Accumulation and Productivity Growth in Industrializing Economies

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Abstract

Historically, episodes of rapid growth are accompanied by significant structural change. In this paper we therefore aim to quantify the extent to which factor accumulation induces structural change and productivity growth in industrializing economies. To fix ideas we present an extension of Barro, Mankiw and Sala-i-Martin's (1995) growth model that incorporates two sectors, traditional and modern, and an endogenous wage gap, due to efficiency wages. The model thus draws on ideas of Lewis (1954) and the dual economy literature. We quantify the model using a panel of 78 countries over the post war era. The results show that these labour reallocation effects can increase the effective return to physical capital by around 30% in many countries. We conclude that the productivity gains through labour re-allocation are potentially a significant contributing factor to transitional growth episodes in industrializing countries, and provide some examples.

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1 Introduction

In 1870 the USA had seventy percent of its labour force employed in agriculture. By 1900 this had halved, and by 1998, the proportion was just three percent, thus mirroring a process that occurred in Europe a century earlier.[1] These structural changes are viewed as symptomatic of shifts in methods of production and organization that were necessary in order to achieve economic development and high income levels, (Williamson (1988), Chenery, Robinson and Syrquin (1986)). Yet, during the post WWII era, only a handful of countries have achieved a similar transformation. Consequently sixty percent of the world's population currently live in economies where more than half of the labour force is employed in agriculture.

Understanding the interaction between structural change and economic growth, is therefore likely to be a critical step toward understanding the post war variation in growth rates, as well as for forming policies to assist growth in under-developed countries. Nevertheless, relatively little of the recent growth theoretical and empirical growth literature has been concerned with these transitional growth effects. In this paper, therefore, we aim to define and quantify some of these relationships, using cross country panel data.

Our analysis extends the existing literature in two ways. First, our focus is specifically on obtaining quantitative estimates of the extent to which physical and human capital accumulation can induce productivity growth, by drawing labour from the low wage Malthusian sector. If these effects are large, this would give greater credence to growth and theories that emphasize the role of factor accumulation, in the process of industrialization. Second, in order to avoid the relatively *ad hoc* approaches used in previous empirical literature on structural change and growth, we provide a rigorous theoretical foundations for our empirical analysis.[2] Specifically, the equations we estimate are derived explicitly from an optimal

[1] Maddison (2001).

[2] The more rigorous attempts to measure the relationship between structural change and growth include Feder (1986) and Dowrick and Gemmell (1991), but neither consider an explicit theory of wage gaps, or sets out an explicit optimizing growth model.

growth model that incorporates a traditional, or Malthusian, sector as well as a modern sector.[3] Moreover our model also features an endogenous wage gap between the Malthusian and modern sectors. This in turn provides a simple quantifiable relationship between factor accumulation and productivity growth.[4]

Given the extraordinary data demands of this type of model, we regard this empirical exercise as exploratory rather than definitive. Nevertheless the results are compelling. We find that there are significant the productivity gains from labour re-allocation due to physical capital accumulation, but not human capital accumulation. We find that for the 40% of the countries in our sample, the productivity gains from labour re-allocation increases the real return to physical capital by 25-30%. We show further, that this implies substantial effects to the growth rates, particularly in countries experiencing rapid growth in the rate of investment.

2 A model of growth and structural change

2.1 Background

The early dual economy literature that followed Lewis (1954), such as Jorgenson ((1961), (1967)) and Ranis and Fei (1961), formalized the conditions under which growth can be sustained, and described how a secular decline in the importance of agricultural, affects the pattern of growth and accumulation. These models were widely used in the 1970's to understand the pattern of growth in industrializing economies, particularly Japan, Ohkawa and Rosovsky (1973), and Kelly, Williamson and Chetham (1972). They were also extended by Dixit (1968) and Stern (1972), who incorporated forward looking expectations, thus

[3]The model thus follows recent papers by following recent theoretical models such as Robertson (1999) and Hansen and Prescott (2002), but is also related to an older development and growth literature that followed Lewis (1954) and Jorgenson (1961). See also Temple (2002) for a paper with a similar theme, but very different methodology.

[4]The theory of endogenous sectoral wage gaps follows the development literature as surveyed by Stiglitz (1999). The role of efficiency wages in two sector growth models is explored more fully in Landon-Lane and Robertson (2002).

endogenizing investment decisions.[5]

In Landon-Lane and Robertson (2002), we introduce a model that builds on this dual economy literature, but incorporates human capital accumulation and endogenous wage gaps through efficiency wages. In this paper we present a version of that model, that is suitable for empirical analysis, and consider in more detail the relationship between factor accumulation and productivity gains. As in Landon-Lane and Robertson (2002) we assume there exists a traditional sector that uses labour intensive methods, with simple organizational structures. Examples include small scale farmers and farm laborers, construction gangs, retainers, domestic services and street-side services.[6] In contrast the modern sector firms use physical and human capital intensive techniques. Examples include factory employment, large scale farms, and government administration.[7] By virtue of the capital intensity, modern sector firms face increasing costs associated with employee absenteeism and coordination. These firms therefore find it profitable ration employment resulting in a wage gap between the traditional and modern sectors. The following section formally sets out this model, before turning to the empirical analysis.

2.2 Household's investment decisions

The economy consists of households and firms. Households own labour and physical and human capital services, and rent these services to firms. They also choose how much to consume at each point in time allocate labour hours of the household members to the traditional or modern sectors. Following Barro, Mankiw and Sala-i Martin (1995), we assume that households can borrow externally at an exogenously given world interest rate, $\overline{r}$. The

[5]Other extensions aimed at understanding the causes and consequences of migration when slow urban sector growth failed to generate employment, Harris and Todaro (1970), Fields (1975), Stiglitz (1999).

[6]We do not assume "surplus labour", Sen (1967), though the model is consistent with a surplus labour story as well.

[7]Thus the traditional and modern sectors are distinguished by the methods of production, and not the commodities they produce. Our sectoral division correspond closely to Lewis (1954), but differs from much of the literature that followed Lewis, which focused on agriculture and industrial sectors, Dixit (1973).

foreign debt may be used to finance consumption or investment plans. Hence the households' optimal consumption plan depends on the external costs of borrowing and any credit constraints.

We assume that a representative consumption good can be produced by either traditional or modern methods. Letting $c_X(t)$ and $c_Y(t)$ be the per capita consumption of traditional and modern outputs respectively. We assume that these are perfect substitutes, so that a representative family's inter-temporal utility function is given by

$$V = \int_{t=0}^{\infty} \frac{N(t)\ (c_X(t) + c_Y(t))^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}\, e^{-\rho t}\, dt \tag{1}$$

Since traditional consumption goods are not durable however we have

$$N(t)c_X(t) = X(t) \tag{2}$$

where $X(t)$ is the value of traditional sector output.

We assume households face credit constraints due to the fact that human and physical capital differ in their degree of ownership rights. Foreigners cannot own domestic human capital, and, in the event of default, human capital investments cannot be re-possessed. Likewise assets in the traditional sector cannot be used as collateral for foreign borrowing. Borrowing therefore requires physical capital as collateral. Hence if $B(t)$ is the value of domestic assets in terms of consumption goods, then

$$B(t) = K(t) + H(t) - D(t) \tag{3}$$

where $K(t)$ is physical capital, $H(t)$ is human capital and $D(t)$ is foreign debt. Since all traditional income is consumed, the flow budget constraint faced by the representative family equals income from all factor modern sector payments, minus interest payments on debt and

consumption of modern sector goods.

$$\dot{B} = w_Y(t)L(t) + q(t)H(t) + \overline{r}K(t) - \overline{r}D(t) - N(t)c_Y(t) \tag{4}$$

where $w_Y(t)$ is the wage in the modern sector, $q(t)$ is there return to human capital and $\overline{r}$, is the international return to physical capital. Hence the household's problem is to maximize (1) subject to (2) and (4).

2.3 Firms and factor markets

Firms rent physical and human capital from households, and hire unskilled labour services in order to maximize profits. The firms may use a traditional or a modern technology. Traditional methods employ unskilled labour, whereas modern production employs unskilled labour as well as human and physical capital. Traditional methods can only be used to produce non-durable consumption goods. Firms maximize profits by choosing the employment of factors taking the returns to capital, $\overline{r}$, human capital, $q(t)$, and labour in the traditional sector, $w_X(t)$ as exogenously given. The production function in the modern sector is

$$Y(t) = A(t)K(t)^{\alpha}H(t)^{\beta}\ M(t)^{1-\alpha-\beta}$$

where $\alpha < 1$, $\beta < 1$, and where $A(t)$ is the time varying productivity level, $M(t) \equiv e(t)L(t)$ is effective labour inputs, and $e(t)$ is an indicator of labour efficiency that is discussed further below. Output in the traditional sector is produced using only unskilled labour and fixed traditional assets under constant returns to scale. The production function is

$$X(t) = \overline{X}^{\,1-\,\gamma}\ (N(t) - L(t))^{\,\gamma}$$

where $\overline{X}$ is the fixed supply of traditional sector specific assets and $\gamma < 1$.

We assume further that modern sector firms choose the wage in the modern sector, $w_Y(t)$, in order to maximize profits. This follows models by Stiglitz (1999) and Bulow and Summers (1986), who argue that the efficiency wages are likely to be paid in the modern sector due to the complexity of the organization, greater monitoring costs, and greater use of fixed capital which increases the costs of shirking and absenteeism.[8]

To formalize these ideas, we assume that labour productivity, and in particular the degree of absenteeism, is determined by the wage paid by firm i relative to the next best wage offered by a rival firm, j. Thus we suppose that effective labour inputs are given by $e(w_i(t)/w_j(t)) \quad i \neq j$ where $e' > 0$ and $e'' < 0$, Stiglitz (1999). A useful functional form that satisfies these properties is the logarithmic function. Further since all modern sector firms are identical, a symmetric Nash equilibrium requires $w_i(t) = w_k(t) = w_Y(t)$ where $w_Y(t)$ is the common modern sector wage. Hence the only rival firms offering a wage lower than firm i, are traditional sector firms. Thus labour market equilibrium requires $e(w_i\ (t)/w_j\ (t)) = e(w_Y(t)/w_X(t))$. Using this expression and the logarithmic functional form we have

$$e(w_i(t)/w_j(t)) = \chi \ln(\mu\ w_Y(t)/w_X(t))$$

where $\mu > 0$ and $\chi > 0$ are country specific efficiency parameters. This implies that if traditional sector wages rise, a similar rise in the modern sector wage is required to maintain the same level of discipline and effort.

[8]This efficiency wage model is supported by number of empirical studies of developed economies, including Bulow and Summers (1986) and Brown and Medoff (1989). In particular, however, there is also evidence supporting the relationship between technology capacity and wages in developing economies. This includes Rebitzer and Robinson (1991), Lillard and Hong (1992) and Tan and Batra (1997). Similarly a number of studies have tested for segmented labour markets based on the distinction between labour employed in formal and informal sectors. Ruiz De Castilla, Woodruff and Marcouiller (1997) find residual real wage gaps of between 12% and 56% in Peru and El Salvador, and Basch and Paredes-Molina (1996) find gaps of around 50% Chile. Other recent studies that support these findings are Verry and Araujo (1996), Magnac (1991) and Pinheiro and Castelar (1994). Interestingly however evidence has been difficult to find for Mexico Maloney (1999), Ruiz De Castilla et al. (1997). Also relevant are the studies of urban-rural wage gaps. Surveys of developing economies by Squire (1981) and Hatton and Williamson (1991) report large wage gaps across different types of "unskilled labour" in rural and urban areas.

A representative firm in the modern sector then has the following profit function.

$$\Pi(t) = Y(t) - w_Y(t)\, L(t) - (q(t) + \delta)H(t) - (\overline{r} + \delta)K(t) \tag{5}$$

where δ is the discount rate for both types of capital. Suppressing the time index, we have the following first order conditions (FOCs).

$$\begin{aligned} &\alpha Y/K - (r + \delta) = 0 \\ &\beta Y/H - (q + \delta) = 0 \\ &(1 - \alpha - \beta)(Y/M)\; e - w_Y = 0 \\ &(1 - \alpha - \beta)(Y/M)\; (\chi/w_Y) - 1 = 0 \end{aligned} \tag{6}$$

Where Y and e are the value of modern output and the value of labour efficiency, as defined above. In a momentary equilibrium where H is given, the first FOC determines the capital stock, while the second determines the rental rate on human capital, q. The last two conditions determine the equilibrium relative wage and demand for labour in the modern sector. Using the last two FOCs and solving for e gives, $e = \chi$. Substituting in the definition of e above then gives

$$w_X = \phi\, w_Y \tag{7}$$

where $\phi \equiv \mu/\exp(1)$ is a constant. Thus in equilibrium there is a constant wage gap between the the sectors. This contrasts with theories where the wage gap is view as a dis-equlibrium and thus declines over time.[9] In this model, however, the wage gap is an equilibrium phenomena. As capital accumulates and modern wages rise, enough labour is drawn from the Malthusian sector so that the wage ratio across sectors remains the same.

To complete the description of labour market equilibrium we simply need to describe the determination of traditional sector wages. We assume traditional firms pay a competitive

[9]For example see Hatton and Williamson (1991).

wage so that in equilibrium

$$X(t) = \gamma \, \overline{X}^{1-\gamma} \, (N(t) - L(t))^{\gamma - 1} - w_X = 0 \tag{8}$$

Thus, households would prefer to allocate more of their members to the modern sector, if employment opportunities were available, since since $w_X < w_Y$. Firms, however, do not wish to employ these additional workers since that would reduce the productivity of the existing workers.

It can be shown that this economy will evolve along transition to a unique balanced growth path where the traditional sector disappears asymptotically, so that $L(t) \to N(t)$. In addition all on all such feasible transitional growth paths, $H(t)/K(t)$ and $H(t)/Y(t)$ must be rising toward their balanced path levels. Moreover the balanced growth path, with $L(t) = N(t)$, is identical to that described by Barro et al. (1995) and Barro and Sala-i Martin (1995).[10] Our present aim however, is to consider the empirical properties of this model, and how these might differ from the conventional approaches, such as Barro and Lee (1994). In the remainder of the paper, therefore we restrict our attention to the observable characteristics of an economy undergoing a transition, with particular emphasis on the interaction between accumulation and the the reallocation of labour from the Malthusian sector.

3 Accumulation and Induced Productivity Growth

We begin our empirical application by considering how the reallocation of labour generates increases in productivity. First, define GDP as $Z(t) \equiv X(t)+Y(t)$, and consider the standard Solow decomposition of the production function.[11] By differentiating this expression we

[10] Details of this transition path and these results are given in Landon-Lane and Robertson (2002), where the properties of this model are explored in more depth.

[11] Recall that these sectors both produce a consumption good that are perfect substitutes, so that the sectoral price ratio is constant as long as both goods are produced.

obtain

$$\begin{aligned} d\ln Z = \ & Y/Z\ \tau\ + Y/Z\ \alpha\ d\ln K + Y/Z\ \beta\ d\ln H \\ & + Y/Z\ (1-\alpha-\beta)(1-\phi)\ d\ln L + \upsilon d\ln N \end{aligned} \tag{9}$$

where Y/Z is the fraction of modern sector output in GDP, $\upsilon \equiv (1-Y/Z)(N/(N-L))\gamma$ and $\tau = d\ln A$ is the constant growth of Hicks neutral productivity in the modern sector.[12] In principle, (9) can be estimated using appropriate data on the modern and traditional sectors employment and factor supplies. Note however, that by definition, all capital and human capital is employed in the modern sector. Hence we can exploit the structure of the model to obtain modern sector labour employment, L, as a function of the aggregate human and physical capital stocks. We can then infer the relative importance of the induced labour migration effects from the size of the estimated coefficients of the modern sector specific factors. Thus, differentiating the equilibrium condition (7) and solving for $d\ \ln L$ gives

$$d\ \ln L = \ \eta\ (\tau + \ \alpha\ d\ln K + \beta\ d\ln H + (1-\gamma)\ (N/(N-L))\ d\ln N) \tag{10}$$

where

$$\eta \equiv \frac{1}{\alpha+\beta+\frac{L}{N-L}\ (1-\gamma)} \tag{11}$$

It can be seen that η is the elasticity of labour supply with respect to modern sector output, and declines as $N-L \to 0$. Finally, substituting (10) into (9) gives

$$\begin{aligned} d\ln Z_{it} = \ & \theta_0\ + \theta_1\ [(I/Z)]_{it} + \theta_2\ [\eta\ (I/Z)]_{it} \\ & + \theta_3\ [(Y/Z)\ (d\ln H)]_{it} + \theta_4\ [\eta\ (Y/Z)(d\ln H)]_{it} \\ & + \theta_5\ [(Y/Z)/(1-l))\ \eta\ d\ln N]_{it} + \theta_6\ [(1-Y/Z)\ /(1-l)\ d\ln N]_{it} \\ & + \theta_7\ [(Y/Z)]_{it} + \theta_8\ [\eta\ (Y/Z)]_{it} + \mu_{it} \end{aligned} \tag{12}$$

[12]Since we are not interested in testing endogenous growth theories *per se*, we adopt the standard neo-classical assumption that technical progress is exogenous. This simple theory enjoys considerable empirical support and has the advantage of transparency.

Where: I is the gross investment rate, $\theta_1 = (\overline{r} + \delta)$; $\theta_2 = (\overline{r} + \delta)\ m$; $\theta_3 = \beta$; $\theta_4 = \beta m$; $\theta_5 = (1-\gamma)m$; $\theta_6 = \gamma$; $\theta_7 = \tau - \delta\ \alpha$; $\theta_8 = (\tau - \delta\ \alpha)\ m$, $l \equiv L/N$ and $m \equiv (1-\alpha-\beta)(1-\phi)$. The parameter θ_0 is simply the constant term, which has the interpretation of any economy-wide technical change.[13] Equation (12) identifies the marginal impact of technology and factor supply on the demand for unskilled labour and on GDP growth. It shows that each of these variables has a direct effect on output, as well as an indirect effect via the labour demand function which is captured by the term m.

Consider, for example, the marginal impact of the investment rate, I/Z on the growth rate. The direct marginal effect of the increase in investment is $\theta_2 = \overline{r} + \delta$. In addition there is a productivity gain from the migration of labour into the high wage sector, $\theta_3\ \eta = (\overline{r} + \delta)\ m\ \eta$. Thus the indirect, or labour reallocation effect, depends on: the size of the percentage mark-up of the modern sector, $1-\phi$; the responsiveness of labour demand to the increase in capital, η; and the elasticity of modern sector output to labour, $1 - \alpha - \beta$. A similar interpretation applies for the effect of human capital, $d \ln H$, and exogenous productivity growth, τ.

4 An Empirical Investigation

4.1 Data

In addition to the usual data requirements for panel growth studies, estimation of (12) requires data on the employment shares, $l = L/N$ and estimates of value added shares, Y/Z. Finding suitable proxies for these variables is not a simple task. In particular the traditional sector, as defined above, does not correspond with any official statistical categories. As emphasized by Fields (1975), it includes workers located in urban areas as well as rural

[13] In deriving (12) we note that $\alpha\ Y/Z\ d \ln K = dK/Z\ (\overline{r} + \delta)$. Since $dK = I - \delta\ K$, this is equal to $(\overline{r} + \delta)(I/Z - (Y/Z)(\delta\alpha)$.

areas.[14] In our empirical application we therefore use the rate of child labour as a proxy for labour share of the traditional sector employment. This is defined as the number of economically active workers in the age group 10-14, as a percentage of the total population in that age group (World Bank 2001).

The incidence of child labour is likely to be indicative of the relative importance of the traditional sector for several reasons. First, although child labour employment in manufacturing industries receives a great deal of popular attention, recent surveys show that only 8% of all child labour is employed in manufacturing sector, and only 5% of all child labour is involved in export industries (International Labour Office 1997). The vast majority of child labour in developing economies, is employed in agriculture, wholesale and retail trade and services. Second, the incidence of child labour is higher in activities where there are no specific skills or occupations where economic activities are elementary (International Labour Office 1997). Thus we expect child labour to be much more prevalent in the traditional sector than the modern sectors.

We also require data on the scaling factor, Y/Z. This represents the value added share of the modern sector and is proxied using the non agricultural share of value added in GDP, from World Bank (2001). Data on the gross investment rate, I/Z, the labour force, N, and GDP, Z, are taken from the the Penn World tables 5.6. All nominal variables are measured using the chained PPP index. The human capital growth rate, $d\ln H$, is measured using growth rate in the average years of schooling, from Barro and Lee (1996).

[14] A closely related concept is the "informal sector" (International Labour Office 1997). However, these data are not readily available for many countries and the definitions of the informal sector are not applied uniformly across all countries, or across time.

4.2 Estimation methods

For each country, we use observations on growth rates for 10 year periods from 1965-75, 1975-85, 1985-1995.[15] The countries that make up the data set were chosen based solely on availability of data for the years 1965 through 1995. We therefore have a panel of 78 countries with three time period observations on each.

There is evidence that there is cross-sectional heteroscedasticity which implies that the OLS estimates of the standard errors will be inconsistent.[16] Hence, the heteroscedastic-consistent covariance matrix estimator for panel data of Beck and Katz (1995) was used. However, the the Breusch-Pagan LM test for a diagonal covariance matrix could not be rejected so that there is no evidence of serial correlation in the residuals.[17]

Other issues relating to the estimation of growth models using panel are raised by Caselli, Esquivel and Lefort (1996). They concentrate on the growth regressions and note that when the dependant variable is a growth rate, and a lagged level of the dependent variable appears as a regressor, there is a correlation between the error term and the regressors, and so OLS is inconsistent. This problem does not occur here as (12) does not have lagged levels of output as an explanatory variable. However, the second point noted by Caselli et al. (1996) is a concern. They note that there is a potential simultaneity problem inherent in growth regressions. As with most empirical growth studies, there is a problem of simultaneity with our explanatory variables. For instance, investment responds to productivity shocks, since firms invest to keep the net marginal product of capital equal to the world rate of return. Benhabib and Spiegel (1994) and Temple (1998) both argue that the simultaneity bias inherent in these types of growth regression is positive. Therefore, there is a possibility that the OLS estimates are inconsistent.

[15] These periods were determined primarily by the availability of child labour data.

[16] The LM statistic for cross-sectional heteroscedasticity was 169.36. Given that this statistic has a $\chi^2(77)$ distribution, it is clear that there is strong evidence that the panel contains cross-sectional heteroscedasticity.

[17] The LM statistic for a diagonal covariance matrix is 3082.4 with a p-value of 0.1529

It has been suggested that lagged values of the growth rate of capital should be used as instruments to solve the simultaneity problem. However, it is not clear that this will solve the problem completely. If there is a significant lag in the effect of capital growth on output growth then there will still be some simultaneity between the instruments and the dependent variable. Compounding the simultaneity bias is the extensive use of proxy variables in the regression. It is, therefore, very difficult to work out the overall sign of any bias as the measurement error inherent in the use of proxy variables would cause a negative bias in the OLS estimates, opposite in sign to the simultaneity bias noted above. In order to try to control for these effects, instrumental variables estimation (IV) was tried using various potential instruments. However the IV estimation produced inconclusive results for all parameters in our model. In all cases, the over-identifying restrictions test was rejected, suggesting that the instruments used were not valid. This is likely to be a consequence of the poor quality of the potential instruments available.

Given the lack of suitable instruments, we focus on the OLS estimation results. Thus we do not regard the the reported OLS results as a formal test of the model, but as an attempt to quantify these aspects of the industrialization process. In particular, the OLS estimates appear to provide reasonable estimates of parameters for which we have strong priors. This reinforces our belief that the OLS estimates have substantial merit in providing reasonable bounds on the labour reallocation effects described above.

5 Results

The OLS estimates are presented in Table 1. We find that the physical capital terms, θ_1, θ_2, and the human capital term, θ_3, all have the expected signs and are significant at the 5% level. The second human capital term, θ_4, is insignificant at this level of confidence. Nevertheless, as shown in Table 2, the joint F-tests $H_0 : \theta_1 = 0$ and $\theta_2 = 0$ and $H_0 : \theta_3 = 0$ and $\theta_4 = 0$

are both rejected at the 5% level.

First consider the coefficient on physical capital, $\theta_1 = \overline{r} + \delta$. This is the real gross return to capital, and is estimated to be approximately 14%. This falls neatly within the range estimated in previous studies, and is very close to Caselli et al. (1996) who obtain a coefficient of 0.15 using GMM.[18] Thus we find no evidence of severe bias in the estimates, based on prior expectation of this parameter.

Likewise the estimate of the coefficient on human capital investment, $\theta_3 = \beta$, is small but significant. This is also in keeping with the existing literature, where the small and often insignificant coefficients are attributed to the low quality of the human capital data.[19] Together with the estimates of the real interest rate, therefore, the results give us some confidence that the any potential bias is small if not negligible.

We now consider the indirect, or labour migration, effects of physical and human capital. It can been seen that θ_2, which captures the interaction between physical capital accumulation and the extra output generated by the re-allocation of labour, is highly significant and positive. We interpret this result as evidence that that: (i) significant differences in labour productivity exist between the modern and traditional sectors, and (ii) that physical capital investment is important factor in increasing labour demand in the modern sector. The size of this estimate and the implications for growth are discussed further below.

Curiously there is no evidence of an indirect effect of human capital investment on growth through shifting of labor from the traditional sector to the modern sector. While this may be due to the problem of data quality, it may also be indicative of a high degree of substitutability between human capital and unskilled-labour.[20] Either way we draw no quantitative

[18]For example Barro and Sala-i Martin (1995) obtain a "preferred" estimate of 9%, and Levine and Renelt (1992) obtain a low bound estimate of 15% and a high bound estimate of 19%. These estimates are also consistent with calibrated values of the depreciation and the real interest rate used for the United States in the Real Business Cycle (RBC) literature (Kydland and Prescott 1996).

[19]For a discussion of this issue see Temple (1999), Benhabib and Spiegel (1994).

[20]This would also be consistent with Hicks-Allen complementarity between physical capital and unskilled labour, resulting in relatively large estimates of θ_4. These interesting possibilities are ruled out $ex-ante$ by

Table 1: Regression Results for (12)

Coeficient	Estimate[a]	Std. Error[b]	T-ratio
θ_0	0.0219	0.0134	1.628
θ_1	0.1457	0.0357	4.079
θ_2	0.0520	0.0154	3.376
θ_3	0.0759	0.0324	2.343
θ_4	-0.0633	0.0503	-1.260
θ_5	-0.0002	0.0004	-0.470
θ_6	0.0287	0.0367	0.781
θ_7	-0.0348	0.0120	-2.898
θ_8	0.0203	0.0150	1.351

p-value for LM Test for Cross-Sectional heteroscadeasticity [c]	0.00
p-value for Breusch-Pagan LM autocorrelation test	0.15
R^2 (Buse)	0.30

[a]The estimates reported in this table are obtained by correcting for the autocorrelation that is common across all cross-sections.

[b]The reported errors were calculated using the panel heteroscedastic consistent estimates of Beck and Katz (1995).

[c]The tests for cross-sectional heteroscedasticity and serial correlation were calculated using estimates from the pooled OLS estimator

Table 2: Joint Significance Tests

	Test Statistic	p-value
Capital	41.82	0.000
Human Capital	8.48	0.014
Labor	0.68	0.711

implications, regarding the indirect effect of human capital on GDP growth.

Thus the results suggest that there are significant effects on labour demand and productivity growth from physical capital, while human capital has an ambiguous effect. In the remainder of the paper we therefore focus on the implication of estimated effects of physical capital accumulation on economic growth.

the iso-elastic specification of the production function used in our empirical section. Thus caution is required in interpreting the results in this way.

5.1 Discussion

To interpret the coefficient on physical capital, Table 1, we consider the the imputed values of direct and indirect effects of physical capital on the growth rate. These are shown in Table 3.

Table 3: Return to Modern Sector Capital

Quintile[a]	Indirect[b] Effect	Total[c] Return	Proportion[d]	L/N
FIRST	0.0635	0.2092	0.3035	0.5935
	(0.0085)	(0.0311)		(0.0841)
SECOND	0.0493	0.1950	0.2528	0.7919
	(0.0093)	(0.0327)		(0.0387)
THIRD	0.0324	0.1781	0.1819	0.9007
	(0.0091)	(0.0333)		(0.0296)
FORTH	0.0127	0.1584	0.0802	0.9705
	(0.0117)	(0.0355)		(0.0161)
FIFTH	0.0002	0.1459	0.0014	0.9996
	(0.0269)	(0.0439)		(0.0009)

[a] ordered by L/N, Column 4
[b] $(\overline{r}+\delta)(Y/Z)_i\ m\ \eta_i$
[c] $(\overline{r}+\delta)(1+(Y/Z)_i\ m\ \eta_i)$
[d] Ratio of indirect effect to total effect

This value is constructed from the data and the estimated coefficients, θ_3, θ_4. Since there are 234 observations we order the data according to the child labor rate variable, L/N, which is our proxy for the employment share of the traditional sector. The data is then grouped into quintiles - the first quintile having the largest traditional sector employment share. Table 3 then presents the means and standard deviations for these the countries in each quintile

Column 1 of Table 3 gives the indirect marginal effect of modern sector capital on GDP, $(\overline{r}+\delta)\ m\ \eta$. To this we add the direct marginal product of capital, $\theta_1 = (\overline{r}+\delta)$ to obtain the total effect for each quintile in Column 2. The ratio of these two effects is reported in Column 3. Finally, for reference, Columns 4 reports the average value of L/N for each quintile.

It can be seen that for countries with the largest traditional sectors, those in the first and second quintiles, a one percentage point increase in the investment rate, I/Y results in a relatively large effect on GDP of around 20%. As shown in Column 3 this represents a 30% increase in the growth effects of physical capital in the least developed economies, relative to the most developed economies in the 5th quintile. Had we not taken account of the productivity gap and segmented market structure, this difference would appear as a productivity residual. Thus, the results suggest that a significant portion of total factor productivity (TFP) can be attributed to a high rate of capital accumulation and segmented labour markets, in developing economies.

The results have important consequences for countries experiencing large changes in the investment rate, such as the newly industrializing East Asian economies. To illustrate this Table 4 shows the ten countries in our sample that experienced largest increases in the investment rate, along with the estimates of the total growth impact of capital for each country. For example, it can be seen that the output gains through capital accumulation and labour reallocation effects were been very important in during the recent investment boom in Thailand, in the 1980s and early 1990s. These effects added more than half a percent to the predicted annual growth rate, over the ten year period - or 25% of the total effect. Similar values can be observed in other countries in Table 4, in particular Botswana, Algeria and Indonesia.

6 Summary and Conclusion

In this paper we have presented a rigorous theoretical framework in order to empirically evaluate some of the effects of structural change on growth rates. The model extends Barro et al. (1995) by incorporating a traditional sector, and an endogenous equilibrium wage gap motivated by efficiency wages. We then used Panel regression methods to explore the

Table 4: The effect of changes in the investment rate

(1) Rank[a]	(2) Country	(3) Date	(4) Change in Investment Rate[b]	(5) Total Return[c]	(6) Predicted Change in Growth Rate[d]
1	BOTSWANA	1965-75	0.20	0.21	0.040
2	ALGERIA	1965-75	0.18	0.17	0.031
3	SINGAPORE	1965-75	0.15	0.16	0.024
4	THAILAND	1985-95	0.13	0.19	0.026
5	KOREA, REP.	1965-75	0.12	0.18	0.020
6	KOREA, REP.	1985-95	0.10	0.15	0.015
7	INDONESIA	1965-75	0.10	0.19	0.019
8	DOMINICAN REP.	1965-75	0.10	0.20	0.020
9	INDONESIA	1975-85	0.09	0.19	0.017
10	ZAMBIA	1985-95	0.09	0.19	0.017

[a] Observations are ordered by Column (4)
[b] $\Delta(I/Z)$
[c] $(\overline{r}+\delta)(1+\eta_i\, m)$
[d] $(4)\times(5) = (\overline{r}+\delta)(1+\eta_i\, m)\Delta I/Z$

quantitative implications of this model, particularly for industrializing economies with large traditional sectors. Our principle finding is that physical capital accumulation, by raising demand for labour in the modern sectors of developing economies, has a significant effect on productivity growth. Interestingly, equivalent effects for human capital could not be identified.

Specifically we find that countries with large traditional sectors and high investment rates, the movement of labour away from the Malthusian, or traditional, sector can generate a substantial amount of output growth. For 40% of our sample, the presence of wage gaps increases the rate of return to physical capital by approximately 25-30%, resulting in a significant increase in growth rates. Thus we find that physical capital accumulation is an important source of productivity growth among industrializing economies. In view of this, the sectoral allocation effects are likely to be important in understanding the composition of "growth miracles" as well as the sources of variation in growth across rates across countries.

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