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Qaisar Abbasa and James Foreman-Peck

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Cardiff Business School
Cardiff University
Colum Drive
Cardiff CF10 3EU
United Kingdom
t: +44 (0)29 2087 4000
f: +44 (0)29 2087 4419
www.cardiff.ac.uk/carbs

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Human Capital and Economic Growth: Pakistan, 1960-2003¹

Qaisar Abbas^{a,*}, James Foreman-Peck^b

^a Comsats Institute of Information Technology, Islamabad, Pakistan & Cardiff Business School, Cardiff University, UK

^b Cardiff Business School, Cardiff University, Aberconway Building, Colum Drive Cardiff, CF10 3EU UK, <http://www.cardiff.ac.uk/carbs/econ/foreman-peckj/>

Email: Foreman-PeckJ@cardiff.ac.uk

Phone: +44(0)29 2087 6395

Fax: +44 (0)29 2087 4419

* Corresponding Author: Qaisar Abbas, Cardiff Business School, Aberconway Building, Room T31B, Colum Drive Cardiff CF10 3EU, Wales, UK.
Email: abbasq1@cardiff.ac.uk
Tel +44 (0)29 2087 5505, (till August 30, 2007)

Department of Management Sciences, Comsats Institute of Information Technology, Plot no.30, H-8/I, Islamabad, Pakistan
Email: qaisar@comsats.edu.pk
Tel: 0092-51-9258481-83, Fax: 0092-51-4442805
(after August 30, 2007)

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Human Capital and Economic Growth: Pakistan, 1960-2003

Abstract

This paper investigates the relationship between human capital and economic growth in Pakistan with time series data. Estimated with the Johansen (1991) approach, the aggregate production function rejects one version of the endogenous growth formulation. But the fitted model indicates that the output elasticity of human capital may be expected to increase with foreign technical progress. Higher productivity of secondary schooling than in OECD economies is consistent with the low levels so far attained in Pakistan. High returns to health spending compare very favourably with industrial investment. Human capital is estimated to have accounted for just under one fifth of the increase in GDP per head, a figure that is probably biased downwards because of the unmeasured dimensions of human capital.

JEL Classification: C13, C22, C51, O15, O53

Keywords: Human Capital, Economic Growth, Cointegration, Pakistan

Human Capital and Economic Growth: Pakistan 1960-2003

Human capital plays a key role in versions of both neoclassical and endogenous growth models (Mankiw Romer and Weil 1992, Rebelo 1991, Sianesi and Van Reenen 2003). The critical difference is that in the first group, economic growth is still ultimately driven by exogenous technical progress, whereas in the second, no additional explanation is needed and human capital is much more important. Endogenous growth models predict that a permanent change in some policy variable can cause a permanent change in an economy's growth rate. Unlike time series evidence for the US, at first sight the data for many developing economies could be broadly consistent with this prediction (Jones 1995), showing accelerated growth after 1945².

The exogenous technical progress of the neoclassical model can change in response to policy as well. According to Parente and Prescott (1999, 2000), individuals may choose how fast they raise productivity, by diverting their time from normal work to productivity-enhancing activities. In doing so, in principle at least they can draw on the world stock of knowledge and borrow capital on world markets. Policy-induced constraints, such as taxation, international capital controls, or entry barriers at the plant level, create international differences in aggregate productivity, even when the stock of useful knowledge is potentially common to all countries.

Mankiw et al. (1992) (MRW) found support for the human capital-augmented neoclassical model in a cross section of countries. But Pungo (1996) showed that the MRW specification exhibits structural breaks, such that the coefficient on human capital is insignificant for a sample of labor-abundant countries and if influential observations are excluded. A possible reason for these last results is that schooling and health services in developing economies tend to be of low and very variable quality³. In Pakistan the largest learning gaps are between (primary) schools. The divergence in English test scores between government and private schools is 12 times that between children from rich and poor families (Das, Pandey and Zajonc 2006).

Variations in the effectiveness and magnitude of state schooling spending, together with the way in which taxes are levied to pay for it, could lead to a negative correlation with economic growth (Blankenau and Simpson 2004). Public spending might crowd out private spending on education. Moreover in the short-term, increasing the proportion of the potential workforce in full time education reduces the workforce and may be expected to lower per capita output. Not surprisingly then, the macroeconomic evidence is mixed concerning the effects of public education expenditures on economic growth.

A second type of human capital, health, in the form of life expectancy, has appeared significantly in many cross-country growth regressions (Bloom and Canning 2000, 2001).

² For instance from 1820 to 1929 Maddison's (1995) estimates show that Pakistan real GDP per head grew at an average rate of 0.31 percent. Then incomes doubled in the course of the nineteen sixties, and high growth by historical standards became sustained in subsequent years, albeit at varying rates.

³ Tested at the end of the third grade, only 31 percent of Pakistani primary school children could correctly form a sentence with the word "school" in the vernacular (Urdu) (Das, Pandey and Zajonc 2006).

Life expectancy can effect economic growth in several ways. As people live longer, they can save more for old age (Lee et al. 1998). Life expectancy can also serve as proxy for the health status of the whole population, because declines in mortality rates are related to falls in morbidity.

National economies are likely to be especially diverse in the supply and demand for human capital because of distinctive institutions, generally strongly influenced and funded by the state. Yet most empirical research has been concerned with cross-sections or panels of large numbers of countries, thereby ignoring economy-level institutional differences. National time series studies offer a way of eliminating or reducing such heterogeneity (Durlauf, Johnson and Temple 2004). For this reason the present paper tests and estimates a time series model of human capital and economic growth for Pakistan 1960-2003. As a low income economy that has invested relatively little in human capital over the past 40 years, Pakistan is an especially helpful case for understanding the relationship with economic growth (Husain, Qasim and Sheikh 2003)⁴.

Most econometric research on human capital in Pakistan has entailed estimating Mincer (1974) earnings on micro data. Nasir and Nazli (2001) find each year of education brings approximately 7 percent (private gross) return for wage earners. Another study by Haroon et al. (2003) estimated that the maximum private gross return (16 percent) is associated with higher secondary education. Furthermore, their results also indicate that private payoffs from primary education declined during the previous decade while the returns to higher secondary and tertiary education rose. Recent research on rural Pakistan by Behrman et al. (2006) showed that ‘social’ and private rates of return to low quality primary schooling versus no schooling were 18.2 percent and 20.5 percent respectively⁵. They also estimated that ‘social’ rates of return to high-quality versus low-quality primary schooling in rural Pakistan were 13.0 percent. Studies of this type are unlikely to capture all indirect benefits of human capital for economic growth, such as the stimulus to physical capital investment, as well as to new technology development and adoption. Therefore there is a strong case for supplementing them with macroeconomic research, as attempted here.

The paper is organized as follows. Section I presents the theoretical framework of the study. Section II outlines the data and the development of the Pakistan since 1960. Section III elaborates the measurement of variables and estimation procedures. Section IV presents the empirical results and section V discusses the sources of growth implied by the analysis of the preceding section.

⁴ A previous time series study of Pakistan industrial growth 1973-1995 (Dutta and Ahmed 2004) investigated the impact of secondary school enrolment but there is some question about the signs of the variables in the cointegrating vector.

⁵ ‘Social’ here does not include spillovers but only the public (as well as private) financial costs of providing education.

I. Theoretical Framework

Neoclassical growth implies conditional convergence; growth of income depends upon initial income plus determinants of eventual steady state income. The most critical determinant is technology improvement, which is expensive and can be influenced by policy (Parente and Prescott 1999). By contrast there is no steady state with endogenous growth, and therefore no conditional convergence, because there is no diminishing returns in the aggregate production function. Poor countries will continue to be relatively poor, and big economies will grow faster than small.

One reason for endogenous growth, (in Rebelo 1991) is that human capital is embodied in labour. This implies that a worker's improved human capital boosts their productivity but cannot benefit another worker in the same way. The total amount of human capital H in an economy is the product of the number of workers and their average embodied human capital. If L is number of workers, the total human capital input is the flow of services from $L \cdot H/L = H$. More workers without any human capital add nothing to output, so a growing workforce in itself will drive down output per head at the rate at which it grows. Constant returns to all three factors are equivalent to constant returns to human and physical capital alone.

It follows that increased investment in human and physical capital, such as might be induced by more benign policies, can permanently raise the growth rate of an economy. Ignoring depreciation, if savings and investment in human and physical capital increase from 5 to 10 percent of output, the steady state growth of output and capital rises from 5 to 10 percent. The ratio of human to physical capital in the steady state will not change because their relative accumulation rates are unaltered. The steady state growth of output and the two types of capital are obtained by substituting both savings/investment rates into the production function.

Human capital in a neoclassical model has less dramatic but still fundamental effects. A human capital-augmented Cobb-Douglas production function consistent with the estimates of MRW has coefficients of one third on each of the three factor inputs; a one percent increase in both human and physical capital increases output by only two thirds of a percent. Accumulation at a constant proportion of output therefore adds less and less to output until the steady state is reached, in the absence of technical progress. Hence the neoclassical model must include exogenous technical progress if it is to explain economic growth in the long run.

The disembodied human capital of MRW implies that an increase in the work force has a greater positive effect on output than a rise in human capital per worker. Where Y is real output, A the technology level that shifts exogenously, K physical capital and $0 < \alpha, \beta, \gamma < 1$ parameters, the neoclassical (Cobb-Douglas) production function is

$$Y = A K^\alpha L^\beta H^\gamma = A K^\alpha L^{\beta+\gamma} (H/L)^\gamma$$

This compares with an endogenous growth Cobb-Douglas production function specification, discussed above, of

$$Y = A K^\alpha H^\gamma = A K^\alpha (L (H/L))^\gamma$$

In terms of output per head, endogenous growth production functions are

$$Y/L = A (K/L)^\alpha (H/L)^\gamma L^{\gamma+\alpha-1} \quad \dots(1)$$

And with constant returns to scale $\alpha+\gamma=1$

$$Y/L = A (K/L)^\alpha (H/L)^{1-\alpha} \quad \dots (1a)$$

This compares with the neoclassical growth production functions of

$$Y/L = A (K/L)^\alpha (H/L)^\gamma L^{\beta+\gamma+\alpha-1} \quad \dots(2)$$

And with constant returns to scale $\alpha + \beta + \gamma = 1$

$$Y/L = A (K/L)^\alpha (H/L)^\gamma \quad \dots(2a)$$

A one percent growth in the average human capital per worker, with no change in the workforce, boosts output per worker by γ percent in the neoclassical model (2 or 2a). In the endogenous growth model with constant returns to scale for physical and human capital (1 or 1a), by contrast, output per worker rises by $1-\alpha$ percent (by twice as much, when 2 or 2a has MRW parameters). An increase in human capital of one percent, simply because the number of workers has grown, without any rise in human capital per worker, lowers the physical capital-labour ratio and cuts output per head by $\beta + \gamma - 1$ percent in the neoclassical model (2) (assuming, as for instance under constant returns to scale, $\gamma + \beta < 1$). In the endogenous model (1), output per worker falls, for the same reason, but by $\gamma - 1$. Under constant returns to scale, it declines by α (when $\gamma - 1 = -\alpha$).

If the labour coefficient is zero or positive when testing equation 1a against 1, or 2a against 2, the function is consistent with endogenous growth. If it is zero or negative it is consistent with neoclassical growth. A critical test of the two models is the relative magnitude of the human and physical capital-labour coefficients in equations 1a and 2a; endogenous growth requires they should sum to unity (for a steady state) whereas neoclassical growth requires they should add up to less than one.

A less critical test is the role of exogenous technical progress, which is not needed for endogenous growth, but required for neoclassical. In a low income country technology transfer is likely to be a major source of growth. The scope for technology transfer will depend on the technological progress of the leaders in the world economy. A simple way to model this is for the domestic production function to shift at a rate given by the technological frontier economy TFP index (F).

$$A = A_0 e^{\lambda F} \quad \text{or} \quad A = A_0 F^\lambda$$

But technology can only be transferred if an economy has the absorptive capacity. So a more realistic formulation allows greater technical progress the higher is the human capital that promotes this capacity.

$$A = A_0 (H/L)^{\lambda_0 + \lambda_1 \log F}$$

This specification can blur the lines between endogenous and neoclassical formulations. On the one hand, technical progress, F, is exogenous (neoclassical) to the domestic economy (though endogenous to the world as a whole). On the other the elasticity of

human capital rises with F, increasing the likelihood that the growth will eventually become endogenous.

In a relatively poor economy the returns to factor inputs, including human capital, should be high because of their scarcity. Yet it has been contended the risks to capital are much higher in low income economies, thereby reducing returns. For human capital, poor quality schooling and an inappropriate syllabus will lower the return to education as a social investment. However, if education is merely signalling, it will not depress private returns, though social returns will be low.

Rates of return to human capital per worker, as measured by the marginal product, are higher the lower is an economy's ratio of human capital per worker to output, in both neoclassical and endogenous models considered here.

$$\partial Y/\partial(H/L) = \gamma/(H/LY)$$

As long as economic development raises the ratio of human capital to output, the rate of return will also be driven down.

In an efficiently functioning economy, at the margin returns to human and physical assets would be equalized. But with human assets, inability to appropriate returns is often expected to deter optimal investment, and thereby to allow persistent higher marginal returns, in the absence of adequate non-profit institutions. If the marginal rate of return to human capital is known, then the parameter γ allows the calculation of the stock of human capital. Conversely, the measure of underinvestment, the (excess) marginal rate of return, can be found from the human capital stock and γ .

II. The Pakistan Economy since 1960

Consistent with the endogenous growth model, in conjunction with a broad policy or environmental shift, the Pakistan economy experienced an apparent permanent increase in growth rate by the 1960s. Pakistan's average annual real GDP growth rate of 5.3 percent since then has not matched those of the East Asian miracle countries. Yet per capita GDP growth surpassed that of the typical developing country (1.3 percent since the 1960s) with an annual average rate of 2.6 percent.

Three groups of Asian countries, East Asian rapid growers, S Asian developing and Asian least developed, in many respects were at a broadly similar level of economic development in 1960. But by the end of the millennium, there were wide gaps in their per capita incomes. Their human capital endowments, both in terms of education and health, also were hugely different.

In the early 1960s, Pakistan was seen around the world as a model of economic development. Many countries sought to emulate Pakistan's economic planning strategy and one of them, South Korea, copied its second Five Year Plan, 1960-65. In the early 1960s the per capita income of South Korea was less than double that of Pakistan

(Maddison 2001). But the former economy became by far the more developed, with GNI per capita in 2006 of US\$17690 (World Bank 2007).

A possible reason for the divergence, again consistent with endogenous growth, is that literacy rates for East Asian developing countries in the early 1960s were as high as 71 percent for the Republic of Korea, and 68 percent for Thailand, while Malaysia achieved a rate of over 50 percent. On the other hand, in all other Asian least developed countries and South Asian developing countries, the literacy rate was low; only 9 percent for Nepal and 16 percent for Pakistan (Table 1). After three decades, during which this group of Asian countries somewhat improved their human capital, literacy rates are still below 50 percent. By contrast literacy in South Korea reached 98 percent and Malaysia managed a rate of about 90 percent (World Bank, 1982; UNESCO, 1999).

Table 1: Human Capital Measures for Pakistan, 1960-2005

Years	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005
Indicator										
Primary schooling enrollment (percent of age group)	20.4	27.4	30.3	38.2	32.1	35.8	47.5	57.3	60.5	68.1
Secondary schooling enrollment (percent of age group)	3.4	4.6	5.7	7.0	6.4	7.3	9.6	12.2	11.6	12.0
Literacy rate	16.7	16.8	20.9	24.3	26.1	28.8	33.8	39.6	47.1	52.5
Public spending on education (percent of GDP)	0.9	1.8	2.5	2.2	2.0	2.7	2.7	2.2	2.0	2.5
Public spending on health (percent of GDP)	0.4	0.6	0.5	0.6	0.6	0.8	1.0	0.7	0.7	0.6
Life expectancy	43.9	46.7	49.4	52.3	55.1	57.4	59.1	60.9	63.0	66.0
Sources: State Bank of Pakistan (2006), UNESCO yearbooks (various issues), World Bank (various issues).										

Another potential contributor to divergence is health. Measured by life expectancy at birth across the three groups of countries in the Asian region, health shows a similar pattern to literacy. In the 1960s, life expectancy at birth was below 45 years in all Asian least developed countries and South Asian developing countries. On the other hand, the East Asian developing countries had life expectancies well over 50 years, with the Republic of Korea achieving a figure of over 54 years, followed by the 53 years of Malaysia and 51 years for Thailand. In the late 1990s, Asian least developed countries and South Asian developing countries enhanced their life expectancy to more than 60 years, at least in the case of Pakistan, India, Bangladesh and Bhutan. Yet the life expectancy rate in both Malaysia and Korea is remains much higher; of the order of more than 72 years, with Thailand reaching a figure of 69 years (World Bank, 1984).

Nonetheless human capital has grown in Pakistan. Table 1 shows that primary and secondary schooling enrolment in Pakistan increased substantially in the years after 1960. However public spending on education as a proportion of GDP stopped rising on trend after 1970, while public spending on health peaked as a proportion of GDP in 1990. Human capital per head, as measured by the chances that a member of the workforce (Insstp_w, figure 1) would have secondary schooling, increased strongly in the 1960s and in the second half of the 1980s.

Schooling particularly in rural areas remained problematic despite land and other reforms during the 1960s. In 1962 four tiers of government were introduced and each was assigned responsibilities in both rural and urban areas, such as maintenance of primary schools, public roads, and bridges. Much military and economic aid was received in this period, and the capital labour ratio (lnksp_w, figure 1) rose most rapidly in this decade.. But this was reduced in 1965, when another war with India over Kashmir broke out. Later the Tashkent agreement of 1966 mediated the conflict. The longer term impact of the war on the economy though was severe, ultimately triggering a downturn in output (lnrgdpp_w) and employment (lnelf) between 1967 and 1968 (figure 1).

The 1970s were a difficult decade for some forms of human capital accumulation and economic growth. A third war with India and Pakistan in 1971, the upheaval associated with the establishment of Bangladesh in January 1972, the first oil crisis in 1974 and the populist and restrictive economic policies of new political regime of 1971-77, all adversely affected the economy. After 1973 Bhutto nationalised basic industries, insurance companies, domestically owned banks, and schools and colleges. The chances that a member of the workforce would have secondary schooling fell in the first half of the decade. Table 1 shows that school enrolments as a proportion of the relevant age group were lower in 1980 than in 1975 and figure reveals a stagnation of the secondary schooling stock per worker (Insstp_w, figure1) in the 1970s.

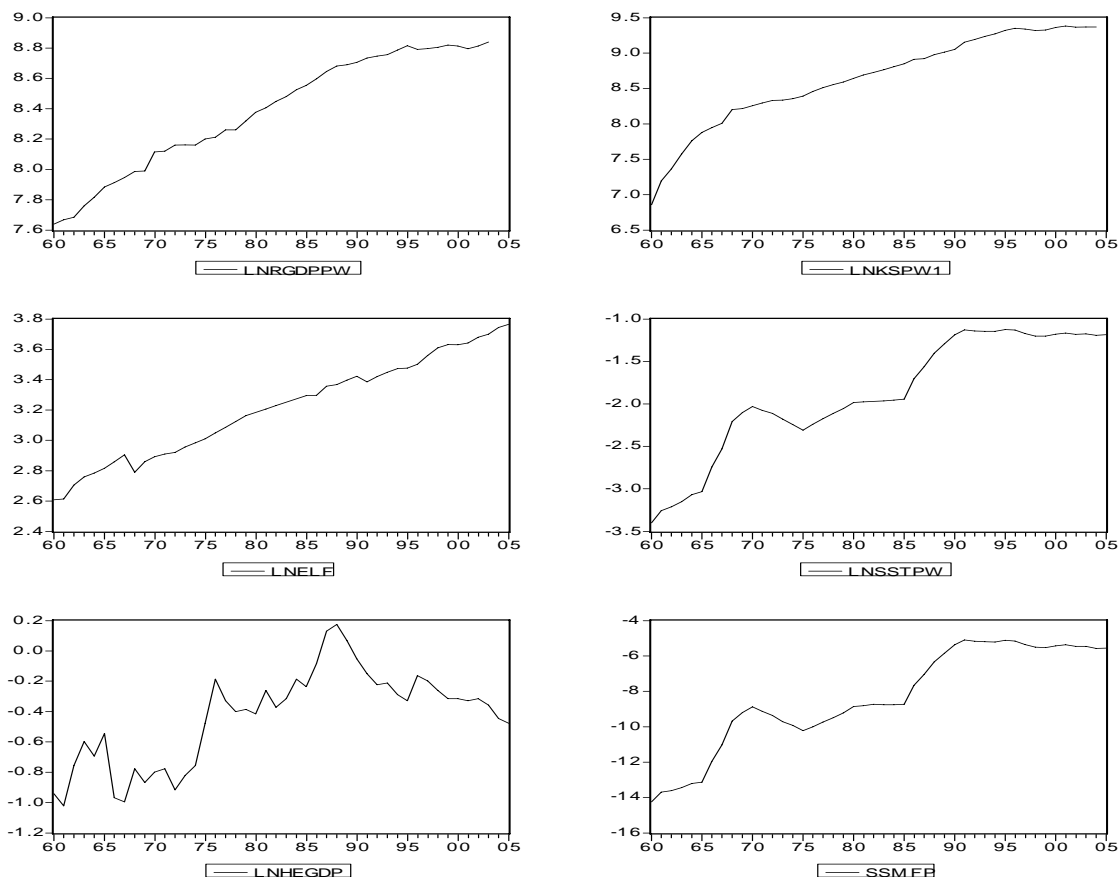
Some, incomplete, structural reform efforts were implemented in the 1990s. Output and employment fell between 1990 and 1991 but recovered the following year. The second half of the decade was marked by economic uncertainty associated with heightened domestic and regional political tensions; the 1998 nuclear explosions and consequent sanctions, droughts, unsustainable debt and the ensuing macroeconomic instability.

Interest payments and military spending by the government exceeded 50 percent of consolidated government spending, shrinking the relative size of public sector development spending, and leaving only limited resources for state-funded education, health and physical infrastructure. External balances deteriorated significantly and foreign reserves fell to dangerously low levels (World Bank, 2002). Health spending as a proportion of GDP (lnhegdp, figure 1) declined.

Since 1999, the government committed itself to reversing Pakistan’s poor economic performance through major macroeconomic stabilization efforts and structural reforms aimed at strengthening microeconomic fundamentals. Employment (lnelf) growth faltered between 1999 and 2000 but quickly resumed. Real output (lnrgdppw) fell for two consecutive years but in 2002 jumped to a previously unattained height (figure 1). Fiscal measures included the privatisation of state-owned banks and strengthening the role of State Bank of Pakistan, together with reform of telecoms and trade policy. Expansion of the US and EU textile quotas further helped to stabilize and revive the economy. Economic growth exceeded the 5 percent mark in 2003 for the first time since the mid 1990s, and reached 6 percent in 2004 (World Bank, 2006).

In the modelling below we attempt to assess what difference these changes have made.

Figure 1 Pakistani Growth Variables 1960-2005 (logarithmic)



III. Measurement, Specification and Estimation

Assessing how these shifts influenced the formation of human capital requires definition and measurement of human capital, skill and competencies over time. It is unclear as to how appropriate are proxies, such as the number of graduates, average years of education, literacy rates, school enrolment ratios or proportion of the population that has completed schooling at different levels of education, to their theoretical equivalents – though if markets work well, relative wages will reflect the marginal productivity differences.

The production function model postulates a flow of productive services from the human capital stock. It follows that a rise in production – or economic growth- depends upon the increase in human capital stock, so long as the service flow is proportional to the stock. The increase in the stock is gross investment minus depreciation. So for example, considering the stock of workers with secondary education, more secondary educated young people may enter the workforce every year, but both secondary educated and uneducated people leave the workforce each year as well. It is the difference between these two magnitudes that is relevant for economic growth, though for the level of gross income, simply the flow generated by the stock of secondary educated workers is pertinent.

When considering year to year variations in human capital, these measurement issues matter particularly. In the case of an increase in the proportion of the relevant age group attending school from one year to the next, while the eventual affect may be to increase human capital services, the immediate effect is to reduce the supply of unskilled labour. If they would have been productive, this will have a negative impact on output, even though eventually there will be a greater positive effect. The opportunity cost of not entering the workforce will be lower, when unemployment is higher.

Given the limited availability of the data, the proxies for human capital here considered are as follows.

- The stock of human capital at the secondary level of education defined as the percentage of the workforce that has completed secondary education. Estimates of the human capital stock at secondary level are constructed from benchmark figures are based on Barro and Lee (2000). Following the perpetual inventory method, net flows of graduates with secondary education are added to bench mark stocks to generate an annual series.
- Health expenditure as percentage of GDP as a measure of health capital services.⁶

⁶ When health expenditure over output (HE/Y) is included in the per capita production

$$Y/L = A (K/L)^\alpha (H/L)^\gamma (HE/Y)^\phi$$

which implies

$$Y = AL^{(1-\alpha-\gamma)/(1+\phi)} K^{\alpha/(1+\phi)} H^{\gamma/(1+\phi)} HE^{\phi/(1+\phi)}$$

This means the production function is constrained to constant returns to the four factors because

$$(1/(1+\phi))(1-\alpha-\gamma+\alpha+\gamma+\phi)=1$$

Data are annual and fully cover the period 1960-2003. Sources of data and a description of variables are given in the appendix.

The demand for human capital is derived from the production function and profit-maximising behaviour, but the supply of human capital is typically dominated by non-profit organizations, especially the state. With forward-looking behaviour, the supply of human capital might be expected to respond to future demands (derived from GDP), as well as GDP depending upon human capital. Although interest centres on measuring the contribution of inputs to output, output may have a causal effect on inputs as well. For example, output growth may stimulate investments in physical capital and may also augment human capital, by facilitating increased schooling and income (see for example Bils and Klenow 2000). Statistically, this reverse causality creates a correlation between the independent variables and the equation error term that renders OLS estimates of the production function coefficients inconsistent.

The parameters of the production function measure a long run relationship, and the time series from which the function is to be estimated are likely to be non-stationary. Regression models using such series may give rise to 'spurious regressions', even when the series are integrated of the same order. A necessary condition for a regression estimate to be a genuine economic relationship is that the variables are cointegrated, in which case the residuals will be stationary.

Parameter estimates of a cointegrating equation are 'superconsistent'; the distributions are asymptotically invariant to measurement error and simultaneous equation bias. However they may be also subject to small sample bias and have non-standard distributions. This last means the usual tests of significance do not apply. Moreover there is possibly a number of different cointegrating relations among a group of cointegrated variables. For reasons already stated, all the inputs into the production function can be endogenous, in which case there may be a cointegrating equation and an error correction model for each input, in addition to the production function.

For such circumstances, Johansen (1991, 1995) proposed a maximum likelihood method for estimating and testing for the number of cointegrating equations, as well as their speeds of adjustments. The approach is to test the restrictions imposed by cointegration on the Vector Error Correction model involving all the series under consideration. In this system the dependent column vector is the first difference of output and all the inputs of the production function ($\Delta \mathbf{Z}_t$). On the right hand side is the column vector of these variables lagged (here we consider only one lag, $\Delta \mathbf{Z}_{t-1}$) and the associated coefficients ($\mathbf{\Gamma}$). Also there is a column vector of the lagged levels of the production function variables (\mathbf{Z}_{t-1}). Matrices of adjustment coefficients (\mathbf{a}) and of cointegrating coefficients (\mathbf{b}) premultiply this vector. The standard errors of the coefficients in the cointegrating equations of the Johansen method have conventional distributions and so may be used for the usual significance tests.

With a one period lag the system is;

$$\Delta Z_t = \Gamma \Delta Z_{t-1} + \alpha Z_{t-1} + e_t$$

where e_t is a vector of error terms.

IV. Empirical Results

Test for unit roots

The degree of integration of each series used has been determined with Augmented Dickey Fuller (ADF) tests statistics, reported in table 2. Trend and additional lags were included when they were statistically significant. The ADFs show that all the variables considered are integrated of order one at 1% level except LNSSTPW which is significant at the 5% level. We cannot reject the hypotheses that all the variables are stationary in the first difference, and integrated of order I(1). So the series may be used to estimate co-integration regressions.

Table 2: Augmented Dickey Fuller (ADF) Tests

Variable	model	Adf stat	lags
<i>Levels</i>			
Lnrkdppw	C and tr	-0.766	2
Lnkspw	C and tr	-2.137	2
Lnsstp	C no tr	-1.801	1
Ssmfp	C and tr	-3.460	2
Lnhegdp	C no tr	-2.213	1
Lnelf	C and tr	-4.02	1
<i>First differences</i>			
Lnrkdppw	C and tr	-4.634	1
Lnkspw	C no tr	-3.968	2
Lnsstp	C and tr	-3.823	2
Ssmfp	C and tr	-4.083	2
Lnhegdp	C no tr	-5.157	1
Lnelf	C no tr	-6.048	1

LNRGDPPW:	Log of real GDP per worker
LNKSPW:	Log of real capital stock per worker
LNELF:	Log of employed labour force
LNLITPW:	Log of literacy rate per worker
LNSSTPW:	Log of human capital stock at the Secondary level of education per worker
LNHEGDP:	Log of government expenditure on health as percentage of GDP
LNMFPP:	Log of US multifactor productivity
C:	Constant
tr:	Time trend

Co-integrating equations

The next stage is the estimation of the long-run relationship. The lag length for the Johansen VAR is chosen to maximise the AIC . With one lag on the first differenced variables AIC is -21.3 and with two lags it is -22.4. With increased lag length the AIC becomes smaller, so one lag is the preferred specification.

The cointegrating model specification that fits the data and the theoretical constraints is a one with a linear deterministic trend in the data, and an intercept but no trend in the cointegrating equation(s). The trace test for numbers of cointegrating vectors rejects the hypothesis of no cointegrating vectors, but not at most one. So the data are consistent with one cointegrating vector (Table 3).

Table 3 The Trace Test for Johansen Cointegrating Vectors

Sample: 1960 2005

Included observations: 42

Test assumption: Linear deterministic trend in the data

Series: LNRGDPPW LNKSPW1 LNSSTPW LNHEGDP SSMFP LNELF

Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.658140	104.1756	94.15	103.18	None **
0.471896	59.09474	68.52	76.07	At most 1

** significant at 1% level

The normalized cointegrating vector is theoretically consistent with an aggregate production function including human capital, although the coefficient on physical capital is small, and on the margins of statistical significance. The other coefficients are more than three times their standard errors (in parentheses)

$$\text{LNRGDPPW} = 0.175\text{LNKSPW} - 1.767\text{LNSSTPW} + 0.310\text{LNHEGDP} + 0.447\text{SSMFP} + 0.357\text{LNELF} - 6.226 \quad \dots(3)$$

(0.092) (0.498) (0.038) (0.110) (0.095)

Log likelihood 518.3626

With output per worker as the dependent variable, the specification takes the US (Bureau of Labor Statistics) multi-factor productivity index as the shift in the technological frontier. The impact of the frontier depends upon an index of Pakistani human capital, as a measure of absorption capacity, and this coefficient (λ_1) (on SSMFP) is statistically significant. From the underlying production function, the output elasticity of the probability of secondary schooling per worker can be calculated to rise from 0.06 in 1960 to 0.23 in 2005.

Health expenditure has an elasticity of 0.24 and the capital elasticity is 0.13. The total human and physical capital elasticity of 0.6 is therefore well below unity, rejecting one endogenous growth model. However the statistical significance and positive sign of the labour input implies increasing returns to scale for all factors together. The labour elasticity is large at $((1-0.17+0.36)/1.31 =) 0.91$. Moreover growth is apparently

endogenous, in the sense of explained by the model. The absorption of technical progress, generated by the most advanced economy, through an increasingly educated workforce, ensures continuing economic growth.

Implied Rates of Return

The elasticity of the stock of educated workers in 2005 can be compared with that discussed Bassanini and Scarpetta (2001) and by Sianesi and Van Reenen (2003) (increasing average education in the population by one year raises output per head by between 3 and 6 percent, and returns are higher for LDCs than for OECD economies). To do so it is necessary to assume that a rise in the proportion of the workforce having attained a certain level of education can be directly translated into an increase in the average number of years of education in the workforce. Since there is no control for primary education in the model, the secondary education impact must be assumed to include years of primary education as well, that is, a total of ten years of education. For the comparison the sample maximum value of the proportion of the workforce with secondary education of 0.276 is considered. One extra year of education for the whole workforce translates into 10 years of education for one tenth of the workforce. Ten percent amounts to $(10/27.6 =) 0.362$ increase in the workforce with secondary education. With an elasticity of 0.3, a 36.2 percent increase in the workforce with secondary education raises output per head by nearly 11 percent. This falls outside the Sianesi and Van Reenan range for the OECD, but given the scarcity of education in Pakistan, an output elasticity of education greater than those for OECD countries is expected.

Turning to the second human capital measure, a rate of return from health investment can be obtained directly. Total health spending can be considered as the flow of services from a health human capital stock. A health investment ratio (0.6%) in the year 2005 (Table 1), and the coefficient of $(0.31/1.31 =) 0.23$ implies a very high return of $(0.23 * 0.006^{-1} =) 39$ percent. This constitutes more than an adequate return to an investment judged by commercial standards, independently of the consumption benefits.

Despite the measurement of two forms of human capital, secondary schooling and health, the coefficient on 'raw' labour is very high and that on capital very low. The modelling is biased against endogenous growth because there are certainly more types of human capital than those measured. Were they included, 'raw' labour might be less prominent. The size of the coefficient at a minimum indicates the strong importance of the human resources side of the economy.

V. Sources of Growth

The proximate sources of Pakistani economic growth can be obtained from a decomposition of the long run growth equation. Table 4 gives the decadal average annual growth rates of inputs and output. The variation between decades has already been noted, but the fall of in the growth of human capital inputs in more recent decades is very obvious in the table. Both health and schooling inputs become negative from the 1990s, and, as a consequence, so to does the absorption of technology variable (technology frontier shift*human capital). Yet the foreign (US) technology frontier shifted faster and therefore the possibilities for absorption were greatest in most recent years.

Table 4 Pakistani Economic Growth Data 1961-2005

	Actual annual average growth rates							
	real gdp per worker	real capital per worker	secondary schooling stock per worker	health expenditure/gdp	technology frontier shift*human capital	labour force	tech frontier	
1961-70	3.73	7.42	7.79	2.19	17.15	2.61	1.53	
1971-80	2.29	2.97	0.88	3.08	2.45	2.42	0.62	
1981-1990	2.63	3.09	5.82	1.91	14.93	1.95	0.57	
1991-2000	0.76	1.89	-0.52	-1.79	-4.08	2.19	0.87	
2000-5			-0.38	-3.24	-4.16	2.36	1.65	

The following growth attribution (Table 5) is derived from the production function estimate, equation 3.

Table 5 Human Capital and Pakistani Economic Growth 1961-2000

	Actual per worker real gdp annual average percentage growth		
	Model predicted	Model predicted due to human capital	
1961-2003	2.73	2.34	0.41
1961-70	3.73	3.42	0.57
1971-80	2.29	2.32	0.74
1981-1990	2.63	3.53	2.13
1991-2000	0.76	0.12	-1.12

The results in Table 5 indicate that, over the whole period 1961-2003, just under one fifth (0.41/2.34) of (predicted) growth in output per worker was due to human capital as measured here. Human capital has been responsible for more economic growth in successive decades from the 1970s until the 1990s. The 1980s appears to have experienced the strongest impact of human capital, accounting for 60 percent of predicted economic growth. However there is a substantial error in the decadal predictions for growth.

Strong growth during the 1960s was largely due to Pakistan's capital accumulation. During the 1980s economic growth was almost as high, but based on a greater human capital contribution. Later, economic mismanagement in general and fiscally imprudent economic policies in particular, caused a large increase in the country's public debt and reduced the input of human capital, leading to slower growth in the 1990s. The human capital contribution was actually negative in this decade.

VI. Conclusion

How human capital contributes to economic growth in Pakistan is elucidated by the rejection of the hypothesis that there are constant returns to labour, physical and human capital. This implies a rejection of the simplest version of the neoclassical growth model. But the rejection of constant returns to human and physical capital, is also contrary to the version of endogenous growth based on human capital considered here. Instead, technical progress appears to be driven by the ability to absorb new technology. Thus the

movement of the foreign technological frontier, coupled with the ability to absorb the technology, dependent on a greater stock of human capital (secondary school graduates), is increasingly critical for economic growth. .

The extremely high implied rate of return to health spending of 36 percent suggests such outlays are sound investments, quite independently of their consumption value. The output elasticity of the secondary education stock is not so readily susceptible to a rate of return calculation. A coefficient of 0.1 would imply a return of 20 percent if the output to stock ratio was 2, but to calculate this ratio, expected incremental net earnings are needed. A rough and ready translation of this stock into years of education for the whole workforce suggests the output generated by secondary education exceeds the range expected for OECD countries. For an economy with Pakistan's education endowments such a larger elasticity is expected.

Compared with the MRW implied production function, the output elasticity of human capital is low⁷, and the elasticity of 'raw' labour is high. This may reflect deficiencies in the measurement of human capital. But it may capture shortcomings in the Pakistani education system as well. With, for example, 15 percent of schools lacking even buildings, attendance at primary education is not easy and often ineffective. Thus a large proportion of the population are precluded from secondary education, even if they wished to choose it, and those who do receive secondary education are not necessarily well prepared. This would reduce the output elasticity estimated.

Since the main interest has been in the form of the production function, the principal focus has been on the co-integrating equation. A decomposition of the sources of growth implied by the co-integrating equation shows that, even the very incomplete measure of human capital employed in this study, explains just under 20 percent of the increase in output per head during the years 1961-2003. But the potential growth impact of human capital rises every year, with advances in foreign technology.

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⁷ MRW's implied result is about one third for human capital, and it should be noted that by excluding technical progress, a similar result can be obtained here.

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Appendix

Table A: Description of variables and data sources

Variable	Definition and unit of measurement	Data Sources
RGDPPW	Real GDP per worker (In US \$ per worker in 2000 Constant Prices)	Penn World Table 6.2
ELF	Employed labour force (in million)	Handbook of Pakistan Economy by State Bank of Pakistan, ILO yearbook statistics
KSPW	Capital stock per worker (in millions)	Miketa, A., 2004: Technical description on the growth study datasets. Environmentally Compatible Energy Strategies Program , International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, October 2004. http://www.iiasa.ac.at/ECS/data_am/index.html
SST	Secondary Schooling Stock (percentage)	Benchmark figures are taken from Barro and Lee (2000) and following the perpetual inventory method, we constructed flows of adult population that are added to benchmark stocks.
LITERACY	Literacy (percentage)	Economic Surveys of Pakistan for different years, World tables by World Bank, Handbook of Pakistan economy by State Bank of Pakistan, Fifty year of Pakistan Statistics by Federal Bureau of Statistics (FBS) Pakistan, and Statistical yearbooks by UNESCO for different years.
HEGDP	Total health expenditure as % of GDP (HEGDP)	Handbook of Pakistan Economy by State Bank of Pakistan
MFP	Multifactor Productivity	US, Bureau of Labour Statistics, Office of Productivity and Technology (May 2007 publication)
RHE	Real health expenditure (in millions)	Handbook of Pakistan Economy by State Bank of Pakistan
LER	Life Expectancy Rate	Handbook of Pakistan Economy by State Bank of Pakistan and World Bank
TELE1000	Telephone in use (000 people)	Statistical Yearbooks by United Nation for different years
Education Expenditure	Government Expenditure on Education as % of GDP (GEEGDP)	Economic Surveys of Pakistan for different years, Statistical Yearbooks by United Nation for different years, Handbook of Pakistan economy

Table B: Descriptive Statistics

Statistics Variables	Mean	Standard Deviation
LNRGDPPW	8.379	0.382
LNKSPW	8.640	0.645
LNELF	3.212	0.329
LNLITERACY	3.341	0.367
LNSST	1.421	0.667
LNHEGDP	-0.433	0.309
LNMFDP	4.471	0.117

Table C: Partial Correlations

Variables	LNRGDPPW	LNKSPW	LNELF	LNSST	LITERACY	LNHEGDP
LNRGDPPW	1.000	0.981	0.980	0.969	0.961	0.802
LNKSPW		1.000	0.961	0.975	0.936	0.755
LNELF			1.000	0.937	0.981	0.765
LNSST				1.000	0.924	0.713
LITERACY					1.000	0.711
LNHEGDP						1.000