	25.1	19.3	13.1
agricultural output share	0.216	0.051	0.180	0.374
" labor force share	0.482	0.126	0.458	0.774
growth of ag. labor force	0.19	-2.13	0.38	1.79
growth of ind. labor	3.73	2.15	4.39	4.34
ag. productivity (/US)	0.195	0.479	0.136	0.033
ind. productivity (/US)	0.421	0.791	0.387	0.173
ag. / ind. productivity	0.294	0.451	0.269	0.198
education enrolment	0.254	0.550	0.224	0.059

Table 6
Estimation of model 9b augmented by an education variable on sample 2, 1973-85

Estimation is by OLS on a pooled sample of 'rich', 'middle' and 'poor' countries. Variables are defined in the appendix with the addition of 'education' which is the proportion of the school-age population enrolled in secondary education in 1965. Variables V2, V3, V8 and V9 have been omitted. '-' indicates a variable has been constrained to zero for that country group. " indicates that the coefficient has been constrained to equal that for the group above. Heteroscedasticity-consistent t-statistics are reported in brackets. A further t-statistic is reported below each regression reporting the test on the hypothesis that the coefficients for the middle and poor groups are the same. n gives the sub-sample and total sizes.

	V1	V5	V7	V10	V11	Education	Constant	n	$\bar{R}^2$
Regression 1									
rich	0.235	0.204	0.822	0.257	-0.018	-	-0.033	27	
	(6.06)	(1.52)	(0.56)	(3.49)	(-2.63)		(-3.77)		
middle	"	"	"	-0.029	"	-	"	27	
				(-1.45)					
poor	0.106	-0.125	-2.738	-0.017	0.066	0.087	0.072	21	
	(1.43)	(-0.78)	(-1.38)	(-1.85)	(5.72)	(2.18)	(3.11)		
	(-1.51)	(-1.57)	(-1.38)	(0.55)	(6.26)		(4.24)	75	0.533
Regression 2									
rich	0.232	0.238	1.14	0.270	-0.020	-	-0.033	27	
	(5.95)	(2.24)	(1.18)	(3.15)	(-3.18)		(-3.67)		
middle	"	"	"	-0.019	"	-	"	27	
				(-2.29)					
poor	0.117	-0.138	-2.08	"	0.066	0.069	0.067	21	
	(1.61)	(-0.85)	(-1.61)		(5.77)	(3.03)	(3.05)		
	(-1.37)	(-2.10)	(-2.07)		(6.71)		(4.07)	75	0.539
Regression 3									
rich	0.227	0.275	1.486	0.103	-0.013	-	-0.035	29	
	(5.32)	(1.95)	(0.97)	(0.96)	(-1.57)		(-3.48)		
middle	"	"	"	-0.035	"	-	"	27	
				(-1.66)					
poor	0.100	-0.086	-2.234	-0.012	0.047	0.082	0.052	22	
	(1.41)	(-0.59)	(-1.19)	(-1.41)	(3.46)	(1.80)	(2.30)	78	0.412

Notes: The F-statistics for the exclusion of variables V2, V8 and V9 for each group and the other restrictions noted above are 0.73 (16,45) and 0.70(17,44) for regressions 1 and 2 respectively. There is no evidence of functional mis-specification from the Reset test. The Harvey test indicates weak heteroscedasticity. The standard errors of the regression are 0.0159 and 0.0158 for regressions 1 and 2 respectively. Regression 3 includes additional observations for Burma, Benin and Mexico which are the only significant outliers on the DFFITS test with t-statistics of 2.14, 3.04 and 2.88 respectively.

applied to a preferred sample of 75 (excluding Benin, Burma and Mexico which are the three significant outliers on the DFFITS test) and also for the full sample.

A number of interesting observations emerge. First, the results for the rich and middle-income countries are broadly similar to those for sample 1. The marginal product of capital is statistically significant and high; industrial sector catch-up, V11, is strong; agricultural productivity levels in the middle group are catching-up (V10 is negative), but they are diverging within the rich group (V10 is positive).

Second, the marginal product of capital in the poor countries is considerably lower than in the richer countries, suggesting that capital is not fully mobile between these groups. The evidence on technological advance in the poor countries is particularly interesting: industrial productivity is diverging both within the group and relative to the richer countries (V11 is significantly positive, and the combined effect of V11 and the shift in the constant term is to predict lower TFP growth for the poor group compared with the richer groups)[13] Agricultural productivity in the poor group, on the other hand, exhibits a tendency to catch-up (V10 is significantly negative at the 10% level in Regression 1, and significantly negative at the 5% level in Regression 2 where we impose the additional and valid restriction of equality with the middle-income group).

Third, whilst we can detect no evidence of significant *ceteris paribus* effects of education for the middle and rich groups, education does appear to boost growth for the poor countries. This result depends, however, on the inclusion of India within the group of poor countries - India's secondary enrolment rate of 27 percent is far higher than the group average of less than 6 percent. Exclusion of India reduces the coefficient to negligible size and

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[13]We are assuming here that all of the shift in the constant term is a shift in the parameter λ_i, ignoring shifts due to breaks in other variables.

statistical insignificance. We have also examined the impact of tertiary enrolment rates but can find no evidence of significant effects.

These results, together with the sub-sample means of the principal variables in Table 5, indicate some of the reasons why per capita GDP in the poorest group is not catching-up on levels in the middle-income and rich groups. Although we have found evidence of reasonably rapid growth in agricultural productivity in the poor countries, agricultural output comprizes less than 40 percent of GDP and agricultural catch-up appears to be dominated by slow productivity growth in the rest of the economy. Labor force reallocation out of agriculture occurs in the poor countries but not nearly as strongly as in the richer groups, despite the very low productivity levels in agriculture in the poorest group. We may speculate that the sluggish growth of productivity in the industrial sectors and the relatively slow transfer of labor out of agriculture are related to the very low levels of investment which in turn may be related to a low propensity to save out of low and declining incomes in the poorest countries. The inability of these countries to take advantage of technological spillovers in industry and their inability to increase capital stocks to keep pace with their burgeoning populations appear to have trapped them in a low income, low growth cycle.

4. SUMMARY

We have attempted in this paper to examine Baumol's (1986) suggestion that, for a large sample of capitalist countries at different per capita income levels, there are three 'growth clubs'. To do so requires a model of the growth process which is capable of explaining systematic differences in growth rates across countries. We have adapted a disequilibrium model of growth which hypothesizes that sectoral reallocation of resources can boost growth rates and we have tested the hypothesis that the degree of disequilibrium is systematically related to observed differences in levels of labor productivity. In addition we hypothesize the possibility of international technological transfer from high- to low-productivity countries, allowing this to vary by sector and by level of development, and we hypothesize the possibility of intersectoral technological transfer.

Testing the model on a sample of 'rich' and 'middle-income' countries over two periods 1960-73 and 1973-85, our results suggest that intersectoral labor reallocation does make a significant contribution to GDP growth. Our tests between three models of labor market disequilibrium clearly reject the hypothesis that labor markets are uniformly in equilibrium (characterized by equality of marginal products across sectors). We also reject the hypothesis that the degree of disequilibrium is the same in all countries, preferring instead a model which assumes that the degree of disequilibrium is proportional to the observed ratio of sectoral labor productivities, a ratio which in turn is closely related to levels of development.

We are unable to find statistically significant evidence in this first sample of systematic differences in the marginal product of capital by levels of development, though there appears to have occured a substantial increase over time. We also reject the hypothesis of systematic sectoral disequilibrium in the capital market and note that single-equation estimates of such disequilibrium may be biased.

We find that rates of technical progress do differ substantially between sectors. Our preferred model has significantly better explanatory power than models which impose uniform rates of TFP growth across sectors. We find *industrial* sector catch-up to be strong, implying convergence of productivity levels both within and between the two groups of countries. *Agricultural* productivity levels on the other hand appear to have been diverging before 1973, but much less so thereafter, especially for the middle-income group. These results are consistent with evidence of the "green revolution" - adoption of agricultural innovations in various middle-income countries in the 1970s enabled the group to at least keep pace with US agricultural productivity growth. We also find some evidence that high productivity in the industrial sector has positive externality effects on the agricultural sector.

These results for the rich and middle-income countries are broadly confirmed when we estimate our preferred model on a larger sample for the period 1973-85. This enlarged sample contains an additional 27 of the poorest countries, mostly African. We find that their growth performance is substantially different. The estimated marginal product of capital in the poor countries is much lower and while their rate of productivity catch-up in agriculture is similar to that of the middle-income countries we find strong statistical evidence that productivity in industry is diverging within the group of poor countries and also falling behind in relation to the world leaders. We report weak evidence suggesting that educational levels may have some positive impact on productivity growth within the group of poorest countries.

Our findings partially confirm the Baumol and Abramovitz hypotheses that technological spillover assists productivity growth in countries at a medium level of development but is unavailable to the least developed countries. While this hypothesis is confirmed for the industrial sector, it does not appear to hold for agriculture where the poorest countries have been catching-up since 1973. This sectoral difference can perhaps be explained by the product-mix hypothesis since the range of agricultural produce is much more stable over levels of development than is the case with the industrial product range.

Two major questions emerge from our analysis: i) why are the middle-income countries - who are benefitting from technological spillover in both sectors and also benefitting from labor reallocation - not converging faster on per capita income levels in the richer countries? ii) why are the poorest countries falling behind so badly despite productivity catch-up in their large agricultural sectors?

The proximate answer to i) is suggested by the evidence that the middle-income countries have lower investment and faster population growth than the rich countries; i.e. their TFP catch-up and labor reallocation gains are substantially offset by a relative decline in the stock of capital per head of population. This same story accounts for the observed intra-group divergence of per capita GDP.

The answer to question ii) is more complex. First, although the potential for gains out of labor reallocation are high in the poorest countries, the actual rate of reallocation has lagged behind that in the middle-income countries. (The rate of reallocation of labour is probably constrained by the availability of funds for investment in industry). Second, although agricultural productivity is catching up, agriculture typically accounts for only one third of measured GDP. Third, we note the inability of the poorest countries to catch-up in industrial technology - indeed industrial TFP levels are falling behind. Fourth, we observe the strong tendency for growth rates of capital per head of population to be even lower in the poor countries than in the middle-income countries.

These observations are indicative of a structural poverty threshold in world development. Once over this threshold, countries are able to follow the route of modernisation and catch-up through industrialisation. Kelley (1988) documents the historical tendency for rates of population growth to diminish with growth in real income per head; we observe an upward-sloping 'Engel Curve' for rates of saving and investment which rise as real incomes move above subsistence levels; and we have estimated that once countries have reached the 'middle-income' level of development they are able to take advantage of strong technological spillover in their industrial sectors with subsequent spillover to their agricultural sectors.

The poorest countries, however, appear to be falling away from the threshold of development. Below this threshold it is extremely difficult to sustain sufficient growth in per capita income to generate the savings and investment (and perhaps to moderate population growth) which might allow further growth. It emerges from our analysis that it would be in vain merely to hope that the fruits of technological advance in the rich capitalist economies will automatically spillover to the benefit of the poorest. The poorest countries in sub-Saharan Africa appear currently to be trapped in a cycle of poverty.

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APPENDIX

The data set used to examine the model of Section 1 is a sub-sample of the 114 countries for which Summers and Heston (1988) provide internationally comparable estimates of real GDP and expenditure components for 1960-85. Since our interest is in medium-term growth we estimate trend growth rates of real GDP for two periods 1960-73 and 1973-85. The S-H data is measured at constant (1980) international prices. Unfortunately agricultural output data on a similar basis are not available. We therefore estimated the share of agriculture in constant domestic price output using World Bank data and combined this with the S-H GDP data to obtain (annual) agricultural output. This provides real agricultural output data evaluated at aggregate purchasing power parity (PPP) and does not therefore allow for different agriculture/non-agriculture terms of trade between countries. However in the absence of an agricultural PPP index this represents the best available data for international comparisons and for our estimates of trend growth rates in agricultural output, only differential changes in the 'internal' terms of trade across countries are ignored. Data on the share of gross investment in GDP are also obtained from S-H (1988) and are measured as the average value within each period.

Labor force growth data for OECD countries were obtained from OECD publications and for non-OECD countries were estimated from two components: (1) trend growth rates of population from S-H (1988) and (2) rates of change in the 'participation rate' from ILO publications. The ILO source provides data on the participation rate for years around 1960, 1973 and 1985 from which average annual changes were calculated for 1960-73 and 1973-85. Subtracted from population growth rates, this gives an, admittedly crude, estimate of labor force growth. However in the light of clear evidence of differences between countries and over time in participation rates we believe that these estimates proxy labor force growth more accurately than the population growth rates which some previous studies such as Ram (1986) have used. The ILO source also provides data for the share of total labor force in agriculture.

These sources give a complete set of data for only 43 countries, 1960-73, and 52 countries, 1973-85, after we have deleted four observations with which we suspect data problems. The main reason for the restricted size of this sample is the absence of ILO data on participation rates for many countries, especially the poorest. However, World Bank (1988) does give estimates of labour force composition and growth for the 1970s and 1980s. Their estimates of labour force growth rates are not as reliable as those which we have compiled directly from ILO sources, partly because of data collection problems in the very poorest countries and also because the World Bank data are generally based on ILO projections rather than on the census of survey data which underly our first sample. Nevertheless, the World Bank source allows us to create a sample of 78 countries for the period 1973-85 including many of the poorest (mainly African) countries excluded from Sample 1.

The variables used in the regression analysis and their data sources are:

Variable		Source
GDP growth	$\dot{Y}$	Summers-Heston (S-H), 1988
V1	dK/Y	S–H, 1988
V2	$(dK/Y)\ell n(\pi_i/\pi_i^*)$	As for V1 and V11 (see below)
V3	dA/Y	World Bank, World Tables+, and S-H, 1988
V4	$\frac{L_i}{L}\dot{L}_i$	labor force from OECD, ILO World Bank+
V6	$\frac{L_a}{L}\dot{L}_a$	"
V5	$\frac{I}{Y}\dot{L}_i$	" , output shares from World Bank+
V7	$\frac{A}{Y}\dot{L}_a$	" "
V8	A/Y	World Bank+
V9	$\frac{A}{Y}\ell n(\pi_a/\pi_i)$	estimated from labor and output data as above
V10	$\frac{A}{Y}\ell n(\pi_a/\pi_a^*)$	"
V11	$\frac{I}{Y}\ell n(\pi_i/\pi_i^*)$	"
Education		World Bank (1988)

+ Data obtained from the International Economic Data Bank computer tape at the National Centre for Development Studies, Australian National University.

Y is real GDP measured at constant 1980 international prices; A and I are real value added in agriculture and 'industry'. dK is gross investment, L is labour force, p is labor productivity and a dot above a variable indicates the annual rate of growth. A complete list of the countries included in the two samples is given in Appendix Table 1. The additional regression results referred to in the text are given in Appendix Table 2.

Appendix Table 1
List of Countries for Sample (1), 1960-85 and Sample (2), 1973-85

'x' indicates that a country is included in the sample. Sample 2 is listed in the first column, sample 1 in the second and third columns. Countries are ranked in ascending order of labor productivity averaged over the period 1973-85. For Sample 1, observations for Greece and Uruguay 1973-85 are included in the 'rich' group and India, Cameroon and Sudan are classified as 'middle-income'.

	(2)	(1)	
"Poor"	73-85	1960-73	73-85
Mali	x		
Zaire	x		
Burundi	x		
Uganda	x		
Ethiopia	x		
Tanzania	x		
Malasia	x		
Cent. African Rep.	x		
Guinea	x		
Burma	x		
Madagascar	x		
Benin	x		
Ghana	x		
Lesotho	x		
Sierra Leone	x		
Niger	x		
Togo	x		
Bangladesh	x		
India	x	x	x
Kenya	x		
Liberia	x		
Mauritania	x		
Senegal	x		
Nigeria	x		
Cameroon	x		x
Ivory Coast	x		
Zambia	x		
Sudan	x	x	
Zimbabwe	x		

	(2)	(1)	
"Middle"	73-85	1960-73	73-85
Congo	x		
Botswana		x	x
Honduras	x	x	x
Thailand	x	x	x
Pakistan	x	x	x
Egypt	x		x
Philippines	x	x	x
Morocco	x		x
Bolivia	x	x	
El Salvador	x	x	x
Turkey	x	x	x
Paraguay	x	x	x
Guyana		x	
Dominican Rep.	x	x	x
Korea	x	x	x
Jamaica		x	
Jordan	x		
Tunisia	x	x	x
Equador	x	x	x
Colombia	x	x	x
Nicaragua	x	x	x
Panama	x	x	x
Peru	x	x	x
Algeria	x	x	x
Costa Rica	x	x	x
Malaysia	x		x
Fiji		x	
Portugal	x		x
Barbados		x	x
Greece	x	x	x
Uruguay	x	x	x

	(2)	(1)	
"Rich"	73-85	1960-73	73-85
Argentina	x	x	x
South Africa	x		x
Chile	x	x	x
Mexico	x	x	x
Singapore	x	x	x
Japan	x		x
Venezuala	x	x	x
U.K.	x		x
Finland	x	x	x
Trinidad & Tob.	x	x	x
New Zealand	x		x
Italy	x	x	x
Austria	x	x	x
Australia	x		x
Iceland			x
Denmark	x	x	x
Sweden	x		x
Germany		x	x
France	x	x	x
Netherlands	x		x
Luxamburg			x
Belgium	x	x	x
United States	x	x	x
Canada	x		x
Norway	x	x	x
TOTAL	78	43	52

Appendix Table 2
Further estimation of model 9b on sample 1 : full set of dummy variables on all the agricultural variables

The estimated model is 9b as in Table 4; dummy variables have been added to V8 and V9 for country groups and periods. '=' indicates a coefficient is constrained to equality across country groups or periods. The F-test on all of the restrictions is 1.83 with 13,63 degrees of freedom. The 5% critical value is 1.9.

Country group	middle	middle	rich	rich
Period	1960-73	1973-85	1960-73	1973-85
V1	0.036 (1.20)	0.248 (5.81)	=	=
V5	0.206 (2.13)	=	=	=
V7	0.490 (1.18)	=	=	=
V8	.060 (1.43)	0.094 (1.27)	-.201 (-2.05)	-.029 (-0.31)
V9	-.096 (-1.70)	-.046 (-0.72)	-.448 (-2.62)	-.933 (-3.54)
V10	.095 (2.45)	.038 (0.82)	0.301 (-1.34)	.803 (3.95)
V11	-.034 (-4.00)	=	=	=
Constant	.019 (2.09)	-0.053 (-4.82)	=	=

Summary statistics

$R^2 = 0.7003$, $\overline{R}^2 = 0.6293$; log likelihood = 280.00; s.e. of estimate = 0.014, n = 95

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