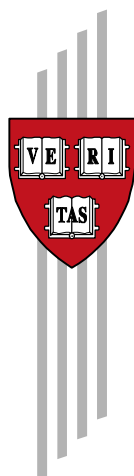# Education and Health at the Household Level in Sub-Saharan Africa

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Education and health at the household level in sub-Saharan Africa

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Abstract

This paper surveys the microeconomic evidence on the determinants of and returns to education and health in sub-Saharan Africa. A year of education is associated with 3-14% increases wages and productivity. The introduction or removal of user fees can have dramatic effects on take-up of health and education services.

Keywords: health, education, human resources, growth, Africa

JEL Classification: O15

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1. Introduction

Ever since Schultz's (1961) seminal article, investments in human capital have been widely viewed as making a substantial contribution to economic growth. Rosen (1987) defines human capital can as "the productive capacities of human beings as income producing agents in the economy" (p682). As is common in most of the literature on industrialised countries, he then goes on to equate it with productive knowledge and skills, often provided by education. However, human capital could also be widened to include physical capacities, which in turn depend on health and nutrition. Healthier and better nourished people are likely to be more productive, being more able to supply labour and, in some cases, having superior physical and - in some cases - cognitive abilities. In this paper we focus on human capital in so far as it relates to health and formal education; we do not consider other ways of accumulating human capital - notably training and experience.

Perhaps the most simple interesting theoretical framework in which to view the contribution of human capital to economic growth is the augmented Solow model (Mankiw, Romer and Weil, 1992). Income (Y) is determined by a simple Cobb-Douglas production function:

$$Y = A\,K^a\,L^b\,H^g \qquad\qquad (1)$$

where the arguments of the production function are technology (A), physical capital (K), labour (L) and human capital per unit of labour (H).

Accumulation of human capital fosters economic growth in the same way as accumulation of physical capital:

$$dY = \frac{dY}{dK}dK + \frac{dY}{dL}dL + \frac{dY}{dH}dH + dA \qquad\qquad (2)$$

Under the assumptions of neoclassical growth theory, this would be a disequilibrium effect: a period of catch-up, before the attainment of steady state at which per capita growth was determined solely by exogenous improvements in technology. However, one could argue that sub-Saharan Africa is currently off the steady state path, making the disequilibrium analysis relevant. Given this simple perspective, the two essential questions about the direct role of human capital in growth are the size of the productive effects of human capital ($\delta Y/\delta H$) and the determinants of its accumulation (dH). Macroeconomic studies of growth have provided numerous estimates of the former, focussing on education rather than health[1]. However, as yet the results are not robust and widely agreed (compare

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[1] Schultz (1997) includes a macroeconomic analysis of the determinants of education and health.

the large positive effects of Gemmell, 1996, with the zero effect found by Pritchett, 1996, on virtually identical data)[2]. In this paper we survey microeconomic evidence from sub-Saharan Africa on both the productive effects of human capital and the determinants of investments in human capital.

The structure of the paper is as follows. In section 2 we briefly define some concepts and sketch a minimalist model of human capital accumulation at the household level. The more substantive sections of the paper are the literature surveys in sections 3 and 4.

In section 3, we review the microeconomic evidence on the effects of education and health on income generation. The survey of the evidence on education (3.1) is much larger than that on health (3.2) due to an imbalance in the literature. Estimating a production function such as that in equation (1) would reveal the productive benefits of human capital. However, although macroeconomists often work with a single national production function, at the microeconomic level, different industries are likely to operate on different production functions. Furthermore, even if industries have common production functions, the marginal product of human capital may vary. In the Cobb-Douglas case, it will be decreasing with the human capital and increasing with other factors of production. The returns to education therefore may vary across industries, over time and across countries. However, some uniformity may be expected if educated labour is allocated efficiently across activities. Moreover, if households face similar discount rates and the market for investment in human capital is perfect, one would expect investments in human capital to occur up to the point where the returns equal those rates. We review estimates of production functions incorporating human capital for small holder agriculture (section 3.1.1) and from manufacturing enterprises in sub-Saharan Africa (section 3.1.2). An alternative approach is to directly estimate the price of human capital, for example, through earnings functions for the employed (section 3.1.3) and self-employed (section 3.1.4). A third avenue of research would be to look at the effect of human capital on household income (section 3.1.5). Such income functions might resemble equation (1), although they are more of a reduced form than a structural relation. A further complication is that production and earnings functions at the microeconomic level, unlike the macroeconomic level, omit external effects of human capital. Very little work has been done on at the microeconomic level to estimate these effects (section 3.1.6). The survey on the effects of education concludes with a discussion of whether partial correlations with productivity reflect causality (3.1.7) and whether they may be interpreted as rates of return (3.1.8).

In section 4, we turn to the determinants of human capital accumulation. Although many factors may be identified we focus on four of particular relevance to policy: user fees (section 4.1.1), quality of service (4.1.2), income (4.1.3) and gender (4.1.4). We also consider the interactions between human resources. These include effects of health on education (section 4.2.1), effects of education on health (section 4.2.2), effects of education on fertility (4.2.3) and intergenerational effects (4.2.4).

Although we focus on the direct effects of education, there may be important indirect effects on technology, physical capital accumulation, labour supply and beyond. Endogenous growth theories

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[2] The conflict may arise because Gemmell includes both the stock and growth of human capital as determinants of growth, whereas Pritchett includes only the growth of human capital. The stock and growth of human capital are negatively correlated but entered jointly both have positive effects on growth.

open the possibility that human capital may affect the long run rate of per capita growth by fostering technical progress (dA may be function of H). This seems plausible, although the argument does not seem to have been satisfactorily laid out even theoretically, still less quantified empirically. The endogenous growth theory which most explicitly focussed on human capital (Lucas, 1988) has since been put aside by its creator since it depends on a new edge assumption about the accumulation of human capital[3]. For sub-Saharan Africa, adoption of existing technologies may be of greater importance than the discovery of new technologies but the process of adoption has attracted less attention from growth theorists than that of innovation. Human capital may also play a role in the accumulation of physical capital. For example, educated farmers may use more capital intensive production, either because they have the necessary skills to use it effectively or because education provides the funds (via off-farm employment) for investment. Microeconomic work on agriculture has addressed some of these issues, although there is not comparable work on other sectors. Health and education also have important effects via labour supply. Whilst education - like physical capital - mainly raises the productivity of workers, the most direct effect of good health is to increase their labour supply. Both education and health may affect population growth through their effects on fertility and mortality. In Barro's (1991) seminal cross country growth regressions, female education raised growth in per capita income mainly by reducing population growth rather than increasing the growth in national income per se.

The focus in this paper on the productive effects of human capital on income is not to deny the other instrumental and intrinsic benefits of education and health. The intrinsic benefits are hard to quantify, but some of the instrumental effects are readily quantified (if not easily valued in money terms) and have been estimated in the microeconomics literature. Some of these results are covered in section 4.2. Other effects - for example, the effects of education on good governance - are probably not best studied at the household level.

2. Concepts and theoretical framework

In discussing education and health, one can distinguish *the use of education and health services* from *education and health outcomes*. The extent to which individuals use education services is often termed their educational attainment and is commonly measured in terms of years of formal education acquired[4]. Education outcomes may take the form of knowledge and cognitive skills acquired. They may be at least partly measured in tests of academic performance and are often termed educational achievement in the applied microeconomics literature. Some educational outcomes that affect productivity (and preferences) may be non-cognitive[5]. Health outcomes are likely to be multi-

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[3] The percentage rise in human capital was assumed to be proportionate to the time invested in human capital acquisition. If instead there is a diminishing relationship, the model because equivalent to the augmented Solow model; if there is an increasing relationship, growth is explosive (see Lucas, 1993)

[4] One may distinguish between levels of formal education - for example, primary, secondary and tertiary. Where grade repetition is common, it may be important to distinguish between actual years spent in education and highest grade of education acquired.

[5] Sociologists have noted the similarity between the requirements of the classroom and the factory-floor; for example, discipline and acceptance of hierarchy, punctuality and working to timetable, teamwork. In a developing country, education may increase people's achievement-orientation, with greater awareness of the possibility of improvements in one's standard of living. There may also be a greater openness to new ideas and modern practices. Against this, it is often argued that education leads to a disdain for agriculture, as students aspire to formal sector

dimensional and are difficult to measure, especially in the absence of clinical measurement (prohibitively expensive for those collecting household data in Africa)[6]. Mortality is an important indicator of extreme ill-health at the national level, but fortunately is rather rare and thus requires large samples to analyse. Instead, household surveys have typically focussed on self-reported indicators or on anthropometric measurements. Self-reported health indicators suffer from their subjectivity. For example, illness is commonly found to be positively correlated with education and income in surveys from developing countries. This may indicate the greater sensitivity of the educated or more affluent to ill-health, rather than ill-health per se. Questions about physical functionings (or Aactivities of daily living@) seem to suffer less from such biases, but often identify only a subset of illness (eg back problems) and perhaps most useful for identifying variations in health amongst the elderly. Anthropometrics - measures of weight and height - are most commonly used for children. Although they measure size rather than health, they are thought to be closely correlated with illness and are predictors of mortality. For example, a young child suffering from repeated bouts of diarrhea is likely to be wasted. The multi-dimensionality of health requires caution in making empirical generalisations. Three examples illustrate this. Child mortality appears to have fallen in Ethiopia during the Marxist regime (1974-91) despite worsening anthropometric indicators (Mackinnon, 1995a). A survey of Uganda shows almost no correlation at a household between child mortality, anthropometrics and reported illness (Mackinnon, 1995b). Strauss and Thomas (1995) cite a health price experiment in Indonesia where increases in prices led to less health care utilization, a deterioration in activities of daily living and more days limited by illness, but also reported better general health and less morbidity.

Some insight into the effects of human capital and its accumulation can be provided by modelling human capital as something produced by the household. Let us consider the health or education inputs, S, which are demanded at least partly in order to generate productive human capital, H. In the case of health, H could be regarded as health status; in the case of education, H could be viewed as knowledge and skills. For simplicity, assume the household has a single member who maximises the following utility function:

(1) $U = U (H, L, S, Z)$

where L is labour supply (a bad) and Z consumption of all other goods that do not contribute to human capital. H and S enter directly in the utility function as they may be intrinsically desirable (eg if H is health and S is food intake).

Utility is maximised subject to three constraints:

The first is a human capital production function: this could be "a health production function" (Grossman, 1972) or an Aeducational production function@ (Hanushek, 1986). This is a technological relationship - reflecting purely biological or educational processes - but the inputs are, to a certain extent, choice variables. We denote this human capital production function as:

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employment.

[6] For further discussion of the measurement of health see Behrman and Deolalikar, 1988; Strauss and Thomas, 1995).

(2) $H = H(S, T; Q, d, L, m)$

where:

       T   household time devoted to human capital accumulation (eg at school; on health care)
       Q   the quality of the services S provided.
       d   observable household characteristics (eg age, sex)
       L   relevant community characteristics (eg the local health environment)
       m   unobservable household characteristics (eg innate healthiness or intelligence)

Other constraints include a wage function:

(3) $W = W(H; d, I, a)$

where:
       I   relevant community characteristics (eg local infrastructure that affects demand for
              labour)
       a   unobservable household characteristics such as ability

This presumably reflects a production function in which human capital is an argument alongside more traditional factors. Indeed, the model can be easily extended to take account of household production - for example, of agricultural commodities. In the empirical section, we investigate the extent to which there are matching effects of education on earnings and production functions.

There is also an income constraint: household can spend no more on goods and human capital inputs than they earn in the labour market and in agricultural production.

(4) $Z + P_s.S = W.L + V$

where
       V   unearned income
       P_s prices of services (price of Z normalised to 1)

Finally, there is a time constraint with a fixed endowment of time, normalised at 1, being allocated to labour, human capital acquisition and leisure, R.

(5) $1 = L + T + R$

Maximising (1) subject to (2), (3) and (4) yields reduced form demand functions for human capital (health or cognitive skills) of the form:

(6) $H = H(P_s, V, d, I, \Lambda, \alpha, \mu)$

It should be noted that the reduced form demand for human capital inputs, S, will be a function of the same exogenous factors. This theoretical framework provides insights into the modelling of both

the determinants of H and S; and their consequences. First, the endogeneity of wages with respect to H and the fact there is an opportunity cost of S in terms of time, implies that there may be problems in modelling H or S as functions of income. Secondly, the fact that a is present both in the reduced forms and in the earnings functions makes interpretation of correlations between H or S and wages problematic. It may be that H (or S) really do raise wages or alternatively, the correlation may simply arise because they are both determined by a. For example, are educated well people more productive or were did they simply have higher pre-existing ability. The framework also suggests solutions to these identification problems. For example, the effect of human capital on wages could be instrumented by the price of services. In practice, this is not always done, partly for data reasons - for example, studies of the effect of education on wages or productivity, typically regard education as predetermined. Endogeneity problems are regarded as more serious when decisions about S have been taken more recently - for example, in studying the effect of nutrition on wages and productivity.

3. Effects of education and health on income generation

3.1 Evidence on the effects of education

3.1.1 Agricultural production functions

Phillips (1994) surveyed 56 studies which included education as a determinant when estimating agricultural productions using farm-level cross-sectional data from developing countries. He reported that on average, four years of farmer education is associated with a 6.1% increase in agricultural production (where the average was calculated weighting study estimates by the inverse of their standard errors)[7]. However, this literature survey includes only two data-points from Africa: both from the early 1970s and both with zero or negative effects of education on agricultural productivity (Hopcraft, 1974; Moock, 1981). Appleton and Balihuta (1996) review a further nine African studies, concluding that the estimated effects of education are typically insignificant although often large in size. Table 1 presents quantitative information on the ten African studies from which the effect of four years of education and its standard error could be estimated[8]. The estimates are all derived from agricultural production functions where a logarithmic dependent variable is regressed on the logs of various inputs (land, labour, purchased inputs and/or capital) with schooling entering as a shift variable but are not fully comparable[9]. The educational variables differ across studies (for example, in whether it is the head's education or the education of all farmers that is referred to) and do not always permit an exact estimate of the effect of four years of schooling[10]. As the supplementary

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[7] Although an unweighted average would also be unbiased, this weighting provides a more efficient estimator.

[8] The study by Gurgand (1993) is omitted since it does not control for labour input; that by Aguilar and Bigsten (1994) is omitted because it perhaps inappropriately controls for off-farm income and uses the same data-set as Bevan, Collier and Gunning (1989).

[9] The preference for a semi-logarithmic functional form over, for example, a fully logarithmic one, does not seem to be the result of empirical testing. Instead, it may be because it more easily accommodates the many observations of zero education.

[10] Weir (1999) provides an example of the complexities. In Table 1, we report a relatively large effect of the most educated farmer having 4-6 years of education, but in an alternative specification, the effect of years of farmer schooling is insignificant with a coefficient of 0.01. This partly reflects a non-monotonic effect of education and may also reflect a divergence between the effects of the education of the most educated and that of average education.

information in Table A1 shows, the surveys also vary in terms of dependent variables and control variables. Only one study, Appleton and Balihuta (1996), used a nationally representative survey.

Taking the mean of the estimates in Table 1, weighted by the inverse of their standard errors, four years of farmer education is associated with a 10% rise in agricultural production. This figure is higher than the developing country figure reported by Phillips. The standard error of the estimate is 0.032 and one can reject the null hypothesis that it is statistically significant from zero at the 2% level. We focus on the impact of four years of primary schooling - often thought to the minimum required for functional literacy - as this may be most important in terms of raising educational productivity. In practice, few studies explore this[11]. Appleton and Balihuta (1996) and Weir (1999) find some evidence of this for Uganda and Ethiopia. Indeed, Weir finds non-monotonic effects of education - with more than seven years of schooling being associated with lower productivity. Appleton and Balihuta find insignificant effects of secondary schooling on farmers. However, the African evidence is insufficient to support strong generalisations about how the impact of education varies with its level. Revisiting the data analysed by Appleton and Balihuta (1996), Appleton (forthcoming 2000) found that the size of the effect of education on agricultural productivity in Uganda was highly sensitive to the measurement of labour in the production function. The results of Appleton and Balihuta were obtained when labour was measured in number of people working on the farm. However, when an estimate of the number of hours in a year worked on the farm was used instead, the return on secondary education increased dramatically - from an insignificant 2% per average year of farmer secondary education to a highly significant 5.6%. The study found that in Uganda, education - particularly secondary education - was associated with a reallocation of labour from the farm to non-farm self-employment and wage employment. This reallocation is not fully controlled for by measuring labour only in workers and not worker hours. Hence, controlling only for number of workers on the farm it appears that farmer secondary education has no effect on productivity when in fact it simultaneously raises productivity and lowers hours worked. More generally, not controlling for hours worked is likely to under-estimate the effect of education on productivity. There are other possible downwards biases. By controlling for inputs, the estimates do not include any allocative benefits of education in terms of leading to a better mix of inputs[12]. In Appleton and Balihuta (1996) find that not controlling for capital and purchased inputs raises the estimated impact of four years of primary education from 7% to 10%. Ram and Singh (1986) find that omitting all other variables, the effect of average years of schooling on agricultural earnings rises by 22%. However, no such effect was found in Ethiopia (Weir, 1999).

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[11] The evidence is also unclear on whose education matters. Appleton and Balihuta find that it is the education of all adult household members working on the farm, women and men equally, that matters in Uganda. However, they obtain the same estimates of the impact of education whether it is defined in this way or simply as the education of the household head. Weir finds that the education of adult non-farming has an equal, if not greater, impact in rural Ethiopia whilst the education of the household head appears to have no effect. Ram and Singh (1986) find that average education in the household has the largest direct effect on productivity, whilst education of the household head may work via increasing other inputs.

[12] For example, Bingswanger, Khandker and Rosenzweig (1993) find that primary education raised agricultural output in India largely through an increase in fertiliser demand. Croppenstedt, Demeke and Meschi (1998) using data from a 1994 fertiliser marketing survey of Ethiopia found that literate farmers are more likely to adopt use of fertiliser than those who are illiterate, though the quantity of fertiliser demanded does not depend on literacy.

A possible upwards bias in the estimated effect of education is the publications process. It is easier to publish significant positive results and often insignificant or negative estimates may not be reported (for parsimony or to suppress a perverse result). The wholly insignificant and near zero estimate by Owens is an example of a result which - quite reasonably - might not be reported in a published analysis of the data and was kindly provided on request of the author.

3.1.2 Manufacturing production functions

Appleton et al. (1999) include education as a factor in production functions estimated for manufacturing enterprises in the early 1990s in Cameroon, Ghana, Kenya, Zambia and Zimbabwe (Table 2 refers). The mean estimate of the effect of an extra year of education on manufacturing output is 3%, after weighting by the standard error of the estimates. The standard error of this estimate is 1.1, making it significantly different from zero at the 5% level. The authors note that the return to physical capital implied by their production functions is much higher, at over 20%. They also note that worker education does not vary much across the countries in the sample and hence can explain little of the substantial differences in productivity.

3.1.3 Wage earnings functions

Table 3 reports estimates of the effects of education based on earnings functions estimated for data-sets for sub-Saharan African from 1980 onwards. In all cases, the estimates come from semi-logarithmic earnings functions of the form:

$$LnW = \alpha + \Sigma \, \beta_j S_j + \gamma_1 A + \gamma_2 A^2 + \delta Z$$

where S_j represents education of level j; A represents age or experience; and Z represents control variables such as sex.

The results are not fully comparable. Those from enterprise surveys will tend to cover a sub-set of employees; some household surveys are not nationally representative. There is some evidence that including rural areas may have a marked effect on estimated returns to education. Appleton et al (1996) report returns to primary schooling in earnings functions in rural Cote d'Ivoire that are around half those reported by Schultz (1993) for earnings functions run on rural and urban areas combined. The specification of the effect of schooling varied between studies: some used years of education of a given level; others used dummy variables for attainment of some (or complete) education of that level. Where dummy variables were used, the effect of a year of education of level j was estimated as $(exp(\beta_j)-1)/J$ where J is the number of years of education needed to complete level j. Studies also differed in the control variables used, although they were generally parsimonious.

Where results are reported separately by sex, we obtain a study average weighting by the proportion of employees of the relevant sex[13]. The mean effect across the 28 studies of a year of primary

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[13] In the main text, we report study averages, possibly over-representing countries such as South Africa which have been studied several times. However, if we take country averages (so that two studies of the same country are each given a 50% weight) the results are similar to the study averages. In particular, the mean effect of primary education is 5%; that of (lower) secondary schooling is 14%; and university 33%.

schooling is to raise earnings by 5%; the median effect is 4%. For secondary schooling (or just lower secondary schooling when results are divided into upper and lower), the mean effect is 14% and median 12%. There are only seven estimates of the effects of upper secondary schooling - with a mean of 16% and a median of 14%. There are sixteen estimates of the effects of university education, with a mean effect of 37% and a median effect of 30%. It should be noted that the latter may be generous, since effects were often estimated from dummy variables for university education on the assumption that university education lasted only three years when in fact students may take longer to finish their courses. Clearly one must be cautious about how much weight are placed on averages of studies conducted in different locations, at different times and with differing quality of data. There is considerable variation in the estimates, with the effect of primary schooling having a standard deviation of 4% and that of secondary schooling having a standard deviation of 6%. However, that the effects of education rise with the level of education is a fairly general finding. In only one study (Bigsten and Kayizzi-Mugerwa on Uganda), is the effect of primary schooling greater than that of secondary schooling; in only two studies (Schultz on Cote d'Ivoire; Khandker and Mason on Tanzania), is the effect of secondary schooling greater than that of university.

One issue is the extent to which returns to education have been changing over time. Table 3 provides little evidence of this. Regressing the estimated effects of education on a time trend yields wholly insignificant results for each level of education. Few studies have looked at changes in returns to education in particular African countries over an extended period. Appleton, Bigsten and Kulundu (1998) looked at the effect of education on earnings of manufacturing workers in Kenya using data for 1978, 1986 and 1995. They find the Mincerian returns to primary education have fallen from 10% in 1978 to 2% in 1995; the returns to secondary schooling have fallen from 34% to 12%; the returns to university have not fallen and may have increased. Moll (1996) reports that returns to primary education for Africans in South Africa fell from 8% in 1960 to 3% in 1975. Thereafter, they remained fairly constant. Two studies covering much shorter periods of time have not observed falls. Krishnan, Selassie and Dercon (1998) find no significant changes in returns to education in Ethiopia in the period 1990-1997. Canagarajah and Mazumdar (1997) find a rise in the returns to education in Ghana, particularly post-primary, between 1987 and 1991.

3.1.4 Earnings from non-agricultural self-employment

Table 4 reports estimates of the effect of education on earnings from non-farm self-employment from seven studies of sub-Saharan African countries. The number of studies is small and the various specifications used not strictly comparable, so the mean estimate across the studies may not be reliable. The mean increase in self-employment income associated with an extra year of education is 7% at the primary level and 12% at the secondary level. These averages are fairly comparable with those given above for earnings in wage employment. Furthermore, in almost all studies, returns in wage employment are also estimated and found to be comparable to those in non-agricultural self-employment. The higher return to secondary education is somewhat less apparent in self-employment than wage employment, perhaps because secondary education plays more of a signalling role than primary education. In particular, access to state secondary schooling in Africa (and some private schooling) is typically rationed by performance in a primary-leaving examination. Primary education is more commonly open access, although lack of availability is still a problem in some rural areas (for example, parts of Ethiopia - see Weir, 1998).

3.1.5 Income and consumption functions

Although the returns to education in different activities are informative, they may miss important effects of education in allocating individuals across activities. Useful summary information can be given by relating the per capita income (or consumption) of a household to the education of its adult members. In a multivariate analysis controlling for other parental background, personal characteristics, demographics, land holdings and location, Appleton (1995c) found significant positive relations in both rural and urban areas of Uganda using data from 1992. Each year of male primary education per adult equivalent was associated with a 2% increase in household consumption per capita, *ceteris paribus*. For secondary schooling, the corresponding figure was 8%. Female primary education had twice as powerful an effect; female secondary schooling had a similar effect to male secondary schooling. However, Glewwe (1992) found no relation between education and economic welfare in a multivariate analysis of rural areas of Cote d'Ivoire in 1985-86 (in urban areas, an effect was found).

Appleton (1992) estimated reduced form models of household income based on rural household surveys in Kenya in 1982 and Tanzania in 1983. Adult education significantly increased incomes only in Kenya. In that country, female primary schooling and male secondary schooling were of particular importance. The effects were large. Ceteris paribus, if a male head had five Forms of secondary schooling, household income is predicted to rise by roughly the sample mean income. If the senior female had eight Standards of primary schooling, the rise would be roughly two-thirds of the sample mean income. One reason why education has more effect in Kenya than in Tanzania may be the more developed labour markets in the former country. In the Kenyan data, 14% of male household heads and 2% of senior females listed non-agricultural employment as their main occupation; in Tanzanian survey, the corresponding figures were 5% and 1%. These higher levels of formal employment in Kenya may explain the greater impact of education, assuming the returns to education are highest in such work. The gender gap in formal employment participation observed in the figures for Kenya may also help to explain why the type of schooling that is significant varies by gender. Secondary schooling is likely to be particularly important in raising earnings from formal employment, which males are more likely to engage in.

Coulombe and Mackay (1996) use household survey data from Mauritania in 1990 to analyse the effect of education both on the type of primary activities engaged in by households and on returns within those activities. Households were classified into four socio-economic groups - non-working, wage employees, agricultural households and non-farm self-employment - based on the which activity household members devoted most of their time to. In rural areas, the education of the household head did not significantly affect the type of primary activity of the household. Modern schooling also had insignificant effects in rural areas in multivariate analysis of the determinants of living standards of each working socio-economic group. Koranic education had a significant positive effect on agricultural households. In urban areas, education of more than five years lowered the probability of the household being classified as non-working. Conversely, schooling had strong effects on urban households primarily engaged in wage employment and self-employment.

Simple reduced form models of household income or consumption provide straightforward information on the overall effects of education. For some data-sets - such those from Cote d'Ivoire, Tanzania and Mauritania - there is some evidence that the effects of education on rural livelihoods are weak and insignificant. Consequently, focussing discussion on rates of return based on samples of urban wage employees may greatly overstate the effect of education on productivity in a country as a whole. For other data-sets such as that from Uganda and Kenya, effects of education on rural living standards do not differ so much from conventional rates of return estimates. From the agricultural production functions presented in Table 1, this is not because education in those samples has a particularly strong effect on agricultural productivity. Instead, the finding presumably reflects the greater importance of education in those samples in securing access to off-farm income. However, more work is required to confirm this interpretation.

3.1.6 External income benefits of education

By focussing only on the effects of own education on own wages or productivity, most microeconomic studies cannot estimate the possible external benefits from the education of others. In the context of agriculture, one approach is to see how the education of neighbouring farmers affects productivity. Both Appleton and Balihuta (1996) and Weir (1999) find that these external benefits appear large although they do not control for many community-level variables which might be correlated with community education. In Appleton and Balihuta (1996), a one year rise in the average primary schooling of neighbouring farmers is associated with a 4.3% rise in output compared to a 2.8% effect of own farmer primary education. In Weir (1999), the figures are reported to be 56% and 2% respectively. The 56% return seems rather high and may reflects exceptionally large differentials in productivity between the sites in the sample used[14]. A related exercise by Jones (1998) examined neighbourhood effects in urban Ethiopia, but stopped short of estimating the effect of neighbours' education on own income.

Some external effects of education may not be confined to particular neighbourhoods: for example, if education promotes good governance or improves technology at the national level. In these cases, these effects cannot be estimated by cross-sectional micro data. Doyle and Weale (1994) make the suggestion that these effects could be estimated as the difference between macroeconomic and microeconomic estimates of the returns to education. They conclude that there is little evidence of such effects at a global level, as from their survey of the literature, microeconomic estimates of returns typically exceed macroeconomic estimates. More comparative micro/macro work on this area may be fruitful as both sets of empirical literature - macroeconomic on growth and microeconomic on education are still relatively young, especially for sub-Saharan Africa.

3.1.7 Signalling and ability bias

Interpreting the association between education and economic outcomes is problematic because of concerns that positive effects of education may not reflect effects of education but correlations with

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[14] In a simple production function controlling for household level variables, dummy variables for different sites indicate that productivity differs by a factor of 22 between the site with the most favoured community characteristics and the least favoured site (equation 2, Table 2, Weir, 1999).

omitted variables such as pre-existing ability, parental background or good land quality (for example, in the model in section 2, the unobservables α appear in both equations 3 and 6). One hypothesis - credentialism - disputes any link between education and productivity. The educated are paid more despite not being more productive than the uneducated. This seems *a priori* unlikely behaviour, at least by private employers. It has also been challenged empirically by the close match in the effects of education on wages and productivity found in manufacturing enterprises in five African countries by Appleton et al. (1999)[15]. A weaker hypothesis is that of screening: educated workers are more productive but only because they have higher pre-existing ability.

Some doubt has been thrown on the screening hypothesis by an influential study of wage employees in Kenya and Tanzania (Boissiere, Knight and Sabot 1985). This found that wages were more strongly related to performance on tests of cognitive skills acquired at school (literacy and numeracy) than to a test of reasoning ability designed to be independent of schooling (Raven's progressive matrices). However, only half the conventional effect of education on wages could be attributed to cognitive skills; the remainder was unaccounted for. Similar studies have been conducted using data from Ghana 1988/89 (Glewwe, 1996) and South Africa (Moll, 1998). Glewwe (1996) found schooling to have a via mathematics and reading skills of the order of 3-6%, with the effect varying by age, location and sector. This compares with a 7% effect direct effect of schooling as estimated by a conventional OLS earnings function. Moll (1996) found tests of computation, but not comprehension, raised wages. However, these test scores appeared to account for only 30% of the effect of education on wages.

Signalling theories are not directly applicable to self-employment, but nonetheless, more general doubts about the causal effects of education may exist there. Two studies of Kenya and Tanzania estimate the effects of cognitive skills (literacy and numeracy) on agricultural production controlling for pre-school reasoning ability as measured by Raven's progressive matrices (Pinckney and Kimuyu, 1995; Husbands, Pinckney and Kimuyu, 1994). They find a threshold level of cognitive skills does significantly raise output and that schooling raises cognitive skills. Their results imply that if the household decision maker has completed primary school, agricultural production would be 10% in Kenya and 18% higher in Tanzania[16]. Given that complete primary schooling is assumed to take eight years in their analysis, these returns are similar to averages reported in Table 1. These findings do not fully deal with the possible endogeneity of schooling but do provide some evidence that schooling effects may arise through cognitive skills controlling for one measure of ability.

3.1.8 Proportional effects on productivity as rates of return

In order to decide whether a given estimate of the effect of education is large in economic terms, a useful interpretation is that of Mincer, whereby percentage effects of a year of education on wages can be viewed as rates of return. This interpretation holds if the cost of a year of education is a year's wages and if the effect is assumed to persist for infinity. Percentage effects of a year of education on Cobb-Douglas production functions (whether agricultural or manufacturing) can be similarly

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[15] This observation - based on the Ghanaian data - was first made by Jones (1994).

[16] The figures reported are the author's own calculations assuming no other educated household member. In Kenya, attending primary school has a direct negative effect on agricultural production controlling for the positive effect via cognitive skills: without this effect, the impact of primary education would be more than twice as large.

interpreted if wages are assumed to equal the marginal product of labour[17]. Under the Cobb-Douglas production function, the marginal product is proportional to the average product. Consequently, if wages equal the marginal product of labour, the percentage effect of a year of education on output is also the percentage effect on wages, ie a Mincerian return. As a formal example, the proportionate effect of human capital on output in equation (1) is:

$$(dY / dH) / Y = g / H \qquad (3)$$

This is also the proportionate effect on the marginal product of labour, since marginal products proportionate to total products:

$$dY / dL = (a + g)Y / L \qquad (4)$$

Thus equation (3) will also give the proportionate effect on wages, if wages equal the marginal product of labour. Assume the cost of education is the wage and benefits accrue to infinity. The net present value, NPV, of education is given by:

$$NPV = -W + (dW / dH) / (1 + r) + (dW / dH) / (1 + r)^2 + ...$$
$$= -(a + g)Y / L + (dW / dH) / r \qquad (5)$$

We know the effect of human capital on wages, $\delta W / \delta H$, is given by (3) multiplied by (4), hence for

$$-(a + g)Y / L + (a + g)(Y / L)(g / H) / r = 0 \qquad (6)$$

the NPV to equal zero, we need:
In other words, that the rate of return on human capital, ρ, equals the proportionate effect of education on output, γ/H.

Despite these arguments, the productions functions and earnings functions estimates in Tables 1, 2 and 3 appear to be of different magnitudes. The agricultural and manufacturing production functions estimates are similar: an extra year of education having to a 2.5% and 3% return respectively. However, they are evaluated at different average levels of education: the calculation for agriculture is for four years of primary school; in the manufacturing production functions, the mean level of worker education in the manufacturing estimates is around eight to nine years, with relatively little variation (around a standard deviation of around two years). However, both sets of production functions estimates are markedly lower than the earnings function estimates. Even primary schooling appears to have a 5% return in the earnings functions, compared to the 2-3% return to schooling in the production functions. Moreover, secondary schooling has a 14% return and tertiary education an even greater return.

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[17] The Cobb-Douglas assumption is not rejected for any of the five countries studied in Appleton et al. (1999). Jones (1994) could not reject the hypothesis that workers are paid their marginal products in the enterprise data for Ghana.

Appleton et al (1999) directly compare the returns to education in African manufacturing enterprises as estimated in earnings and production functions[18]. They report a weighted average to education of 8% in the earnings functions (Table 5) - far in excess of the 3% implied by the matching production functions (Table 7). However, the lower value for the production function does not seem to represent a fundamental discrepancy between the productivity and earnings data. When earnings functions are estimated at the firm-level with firm-level controls such as the capital-labour ratio, the return to education falls from 8% to 2%, very close to the 3% figure in the production functions (see Table 11 of Appleton et al, 1999)[19]. Instead the discrepancy is partly due to the failure of conventional earnings functions to control for firm-level variables such as the capital labour ratio. More educated workers tend to be employed in more capital intensive firms. However, this is not the full story - estimating earnings functions at the worker level produces much higher returns to education (7%-9%) even after including firm level controls or firm fixed effects. Estimation at the firm-level may understate the returns to schooling, perhaps by reducing the variance in the education measures and increasing the multicollinearity with firm level variables such as capital. After due attention to specification issues, Appleton et al (1999) imply that the returns to education in manufacturing are comparable whether estimated from production functions or wage earnings functions.

It is widely assumed that returns to education are lower in agriculture than in off-farm activities. A comparison of the above estimates from the agricultural production functions and wage earnings functions would seem to support this assumption. However, this may be premature. As in the case of African manufacturing enterprises discussed above, the treatment of enterprise-level controls - such as enterprise capital - may be one source of difference. Furthermore, Appleton (forthcoming) reports a remarkable similarity in estimates of the effects on education on earnings from farming, non-farm self-employment and wage employment in Uganda. Increasing the average years of worker education by one has the same effect on farm productivity and wage earnings (4% in the case of primary education; 6% in the case of secondary education). The Uganda case suggests that returns to education in agriculture may tend to be understated when hours of labour input are not properly controlled for.

A key limitation to the Mincerian interpretation is the assumption that the cost of a year of education is a year's wage. On the one hand, this might over-estimate the opportunity cost of education. For younger children, the opportunity cost of their labour is likely to be substantially less than an adult formal sector wage. Even for young adults, if not in school, they may be unemployed or engaged in activities with much lower returns than formal sector wage employment. On the other hand, the Mincerian assumption, completely neglects the direct pecuniary costs of education - both in private costs (fees) born by the user and in social costs (educational subsidies) born by the government.

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[18] Although the Appleton et al (1999) paper covers only five data-sets, it should be noted that the earnings functions estimates it produces are generally in line with those in Table 3. The mean Mincerian returns to education in the five data-sets used in Appleton et al (1999) are 3% for primary, 14% for secondary and 43% for university. These results are in line with the study average from Table 3.

[19] Whether rates of return should control for firm-level variables such as the capital-labour ratio is a moot point. From the point of view of an individual deciding to invest in their own schooling, such controls are inappropriate. Whether they are appropriate for estimating the social return to education depends on whether the controls are exogenous to education - for example, on whether education facilitates capital accumulation.

In principle, it is straightforward to adjust for the direct costs of education. For example, in their study of Kenya, Appleton, Bigsten and Kulundu (1998) report estimates of total direct costs for the 1995 that would increase the costs of education (with opportunity costs assumed equal to wages) by 6% at the primary level, 34% at the secondary level and roughly 200% at the tertiary level. It is less obvious how to adjust for discrepancies between opportunity costs and wages. Bennell (1996) reports that all African studies he reviewed assumed opportunity costs equalled wages for post-primary education, but that there was no consensus at the primary level. Some studies assumed no opportunity cost; others assumed a cost equal to some fraction (no more than one third) of wages. Given the relatively low direct costs of primary schooling, the final rates of return are very sensitive to such assumptions about opportunity costs. For example, Bennell shows how a study of Burkina Faso would imply a 200% rate of return to primary school if zero opportunity costs are assumed compared with a 14% return if opportunity costs are assumed to be half the average income of uneducated adults. There has been relatively little research into the value of child labour in Africa. One study of Ghana suggests opportunity costs may be modest, since children not in school are not more likely to engage in child labour than those in school (Bhalotra and Heady 1998). In addition, studies typically do not allow for the cost to adults of minding school-age children: schooling may free mothers to seek employment. Hence it is possible that primary education does have the very high returns conventionally attributed to it. This is not because it has a large productive benefit - Tables 1, 2 and 3 seem to refute that - but because it has very low costs.

It is a matter of some debate how much rates of return estimates of the kind reviewed here should guide educational policy decisions. It could be argued that they reflect only private benefits and so, even if large, provide no justification for government subsidy. Indeed, given the very large government subsidies, they yield social rates of return less than private rates of return and hence provide a justification for cutting government educational expenditure. Whilst it cannot be denied that a wider view of benefits is necessary when making policy decisions, the conventional rates of return are nonetheless of interest. If they are very high, they suggest that there are barriers to the private sector making lucrative investments in human capital. These barriers may include market failures such as credit rationing combined with poverty, risk aversion, Principal-Agent problems between children and their parents and informational problems. Government controls may also constitute a barrier - for example, if places at government schools are rationed by performance and private schools tightly controlled.

3.2 Evidence on effects of ill health and malnutrition

Less research has been done on the returns to health and nutrition than on the returns to education. This is partly because the non-monetary aspects of these returns - greater longevity, reduced suffering and absence of disability - are arguably more central than in the case of education. Attempts have been made to put financial values on these non-monetary outcomes, but the judgements involved are complex and subject to considerable controversy. More promising are attempts to assess the cost-effectiveness of various interventions in improving particular health indicators (see, for example, the analysis of cost-effectiveness in terms of "disability life years" in the World Development Report, 1993). Here we consider some of the direct economic costs of ill-health in

terms of reduced labour productivity. Possible indirect effects, in terms of lower investment in the quality of future labour, will be considered next.

Labour supply is adversely affected by illness in various ways. Most directly, days of work are lost when workers fall ill. Table 5 reports estimates of the cost of this using data from the Living Standards Measurement Surveys. On average, adult workers in the three African countries were ill for between 7% (in Mauritania) and 11% (in Ghana) of the 30 days prior to the surveys. Estimated income losses arising from absence due to illness range from around 5% in Cote d'Ivoire and Mauritania, to over 10% in Ghana. These losses are substantially higher than in the American countries for whom comparable figures are available. These figures are probably underestimates, since they exclude a number of other important effects of ill-health. Often people may continue to work when ill, but with lower productivity. Healthy workers are likely to have to stop work to care for sick household members (particularly children). Invalidity and premature death may also substantially reduce labour supply. Low life expectancy and the risk of serious illness may reduce incentives to undertake longer term investments which might raise productivity.

There has been a large literature on the effects of nutritional status on labour productivity. Behrman (1993) provides a recent review of the literature on two types of evidence. The first type of evidence is provided by data from socio-economic surveys which enable the association between measures of nutrition and worker productivity to be investigated. One African study, Strauss (1986), studied the link between calorie intake and agricultural labour productivity in Sierra Leone. Care was taken to control for the simultaneity of the relationship[20]. A one standard deviation increase in calories per equivalent adult was predicted to raise farm output by 20%, compared to the 33% impact of a one standard deviation in labour input. In a study of farm productivity in Ethiopia, Croppenstedt and Muller (1997), find a one standard deviation increase in the household head's weight-for-height would increase output by 27%. The second kind of evidence is experimental: different groups of workers are given different kinds of nutritional supplement. One experiment gave Kenyan construction workers supplements of 1,000 calories per day. Since less food was consumed at home, this translated into an increase of 500 calories per day (a low-calorie supplement of 200 calories per day was almost completely offset by reduced consumption at home). Workers on the high-calorie supplement increased their productivity by 12.5% per day, a large increase (implying an output elasticity of 0.5 compared with the 0.33 estimated for Sierra Leone)[21].

Analysis of household survey data from Cote d'Ivoire and Ghana has found that improvements in anthropometric status is associated with higher wages, after instrumenting for anthropometric status (Schultz, 1996). A unit increase in the Body Mass Index is associated with an increase in wages of 16 to 10 percent increase in Cote d'Ivoire, and by 8 and 10 percent in Ghana. An increase in the height of one centimetre is associated with a 5.7 to 7.5 percent increase in the wages of men and women in Ghana, respectively. In Cote d'Ivoire, height has perversely negative effects.

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[20] Nutritional status may be expected to raise income, but one must be careful about reverse causality - higher incomes should also improve nutritional status

[21] The study is subject to limitations: it covered only 47 workers; there was high and probably selective attrition; and the results were only significant at the 7.5% level.

4. Determinants of health and education

The determinants of human capital accumulation are of interest for at least three reasons. They indicate how policy interventions - for example, changes in user charges or quality of service - may affect human capital. Secondly, they provide evidence which bears on the extent to which policy interventions are justified. For example, they may reveal inequalities or suggest market failures in human capital investments. Thirdly, they suggest how human capital can be modelled as endogenous in order to estimate returns to human capital uncontaminated by endogeneity bias. In this section we review the effect of four policy-relevant variables - user fees, service quality, income and gender - on four variables - health care demand, health status, educational attainment and educational achievement. Inevitably, the review is not comprehensive - partly in regard to the range of determinants considered[22].

4.1.1 User fees

Effects on health care demand

From an economic perspective, price is a central determinant when considering the demand for education and health services. However, for much of the post-war period, African governments have attempted to provide some education and health services free at the point of delivery. This - together with a lack of cross-sectional price variation - has meant that there has been insufficient data on fees with which to estimate price elasticities for social services in Africa. Some studies have tried to overcome this problem by estimating the time costs of using social services (eg Gertler and van der Gaag, 1990). Some scepticism is warranted with these cross-sectional estimates. Estimates of time costs are correlated with other variables - notably wages and distance from urban areas - which may have direct effects on health care demand. Estimates of direct costs are no less problematic. These are typically based on actual expenses incurred by those who sought treatment - hence they partly reflect quantity demanded, rather than price alone. Direct costs are not observed for those who did not seek treatment and, unless genuine price data can be found from other sources (such as matching facility surveys), imputations must be made - often by taking averages for a location. Once again, it becomes possible that these reflect other unobserved locational effects. To the extent that there is genuine spatial price variation, one must ask whether it reflects variations in demand - for example, due to variations in the quality of services provided, in income or in morbidity.

Given these data problems, it is not surprising that estimates of the elasticity of demand for health services in African countries vary widely (Table 6 refers). Some studies (of Ghana, Ethiopia, Sudan and Swaziland) yield relatively low figures. However, those for Benin are extremely high, whilst those for Burkina Faso and Cote d'Ivoire are sizable - for some groups, greater than unity. The latter two studies also disaggregate by age and income group: elasticities are found to be markedly higher for the poor and children. Interestingly, Lavy and Germain (1994) find elasticities of health care in

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[22] For example, water and sanitation are potentially important policy variables. Lavy et al. (1996) find a strong effect of clean water and sanitation on child health in Ghana. They estimate that if rural water and sanitation were improved to the level of urban areas, the rural-urban gap in outcomes would be narrowed by a third in the case of height and by half in the case of weight-for-age while the expected survival time of rural children would be increased by almost 10%.

Ghana with respect to distance to be much higher than those with respect to user fees. A fifty percent reduction in distance would increase demand for public facilities by 96% in Ghana, whereas a 50% increase in user fees would lead to only a 6% fall. Subjective questions about willingness to pay indicated that distance was the most important consideration, followed by drug availability.

Before and after studies of cost recovery in Africa in the late 1980s and the 1990s arguably provides more reliable evidence on the impact of user fees than cross-sectional econometric estimates of demand elasticities. Indeed, where fees are introduced, it is not clear that the elasticity of demand is a useful concept; since the proportionate price change when moving from zero to some positive charge is infinite, it may be that even low estimated price elasticities are consistent with a large demand response[23]. There are many examples of sharp reductions in usage of health facilities following the introduction of user charges. One of the more econometrically sophisticated studies of such experiences is the analysis of the implementation of user charges in Kenya in 1989 by Mwabu, Mwanzia and Limbila (1995). Using a multivariate analysis controlling for distance, travel costs and changes in the quality of services, they estimate that the introduction of charges led to a 52% decrease in outpatient visits at government health centres. When fees were suspended in 1990, the number of outpatient visits rebounded by 41%. Implementing fees seems to have led to similarly large demand effects in some other African countries, as suggested by reports from Zambia (Booth et al, 1995; Kahenya and Lake, 1994; Lake, 1994) Mozambique (Green, 1994); Swaziland (Yoder, 1989); Zimbabwe (Hongoro and Chandiwana, 1994). There are caveats to this conclusion. The implementation of user fees in some facilities (eg government hospitals) can lead to significant switching of demand to other facilities (eg private facilities or government facilities unaffected by the charges) (Shaw and Griffin, 1995; Mbugua et al, 1995). The long run price response may be less than the short run response (Waddington and Enyimayew, 1990). Where travel costs are already high for high quality facilities, introducing a small charge may have an insignificant effect on total user costs and hence demand (Booth et al, 1995). Where quality improves alongside the introduction of fees, demand may not fall. Litvack and Bodart (1993) studied five health facilities in Cameroon; in the three that improved quality, demand increased despite the introduction of fees and the increase was proportionately greatest amongst the poorest quarter of households. It has been reported that where increases with fees were associated with improved quality - in Benin, Guinea and Sierra Leone, increases in utilisation were observed; where fees increased without quality rising - in Ghana, Mozambique and Swaziland - utilisation fell (UNICEF, BIMU and Renzi, 1990). An exception to this is Zaire, where utilisation fell with the introduction of fees even though they were used to fund improvements in drug supply and the maintenance of buildings (Haddad and Fournier, 1995).

Effects on health status

There are few studies which estimate the effect of user charges on health, rather than health care. Lavy et al. (1996) report a negligible effect of the price of medical care on child mortality using survey data from Ghana in 1988, but caution against placing undue emphasis because most child health services are exempt from charges. However, they also find that higher consultation charges are negatively associated with child height and weight-for-height. Benefo and Schultz (1996) find that the price of antibiotics is a significant determinant of child mortality in Ghana: doubling drug

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[23] I am grateful to Germano Mwabu for making this point to me.

prices would increase child mortality by 50%. They also find that increased travel times to health facilities have negative partial correlations with child mortality.

Effects on education attainment

Early estimates of the price elasticities of demand for education yielded figures of -0.52 for Malawi in 1983 and -0.98 for Mali in 1982 (Mingat and Tan, 1984; Birdsall, 1983)[24]. In practice, these estimates seem rather high. Glewwe and Ilias (1996) found no significant effect of school fees on the educational attainment of those aged 11-20 in Ghana in 1988-89, although travel time does have the anticipated significant negative effect. This finding is replicated by Lavy (1996) using data from rural Ghana in 1987-89. Lavy stresses that distance from secondary school negatively affects primary school enrolment, arguing that this implies a cross-price elasticity. This is plausible but speculative given the direct measures of prices are insignificant. Proximity to secondary school will typically capture many other community level factors, since secondary schools are commonly located in towns or in rural areas with a high demand for education. No significant effect of education costs were found on educational attainment in Tanzania in 1993 by Mason and Khandker (1995). These estimates of the effects of direct cost measures on education attainment typically suffer form similar data problems to those identified above int he health literature.

Evidence on enrolments before and after the introduction of fees typically shows increases in drop-out rates. Some times these effects may be large. For example, in Nigeria in 1984, the introduction of user fees in 1984 led to a fall in primary school enrolments from 14.7m to 12.5m. In Bendel state, the gross enrolment ratio fell from 90% to 60% in 18 months (Hinchcliffe, 1989)[25]. In other instance, responses are more modest. In Ghana in 1992, introducing fees for primary school in 1992 led to a decline of over 4% in first year intake (World Bank, 1993). Negative responses to increased fees of a similar magnitude were observed in Cote d'Ivoire (World Bank, 1993); in Zimbabwe (Chisvo and Munro, 1994); in Zambia (Booth et al., 1995); Malawi (Tan, Lee and Mingat, 1984). One reason why introducing or raising fees may have less impact on the demand for education than it does on health is that new charges are likely to be smaller relative to existing user costs. Even where there are no school fees, there are sizable monetary costs in terms of books, uniforms, and miscellaneous charges such as those for parent-teacher association. Moreover, monetary costs may be a smaller proportion of total costs in the case of education than in the case of health. However, it is important to note that there is appears to be an asymmetry in the response of demand for education to raising and removing fees. Whilst introducing or raising fees often appears to have a small effect on school enrolment, abolishing fees altogether can have very large effects. An example of this is Malawi, where raising fees in 1982 led to a small rise in the drop-out rate and did not lead to a fall in overall school enrolment over time. However, abolishing primary school fees in 1994 led to a 50% surge in primary school enrolment (Reddy and Vandermoortele, 1996). In Uganda in 1997, abolishing primary school fees (for four children in each household) led to a doubling of the number of children in school. Other substantial responses to free primary education occurred in Kenya and

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[24] The elasticity for Malawi is with respect to total educational costs; that for Mali is with respect to school fees only.

[25] Before and after studies typically cannot control for the impact of changes other than those in fees - for example, downturns in economic fortunes. However, given the magnitude of some of the changes in usage observed, it is hard to believe

Tanzania in the mid-1970s (Lockheed and Verspoor, 1991). The asymmetry between the effect of raising and abolishing fees may be explained as follows. Drop-outs amongst existing students may be fairly insensitive to fees and amongst those not in school, increases in fees only affect the year group who would otherwise enter school. However, there is often a large number of children of all ages out of school who might be induced to enrol if fees are abolished. There is almost no evidence on price elasticities for secondary and tertiary education in Africa, although these are often the levels at which cost-recovery is most strongly advocated.

4.1.2 Service Quality

Effects on health care demand

There is evidence that quality affects the demand for health services in addition to that based on variations in responses to user fees[26]. Collier, Dercon and Mackinnon (1997) estimate that bringing health facilities in rural Ethiopia to optimal levels would raise the probability of seeking treatment by eight percentage points (the mean proportion of seeking treatment in the sample was 50%)[27] Lavy and Germain (1994) estimate that improving drug availability in public health facilities in Ghana from its mean 66% to 100% would increase usage by 44%.Improvements in infrastructure, service and personnel would also lead to sizable increases in take-up. Akin, Guilkey and Denton (1995) estimate that improving quality in both public and private facilities in Nigeria would switch demand to public facilities, largely at the expense of demand for private facilities. However, Mwabu et al. (1993) found no significant effects of the number of medical staff or the availability and type of drugs on the demand for health services in Kenya. They argue that the insignificance of drug availability is due to its endogeneity: shortage of drugs may reflect a low supply or alternatively, high demand.

Effects on health status

Strauss (1990) found shortages of drugs and congestion problems in health facilities have significant negative effects in multivariate analysis of child anthropometrics using data from Cote d'Ivoire in 1996. Thomas, Lavy and Strauss (1996) combined health facility data with the 1998 Cote d'Ivoire Living Standards Survey to examine the impact of health facilities on anthropometric indicators. In multivariate analysis, they found significant effects of drug availability. Multivariate analysis implies that where quinine, antibiotics and aspirin are available, child height would be 0.3 standard deviations higher than in communities where none of the drugs were in stock. They note that this effect is equal to a third of the shortfall in height of Ivorian children from those in the US. Immunisations also have an important effect on child height in rural areas. Interestingly, they find that both drugs and immunisations have particularly strong effects on children from households where both the head and spouse are uneducated. Lavy et al. (1996) found that the number of hours

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[26] Measuring the quality of education and health services is problematic: there are many possible indicators of quality, only some of which may actually objectively improve outcomes (learning or health) and only some of which may be subjectively valued by users. Moreover, there is no guarantee that the objectively and subjectively valuable indicators will be the same.

[27] They find that fully functioning fridges and full drug availability are the most powerful quality variables in raising demand.

that health facilities were open to provide services for children had a positive and significant effect on child survival in a multivariate analysis of the 1988 GLSS. This result held for rural areas only, although it was in those areas that services were more limited. They also estimate the impact of availability of chlorochine, paracetmol and aspirin in rural areas. Multivariate analysis implies that where quinine, antibiotics and aspirin are available, child height would be 0.2 higher than in communities where none of the drugs were in stock. They note that this effect is equal to 13% of the shortfall in height of Ivorian children from those in the US. However, once again, this effect is specific to rural areas. Unlike the case in Cote d'Ivoire, they find no evidence that the impact of health services differs by income group.

Effects on education attainment

In two studies of the same data-set from Ghana, Glewwe and Jacoby (1994) and Glewwe and Ilias (1996) look at the effect of school quality variables on school attainment. The former paper concludes that improving classroom facilities is a more useful policy intervention than investing in either better instructional materials or teacher quality. This finding is rather surprising given that educational production functions typically find instructional materials to have a larger effect on school performance than classroom facilities. The second study also finds some indicators of school quality - specifically leaking roofs and presence of blackboards - significantly affect educational attainment in Ghana. However it also reports insignificant or perverse estimates of the effect of a range of other indicators - books per classroom; presence of a library; lack of desks; unusable classrooms; presence of water and electricity. Case and Deaton (1996) find that teacher-pupil ratios are an important determinant of school enrollments and test score in South Africa, even after controlling for parental education and income. Deolalikar (1997) found improved class sizes in Kenya in 1994 were associated with higher enrolment amongst the top quintile, but actually decreased enrolment amongst the bottom quintile. Conversely, expansion of school facilities increased enrolment of the poorest quintile and had no effect on the enrolment of the top quintile. As with health, there are potential endogeneity problems and some scepticism is required over estimates of quality effects on enrolment in the absence of experimental evidence[28]. Interesting preliminary experimental evidence is provided by Kremer et al. (1997). They studied the impact of an NGO providing quality improvements (primarily textbooks and free school uniforms) to a randomly selected group of schools in Kenya. Early evidence suggests that these interventions significantly raised enrolments. However, most of the extra enrolments came at the expense of neighbouring schools.

Effects on educational achievement

Whilst there is a wealth of research on what factors raise educational achievement in developing countries (Fuller, 1987), there are relatively few African studies. Educational production functions have been estimated for performance in the primary leaving examination in Kenya, Uganda and Tanzania. Appleton (1995a) surveyed 1265 students in 50 schools in Kenya. Textbooks were found

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[28] With class size, the endogeneity bias may be downwards, as class sizes may be higher where there is high demand. With other indicators of quality such as material resources, it may be upwards: with high demand leading to more funding from parents.

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to have a positive effect although the quantitative impact was modest - a one standard deviation in the number of textbooks per pupil (equal to nine books) would raise performance by 2.5%. Performance was higher under teachers who had passed the upper secondary leaving examination; where they only taught subjects they had passed at that level the effect was even stronger. Class sizes were insignificant. Heyneman (1975) surveyed 61 schools in 1972, sampling 598 teachers and 1900 pupils. Textbooks had a significant effect in an educational production function estimated using the data, as did teacher's performance in a simple text of English (Heyneman and Jamison, 1980). Class size was insignificant, with teacher education and experience having only weak effect. Ndabi (1985) studied performance in the primary leaving examination in Tanzania. He surveyed 40 schools in 1984, sampling 1954 students and 233 teachers. Along with most studies, he found shortages of material inputs was associated with lower performance, but - unlike most studies - he found class size also had a significant negative effect.

4.1.3 Income

To the extent that education and health care are purely investment goods, then income should not be a determinant of their usage with perfectly functioning markets (especially capital markets). In reality, education and health also have consumption aspects while credit constraints imply ability to pay is an important consideration. Nonetheless, the investment aspect of education and health may explain why income elasticities are often weaker than might be expected.

Effects on health care demand

In multivariate analysis of whether sick individuals were sent for treatment, Appleton (1992) found no consistent significant effects of household consumption per capita (instrumented) in Cote d'Ivoire; nor any any positive effects of assets (land and livestock) in rural Kenya and rural Tanzania. However, Collier, Dercon and Mackinnon (1997) find a significant effect of household consumption per capita on the probability of seeking treatment in rural Ethiopia, with an elasticity of 0.3 at the mean.

Effects on health status

As noted in Section 2, data on reported illness often find no or perverse associations with income (see Appleton, 1992, on Cote d'Ivoire, rural Kenya and Tanzania; data from the Ghanaian Living Standards Measurement Survey show similar patterns). Controlling for age, parental education and household demographics, Deolalikar (1996) finds income elasticities of 0.7 and 1.9 on weight-for-age and weight-for-height respectively in Kenya in 1994. Income is statistically highly significant in determining mortality and height-for-age in multivariate analysis of data from Uganda in 1992, but not in determining weight-for-height (Mackinnon, 1995b). In a multivariate analysis of data from Cote d'Ivoire, 1985-87, and Ghana, 1987-89, Benefo and Schultz (1996) only find a negative effect of household income on child mortality in the latter and even then, it is not statistically significant. It should be noted that compared to Deolalikar, Mackinnon and Benefo and Schultz include a much larger number of controls - such as sanitation - through which income may work. Sahn (1994) analyses the determinants of child height-for-age and weight-for-height in Cote d'Ivoire in the CILSS of 1987. For the bottom income quintile, he reports elasticities of height-for-age of 1.07 and 0.28 in

urban and rural areas respectively. The effects of income on weight-for-height, by contrast, are small and statistically insignificant. He concludes that income has little effect on wasting, which is "precipitated by environmental factors and communicable diseases over which income exerts relatively little control" (p.52). Thomas et al. (1996) report income elasticities of the Body Mass Index of adults in Cote d'Ivoire as being 0.09 and 0.11 for women in rural and urban areas respectively; for men, the elasticities are much smaller, at 0.01 and 0.04 for rural and urban respectively.

Effects on educational attainment

Using data from rural Ethiopia, Weir (1998) shows gross primary school enrolment rates varying from 23% amongst the bottom income quintile to 28% amongst the top quintile. This variation is entirely due to variation in enrolment of girls. Gross secondary school enrolment rates appear more sensitive to income, varying from 3% at the bottom quintile to 15% at the top. However, this does not imply a high income elasticity of demand, since the top quintile have ten times as high income as the bottom quintile. Furthermore, in multivariate analysis, the effect of income on the probability of attending school was effectively nil. Glewwe and Ilias (1996) instrument for household expenditure per capita and examine the impact on the grade attainment of children aged 11-20 in Ghana in 1988-89, controlling for a range of other determinants. Interestingly, they are not able to reject exogeneity - perhaps because of the low (or non-existent) opportunity cost of schooling in Ghana (Bhalotra and Heady, 1998). Weir (1998) is also unable to provide evidence that children not in school work less than those in school; indeed, she argues that it is as likely that they work more in order to contribute towards the cost of sending them to school. They find that the impact of income is twice as strong for girls as for boys. However, both income elasticities appear relatively weak. They report simulations showing that 1.5% per capita growth for twenty-five years would raise education attainment of girls to 8.52 years compared to the counterfactual figure of 8.07 years. In other words, a 45% rise in income would lead to only a 5.5% rise in educational attainment - an income elasticity of 0.12. For boys, the corresponding elasticity is 0.045. Mason and Khandker (1995) report weak effects of income in multivariate analysis of primary school enrolment in Tanzania in 1993, although effects on secondary schooling and on the delay in enrolling in primary school are more significant (insufficient data is presented to quantify the effects). Other relatively weak effects of income on educational attainment have been estimated for Cote d'Ivoire, rural Kenya and rural Tanzania by Appleton (1992). Early studies of Uganda have reported no relation between household income and primary school attainment (Kakande and Nalwadda, 1993).

Effects on educational achievement

Children from higher income families typically perform better in school, although this is not uniformly true (as shown by a study of primary school performance in Uganda by Heyneman, 1979). This may reflect effects of parental education rather than income per se. Moreover, both income and parental education appear to have large effects via the type of school attended. More affluent and more educated parents typically send their children to higher quality schools. Appleton (1995a) found half the effect of parental education on primary school performance in Kenya attributable to this effect.

It should be noted that these multivariate estimates do not always imply the absence of a simple correlation between household income and investments in human resources. Other factors are often correlated with both child schooling and household income. For example, for children, parental education is usually stronger determinant of health care demand, health status, educational attainment and educational achievement than household income. An important mechanism by which rises in income raise investments in human capital is through improvements in the quality and availability of public services. This may explain why macroeconomic correlations between income and human development are much closer than microeconomic ones.

4.1.4 Gender

There are clear gender inequalities in education in most of sub-Saharan Africa, but not in health. Unlike parts of South Asia, there is no strong evidence of excess female mortality or under-nutrition[29]. However, African women are severely disadvantaged in terms of their education. Only 43% of African women are literate compared to 64% of African men. Girls in African are generally also less likely to be sent to school than boys. Gross primary school enrolments are 85% for boys, but only 73% for girls. A comparison of the gender differences in literacy and enrolment shows that gender inequalities in education are falling over time. This is also apparent in data on educational enrolments in the 1980s. What may be of increasing concern is the inferior academic performance of girls in many African countries. This is seldom reported in official statistics, but has been observed in countries such as Cote d'Ivoire, Ethiopia, Kenya and Tanzania. There is no presumption that girls are naturally less able: indeed, in countries such as the UK they outperform boys.

There is as yet no clear explanation of the gender differences in educational attainment and achievement. The fact that it similar biases do not arise in health and nutrition suggests that the explanation is not pure pro-son bias. It is also hard to argue that there are gender differences in the pecuniary cost of education in most African countries, since at least primary schooling is typically co-educational. In some countries, one could argue that girls contribute more in terms of household labour - implying a higher opportunity cost - but this seems more like a restatement of the problem (why do households require girls to work more than boys?) than a fundamental explanation. There is no strong evidence of lower female returns to education in earnings functions (see Table 3). Appleton and Balihuta (1996) find no significant gender difference in the effect of education on agricultural production in Uganda. Nonetheless, it is possible that because women are less likely to be in formal wage employment, where the returns to education are highest, the overall impact of female education on household income is less. However, this is not apparent in reduced form analyses of household income (for example, see Appleton, 1995c, on Uganda). These analyses may suffer from endogeneity biases due to assortive mating: higher earning men may marry more educated women, so that female education appears to causes higher household earnings. More work is required to investigate this possibility. Another possibility not rigorously explored is that parents

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[29] See Svedberg (1990). These assertions are challenged by Klasen (1996). However, Klasen's claim of excess female mortality in Africa hinges on making comparisons between life tables for Africa with those of Europe at an earlier stage of development (when it is far from clear the medical technology and natural environments permit a meaningful comparison) and on technical issues such as whether absolute or proportionate relationships should be assumed between the two sets of life tables.

value the returns to the education of their sons more since patrilocal traditions imply that they will receive more from their sons than their daughters in terms of remittances and old age support.

Some work has been done on the determinants of gender difference in educational achievement in Africa. In the Cote d'Ivoire, the gender gap in performance in the primary leaving examination arises amongst poorer households and girls in these households tend spend less time in school, lowering their performance (Appleton, 1995b). In Kenya, poverty and time allocation do not appear to play a key role (Appleton, 1995a). A multivariate analysis of performance in the primary leaving examination found poorer performance in tests of reasoning ability, supposed to be independent of schooling, explained half of the gender gap. This implies fairly long term factors - perhaps due to pre-school socialisation - were responsible. Parental attitudes were also important, with daughters being less likely to perform well if their parents believed women to be less able than men.

4.2 Health-education interactions

Expenditures on education may affect health and parental education may benefit children. Health expenditures may themselves affect the value of education. These links are important for understanding the potential range of benefits which accrue to expenditures on human capital.

4.2.1 Effects of health on child schooling and cognitive development

Ill-health and poor nutrition may have indirect effects on labour productivity by adversely affecting schooling. Illness often leads to absence from school and nutritional deficiencies can reduce the ability to learn. Some experimental studies imply substantial benefits from particular interventions. One African example found positive effects of deworming medication on school attendance and achievement in Kenya (Jamison and Leslie, 1990). Cross-sectional evidence is more difficult to interpret but still suggestive. In Ghana, one econometric study attributed delayed primary school enrolment on low height-for-age (Glewwe and Jacoby, 1995). A study of Kenya found no effect of height-for-age on children's school performance (Sigman, Newman, Jansen and Bwibo, 1989). However, calorie intake did affect school performance by affecting time off task for girls. Ill-health inhibits school attendance; this may be true of the ill-health of other household members as well as morbidity of the pupil herself. Adult mortality - such as that from AIDS - is likely to pose grave threats to the schooling of bereaved children (Ainsworth and Koda, 1993).

4.2.2 Effects of education upon health and nutrition

One indirect effect of expenditure on education may be its effects on health. Within developing countries, the children of educated parents face lower risks of premature death. This is apparent from analysis of both the World Fertility Surveys and the subsequent Demographic and Health Surveys (Hobcraft, 1993). Parental education is also associated with better child anthropometric status (weight and height), although the association is less marked than that with mortality. However, in socio-economic surveys, educated parents are often more likely to report that their children have been ill. This suggests that educated parents are better at recognising medical problems in their children.

Caldwell (1979) reports child mortality estimates for Nigeria by education of the mother, based on a survey of 6606 women in Ibadan in 1973. Life expectancy at birth is estimated to be 51.2 for children of uneducated mothers; 58.5 for children whose mothers have some schooling; and 65.2 for children whose mothers have some secondary schooling. A smaller rural survey of the same yield similar results, with remarkably little rural-urban differential in life expectancy after controlling for maternal education. Benefo and Schultz (1996) report associations between maternal education and child mortality based on data from Cote d'Ivoire 1985-87 and Ghana, 1987-89. For women who had given birth in the five years prior to the surveys, child mortality rates were 0.19 amongst the uneducated in Ghana and 0.18 in Cote d'Ivoire. If the woman had 5-10 years of schooling, the rates were 0.12 and 0.09 respectively. The differentials were wider in rural areas than urban area. These simple associations are sizable, but Benefo and Schultz do not find a significant effect of maternal education in multivariate analysis after controlling for community health infrastructure, local health problems, food prices, household assets, ethnicity and region. Secondary schooling in Cote d'Ivoire and middle schooling in Ghana have the strongest effect - relative to other levels of schooling - with each additional year being associated with a reduction in the mortality rate of around 0.01. Given the means of the mortality rates, these effects are fairly sizable and, although they are not significant at conventional levels, the t-ratios non-negligible (1.21 in Cote d'Ivoire; 1.73 in Ghana). This finding of insignificant effects in the Ghana data is replicated by Lavy, Strauss and de Vreyer (1996).

Sahn (1994) finds no positive independent effects of parental education on height-for-age in the Cote d'Ivoire in 1987 after controlling for income and parental height. However, maternal education does improve weight-for-height (paternal education has no effect). An additional year of maternal education raises the weight-for-height Z score by 0.028 in urban areas and 0.039 in rural areas. This implies that a one standard deviation increase in maternal education would improve weight-for-height by 0.11 of a standard deviation in urban areas and 0.8 of a standard deviation in rural areas.

Part of the association between parental education and child mortality may work via household income. However, the independent impact of education in models which carefully control for income shows this cannot be the only transmission mechanism. Indeed, many studies have found education to have a stronger direct effect on child health than income[30]. The direct effect of education may be informational. In Uganda, recent work found educated mothers to be better informed about various diseases and that such information was strongly associated with lower child mortality (Mackinnon, 1995). In Cote d'Ivoire and Kenya, educated mothers are more likely to send sick children for treatment (Appleton, 1992).

4.2.3 Effects of education upon fertility

Whether and how government policy should affect fertility is a controversial ethical issue. However, the UN International Conference on Population and Development in Cairo in September 1994 highlighted the importance of enhancing female education as part of a successful population policy. More educated women commonly tend to have smaller families, although this is less marked in Africa than elsewhere. Perhaps the best evidence on the relationship between fertility and female

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[30] See Deolalikar (1996) on Kenya; Sahn (1990) on Ghana; Alderman (1990) on the Cote d'Ivoire and Mackinnon (1995) on Uganda.

education in Africa is that provided by the Demographic and Health Surveys (DHS) carried out in the late 1980s. Table 6 provides descriptive statistics on the differentials by education in total fertility rates of women aged 15-49 in fourteen African countries. Women with primary education tend to have fewer children in most countries, but the relationship is weak. By contrast, women with post-primary education have markedly fewer children. These associations persist even after controlling for other variables (Ainsworth, Beegle and Nyamete, 1995)[31]. In half of the countries, there was no significant association between primary education and fertility after controlling for income, age and a few other variables. For the other half of the countries, there was a significant negative relationship but it was less strong than with secondary schooling. By contrast, there was a universally negative relationship between fertility and female secondary schooling. The effects of higher secondary schooling (11 years of schooling or more) were 2-4 as large as those of lower secondary schooling. Husbands' education also had a negative effect on fertility where it was significant, although the effect was weaker than that of wives' education. Education appears to reduce fertility more in the DHS data than in the earlier World Fertility Surveys carried out in the late 1970s (see UN, 1987). Although this may partly be accounted for by methodological differences in the data analysis, this seems to reflect a genuine change over time. In particular, amongst women in the older cohort (aged 35 and over) of the DHS, schooling of less than eleven years was seldom associated with lower fertility.

The associations between female education and fertility are likely to be, at least partly, causal. Educated women may be able to obtain higher wages, increasing the opportunity cost of time spent rearing children. They may also have a preference for more educated children, making it more expensive to have large families. Education may also change knowledge of and attitudes towards the use of modern contraception. However, there is a simultaneity between female education and fertility. In most countries, child-bearing and school attendance are incompatible, so girls face a choice between staying on at school and marrying young. This may partly explain why higher secondary schooling has such a large impact on fertility, since the age of students often coincides with the typical age at marriage in many African countries.

4.2.4 Effects of education upon child schooling and cognitive development

Children are typically more likely to go to school if their parents are educated. They also tend to perform better in school and in some cases may earn higher incomes in adulthood. For example, a study of Kenya and Tanzania compared the probability of manufacturing workers having completed lower secondary schooling as a function of the education of their parents. In Kenya those entering school around 1960 were predicted to have a 21% chance of completing lower secondary if both their parents were uneducated and an 83% chance if one of their parent had at least secondary education and the other at least primary education. The figures were similar Tanzania. Since most secondary schools at that time were state schools, where access was rationed by performance in the primary-leaving examination, these figures also suggest large differentials in academic performance by parental education. More recent research drawing upon data from Kenya in 1993, also found a large differential in performance on the primary-leaving examination - around half of which was

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[31] Variables controlled for are: age, age squared, area of residence, ethnicity, religion, ownership of durable goods and quality of housing. Some of these controls may be inappropriate: for example, education is likely to raise the ownership of durable goods and the quality of housing; it may also change the area of residence.

explained by the different local neighbourhoods and primary schools which children from different educational backgrounds attended (Appleton, 1995a). As with the effect of education on earnings, part of the effects of parental education on enrolment may represent the effects of cognitive skills or reasoning ability. In a multivariate analysis of school enrolment in four sites in rural Ethiopia, Weir (1998) finds no significant independent effects of parental education. However, reasoning ability - as measured through Raven's progressive matrices - has significant positive effects on enrolment; cognitive skills of the head are have a positive effect significant only at the 20% level.

These results suggest that educating one generation will have favourable effects both on the cognitive skills and the health of the next. They also imply that there may be a "ratchet effect" to educational expansions: parents may be reluctant to see their children obtaining less education than they received. Similar effects arise in health, as suggested by the correlations between parental and child height. A mother's nutrition affects the health not only of her children, but of her daughter's children. Compared to much physical capital, human capital is long-lived and more irreversible: if people are not given adequate nutrition, health care and education in childhood, this is will have consequences that cannot be remedied in adulthood.

5. Conclusions

There is a variety of microeconomic evidence from Africa which can inform estimates of the contribution of education to economic growth. The largest body is earnings functions estimates based on samples of wage employees. A survey of 28 studies from sub-Saharan African from 1980 onwards produces a mean Mincerian return to education of 5% for primary schooling, 14% for secondary schooling and 37% for tertiary education. Only seven estimates were found of the effects of education on earnings from non-farm self-employment, but they showed roughly similar returns to education - averaging 7% at the primary level and 12% at the secondary level. Estimates from agricultural and manufacturing production functions yield noticeably smaller numbers. The effects of education on agricultural productivity are highly variable but suggest that four years of farmer primary education is associated with a productivity increase of around 10%. Manufacturing production functions imply similarly low returns to education, at around 3%. We have argued that the two sets of estimates - from earnings functions and from production functions - may not be inconsistent. Manufacturing production function estimates appear to be lower because they control for firm-level variables such as the capital-labour ratio and because they are estimated at the firm-level rather than the individual-level. Similar issues may arise with agricultural production functions. In addition, it is possible that existing estimates of the effect of education (particularly secondary education) on agricultural productivity may be understated because they do not fully control for the effect of education in reallocating labour out of farming. The two sets of estimates - from earnings and production functions - may represent upper and lower bounds for the true effect of worker education on own-productivity. However, these estimates do not include external benefits of education on income generation and indeed there is almost no research on this. A couple of studies indicate sizable effects of the education of neighbouring farmers on own farm productivity but these are indicative at best.

The existing evidence cited above suggests that the productivity benefits of further expansions in schooling in sub-Saharan Africa - excluding externalities - may be in the range of 3-14% per year

of education. If these benefits are interpreted as rates of return following Mincer, then they cannot be said to be large. For example, they are not obviously higher than the 10% social discount rate often used to appraise public sector investments. Mincerian returns may understate full returns because they exclude direct pecuniary costs of education and assume that the benefits of education will accrue in perpetuity. This is particularly important at the tertiary level, where direct public costs are high. Consequently, although tertiary education has a noticeably higher Mincerian return than primary or secondary education, the adjustment for direct costs level is substantial - a reduction of two-thirds in the case of Kenya. At the primary level, rates of return may be much higher than the low Mincerian estimates if such schooling has little opportunity cost. However, in this case, the high return would be driven by very low costs - one should not expect large benefits in productivity. These results suggest that further investments in education may have a modest effect on growth, not considering external benefits about which we know little.

This conclusion is quite different from that of Psacharopoulos (1994), who reported from a survey of rate of return estimates from wage employees in Africa that there is a 41% private return to primary schooling and a 24% social return. At the secondary level, he cited a 27% private return and an 18% social return; at the tertiary level, private and social returns were 28% and 11% respectively. These rate of return estimates reported by Psacharopoulos are mainly "full" estimates - including pecuniary costs and assuming the opportunity cost of primary schooling is less than the adult uneducated wage - rather than the Mincerian returns reported in this paper. Nonetheless, there does appear to be a discrepancy between Psacharopoulos's survey of the literature and that reported here. Two possible explanations suggest themselves. Firstly, Psacharopoulos's estimates may be inflated - particularly at the primary level - by the inclusion of the extremely high returns generated from a handful studies with very poor data (Bennell, 1996). Secondly, Psacharopoulos's estimates may be dated - being derived mainly from studies in the 1960s and 1970s when education was more scarce in Africa and economic conditions more buoyant. Evidence from Kenya suggests that returns to schooling were far higher in the 1970s than in the 1980s and 1990s when the post-Independence educational expansion had fully fed through to the labour market. One hypothesis worth further research is that educational expansion has allowed many African households to approach something of an equilibrium in terms of the amount of schooling provided whereby rates of return have been brought down to something approaching a private discount rate. This is probably not true of tertiary education, perhaps partly because of the large subsidies per student and the controls (often prohibitions) on private provision.

There is much less evidence on the returns to health in Africa. A handful of studies suggest substantial benefits from good health status but these need to be replicated. Moreover, since little is known about the effects of government expenditure on health, we are far from knowing the return to health services.

There is a growing body of work on the socio-economic determinants of health and education. We have focussed on the effects of user fees and service quality, since these are important policy variables, and also of income and gender, since these raise important equity issues. Cross sectional studies of the effect of user fees and service quality are rendered problematic by data problems and by possible correlations with community level unobservables. Before and after studies of changes in user fees and quality provide arguably more reliable insights. The introduction of user fees for

health care has often had dramatic effects on utilisation of services. In education, effects are less marked although instances of the abolition of fees both in the 1970s and the 1990s have sometimes led to very large increases in enrolments. The argument sometimes made in the 1980s that introducing cost sharing in the social sectors would not have strong effects on demand appears not to have been born out in practice[32]. There is also evidence that demand for health and education is responsive to indicators of quality, although there is a danger in generalising about any one indicator. However, if one hand to highlight particular indicator, availability of drugs might be the most important for health care demand whereas instructional materials may have the most consistently positive associations with educational achievement (if not attainment).

There are inequalities in health and education along lines of income and gender. However, these are not as uniform and pervasive as might be expected. There is no strong evidence of gender inequalities in health, whereas gender inequalities in education are they are pervasive outside of southern Africa. Primary school enrolment does not always vary as strongly with household income. However, associations are stronger at the post-primary education - perhaps because of higher pecuniary costs and rationing by examination performance. Income elasticities of health care and health outcomes are often weak, especially after controlling for other factors such as community level variables and parental education. These findings suggest that disadvantage is multi-dimensional and that deprivations in education and health cannot be reduced to inequalities in income.

Finally, there are powerful interactions between human resources. Ill-health inhibits educational attainment and in some cases achievement. Parental education has simple positive associations with improved child health and child schooling, together with negative associations with fertility. Caution is required about generalising about the relative effects of primary and secondary schooling, or male versus female education. However, one working hypothesis might be that it is secondary schooling, perhaps particularly of the mother, that has the strongest associations. More research is required to uncover the mechanisms underlying these associations.

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[32] The assumption of price inelasticity was buttressed by the very high returns to education reported in periodic literature surveys by Psacharoupoulos (1994 being the latest). If private returns to primary school were in fact 41%, one would not expect modest variations in user fees to substantially affect enrolments.

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Table 1: Estimated effects of education on agricultural productivity in sub-Saharan Africa

area and study	sample size	coefficient on education (of household head unless otherwise stated)	coefficient on physical capital	estimated percentage increase in output for 4 years of primary schooling	comments
Kenya (Moock, 1981)	101	1-3 years:: -0.111 (-1.68) 4 + years: 0.018 (0.25)		2	
Kenya (Hopcraft, 1974)	674	1-3 years: 0.0086 (0.007) 4-6 years: -0.0099 (-0.009) 7 years: -0.0277 (-0.036)		-1	4-6 years of education significantly negative effect on maize production functions
Kenya (Bigsten, 1984)	1613	1-4 years: 0.18 (2.57) 5-7 years: 0.03 (0.3) 8+ years: 0.12 (0.67)		20	
Kenya (Bevan, Collier and Gunning, 1989)	189 for coffee 159 for maize	4-7 years of education: 0.194 for coffee (1.03) 0.246 for maize (1.38)		25	effect is derived weighting by value shares (coffee 39%; hybrid maize 61%)
Tanzania (Collier, Radwan and Wangwe, 1986)	540	5 level categorical variable 0.09 (2.46)		19	apparent typo in reported equation; coefficient from text
Burkina Faso (Ram and Singh, 1988)	51	years of schooling of all members 0.07 (3.27)		12	
Ethiopia (Weir, 1999)	616	highest farmer education is 4-6 years 0.18 (1.89)		20	highly non-linear; more than 6 years has negative effect; non-farmers' education has large positive effect
Uganda (Bigsten and Kayizzi-Mugerwa, 1996)	198	some primary :0.111 (0.33) some secondary: 0.229 some post-secondary: 0.663		12	
Uganda (Appleton and Balihuta, 1996)	4877	4 years of education: 0.070 (1.90)		7	there are indicators for all other levels of education (not reported here for brevity)
Zimbabwe (Owens, 1999)	1153	years of schooling : 0.0038 (0.619)		2	varous specifications tried; essentially zero impact

Table A1: Supplementary information on studies of education and agricultural production

area and study	data-set	educational variables	dependent variables	other explanatory variables	comments
Kenya (Moock, 1981)	male-headed farms in Vihiga district 1971-72	indicators for 1-3 and for 4 or more years of schooling of farm manager	bags of maize produced per acre	labour, purchased inputs and many other controls	
Kenya (Hopcraft, 1974)	subsample of a stratified random sample of 1,700 small farms, 1969-70	dummy variables for education of household head	combined agricultural output	land; labour; purchased inputs; extension	
Kenya (Bigsten, 1984)	Integrated Rural Survey 1, 1974	indicators for education of household head	combined crop output	land, labour, purchased inputs	
Kenya (Bevan, Collier and Gunning, 1989)	Integrated Rural Survey 5, 1982	indicator: 4-7 years of education of household head	maize and coffee ouput	land, labour, pesticide, fertiliser, provincial dummy	for pure stand plots only
Tanzania (Collier, Radwan and Wangwe, 1986)	survey of 20 villages from 18 districts, 1980	5 level categorical variable: 1=uneducated; 2=literacy programme; 3=part primary; 4=complete primary; 5=post-primary	combined crop output	land, labour, purchased inputs	
Burkina Faso (Ram and Singh, 1988)	seven vilages in Mossi plateau 1980	years of education of household members; students and children are excluded from the education variable (information given in private correspondence)	agricultural income (crop and livestock output minus costs)	land, labour, capital, animal traction	households interviewed weekly for entire production year
Ethiopia (Weir, 1998)	Survey of 17 sites in 1994	Dummy variables for schooling of most educated farmers and non-farmers (most not reported in Table 1)	combined crop output	land, labour, capital, purchased inputs and many more controls including village fixed effects	
Uganda (Bigsten and Kayizzi-Mugerwa, 1996)	Masaka district, 1990	indicators for household head;: some primary education some secondary education some post-secondary education	combined crop output	land, labour, purchased inputs and age of household head	
Uganda (Appleton and Balihuta, 1996)	Integrated Household Survey	farm workers' primary schooling and its square; farm workers' secondary schooling and its square	combined crop output	land, labour, capital, purchased inputs and many more controls including village fixed effects	nationally representative survey
Zimbabwe (Owens, 1999)	pooled data for 400 households in 1994, 1995, 1997 in 3 resettlement zones	years of schooling of the household head	gross yield	land, labour, capital, fertiliser, oxen, extension, rainfall	

Table 2: Manufacturing production functions in five sub-Saharan African countries

Variable	Cameroon	Ghana	Kenya	Zambia	Zimbabwe
Constant	4.66 (5.0)	5.23 (10.2)	4.56 (7.9)	5.44 (6.1)	3.95 (6.7)
ln (employment)	0.25 (0.8)	0.63 (2.6)	0.16 (0.7)	0.57 (2.5)	0.13 (0.5)
ln(capital)	0.32 (4.7)	0.32 (8.2)	0.36 (6.9)	0.2 (2.7)	0.44 (11.1)
ln(education)	0.43 (1.5)	0.04 (0.2)	0.48 (2.0)	0.23 (1.1)	0.43 (1.7)
number of observations	170	230	199	98	261
rates of return					
physical capital	19	32	22	10	35
education	4.5	0.4	6.3	2.7	5.4
mean years of education	9.7	9.3	7.9	8.6	8.2

Source: Appleton et al. 1999

T-ratios in brackets

the rate of return to education is: $[(E+0.5)/(E-0.5)^{\beta}-1] \times 100$ where E is mean years of education and β is the coefficient in the production function

the standard error of the estimate is $[e^{2\beta \ln[(E+0.5)/(E-0.5)]} e^{\{\ln[(E+0.5)/(E-0.5)]\}^2 \sigma^2} (e^{\{\ln[(E+0.5)/(E-0.5)]\}^2 \sigma^2} -1)^{1/2}$ where σ is the standard error of the coefficient

Table 3: Returns to education from Mincerian earnings functions

Area and Study	Data	Mincerian returns				Comments
		Primary	Secondary		University	
			Lower	Upper		
Cameroon (Appleton et al, 1999)	1655 manufacturing employees in enterprise survey 1993-1995	3%	8%		38%	
Cote d'Ivoire (Appleton et al., 1996)	1828 employees from households in Living Standards Surveys 1985-87	m: 12% w: 8%	m: 24% w: 21%		m: 20% w: 20%	21% sample female. Appleton et al. (1996) report much lower returns for urban subsample.
Ethiopia (Krishnan, Selassie and Dercon, 1989)	1027 employees from urban household survey in 1994	m: 4% w: 1%	m: 11% w: 12%		m: 56% w: 34%	weighted average of public and private; from dummy variables; assuming 3 year university course; 35% sample female
Ethiopia (Krishnan, Selassie and Dercon, 1989)	958 employees from urban household survey 1997	m: 3% w: -1%	m: 15% w: 18%		m: 73% w: 48%	Most employees same as those surveyed in 1994; 39% sample female
Ghana (Schultz, 1993)	1925 employees from national household surveys 1987-1988, 1988-89	m: -1% w: -1%	m: 8% w: 14%		m: 12% w: 10%	24% sample female. Canagarajah and Thomas (1997) report 43% return to university in 1987-88 data
Ghana (Canagarajah and Thomas, 1997)	1140 employees from national household survey 1991	0	13%	29%	75%	From dummy variables for highest level of education (not nec.completed)
Ghana (Appleton et al, 1999)	2557 manufacturing employees in enterprise survey 1992-1994	3%	15%		29%	
Kenya (Knight and Sabot, 1990)	approximately 2000 urban wage employees	6%	14%		NA	
Kenya (Appleton et al, 1998)	2494 employees in urban households 1986	9%	26%	29%	30%	
Kenya (Appleton et al, 1998)	1123 manufacturing employees in enterprise survey 1995	2%	12%	9%	69%	
South Africa (Moll, 1996)	1980 Population Census	2%	9%			Africans only

South Africa (Moll, 1996)	1980 current population survey	3.4%	9.6%			Africans only
South Africa (Moll, 1996)	1985 Bureau of Market Research	2.7%	12%			Africans only
South Africa (Moll, 1996)	16200 households in 13 urban areas in 1990 CSS/HSRC survey	2%	11%		NA	Africans only
South Africa (Mwabu and Schultz, 1995)	6016 employees from households in 1993 survey	4%	16%		25%	
Tanzania (Knight and Sabot, 1990)	approximately 2000 urban wage employees from 1980	5%	10%		NA	
Tanzania (Mason and Khandker, 1995)	4217 employees from 1990-91 labour force survey	m: 9% w: 21%	m: 14% w: 18%	m: 2% w: 14%	m: 14% w: 2%	direct calculations from Table 2 (differ somewhat from authors' reports); 44% sample female
Uganda (Bigsten and Kayizzi-Mugerwa, 1992)	298 employees from households in Kampala 1990	m: 8% w: 10%	m: 3% w: 1%		m: 15% w: 4%	"University" refers to post-secondary institution; 36% of sample female
Uganda (Appleton et al., 1996)	2174 employees in urban households of 1992 Integrated Household Survey	m: 4% w: 5%	8%	m: 0% w: 20%	m: 30% w: 24%	university returns derived from dummy variable assuming 3 year course; 29% sample female
Zambia (Andersson, 1993)	1413 workers in 1985 labour force survey of urban Lusaka	m: 7% w: 16%	m: 12% w: 30%		m: 29% w: 20%	returns inferred from dummy variables on completed primary and secondary variables; 20% sample female
Zambia (Appleton et al, 1999)	2471 manufacturing employees in enterprise survey 1993-1995	5%	22%		65%	
Zimbabwe (Appleton et al, 1999)	1960 manufacturing employees in enterprise survey 1993-1994	2%	27%		37%	

Table 4: Returns to education in non-farm self-employment

Area and Study	Data	Mincerian returns		Comments
		Primary	Secondary	
Cote d'Ivoire (Vijverberg, 1993)	240 men and 453 women nonagricultural workers in pooled Living Standards Surveys 1985-87	m: -2% w: 13%	m: 4% w: 4%	secondary refers to all post-primary education
Ghana (Vijverberg, 1995)	2970 family enterprises: pooled data from two household surveys in 1987 and 1989	3%		Education is that of most educated worker on enterprise; most of the effect is via inputs; stronger on monthly than hourly income
Kenya (Appleton et al, 1998)	254 urban workers in 1978	9%	40%	
Kenya (Appleton et al, 1998)	629 urban workers in 1986	12%	15%	
Kenya (Neitzert, 1996)	188 workers in micro-enterprises (<6 employees)in Kenya 1990	NA	9%	regular workers only; no return to causal and pieceworkers; high but insignificant return to apprentices
Uganda (Appleton, forthcoming)	2745 household non-agricultural enterprises in 1992	6%	7%	estimates based on production functions for small household enterprises
Zambia (Andersson, 1993)	385 men and 358 women in 1985 labour force survey of urban Lusaka	m: 3% w: 6%	m: 8% w: 10%	estimates for informal sector, defined as self-employed and those employed in enterprises with less than 6 workers

Table 5: Expected income loss due to illness in the last 30 days, adult workers aged 20-59

Country	Expected days ill	Expected work days absent	Expected income loss (% of normal earnings)
Cote d'Ivoire	2.7	1.3	4.6
Ghana	3.5	1.4	11.0
Mauritania	2.2	1.6	5.2
Memo items:			
Peru	4.5	0.9	3.4
Bolivia	-	1.0	3.8
Jamaica	1.2	0.5	2.1
United States	-	0.3	1.3

Table drawn from King and Wang (p23, 1995)

Table 6: Estimates of the price elasticity of demand for health care

Study	Data	Results
Dunlop (1987)	Ethiopia (1985)	-0.05 to -0.50
Schwabe (n.d.)	Sudan (1985)	-0.37
Yoder (1989)	Swaziland (1985)	-0.32
Gertler and van der Gaag (1989)	Cote d'Ivoire (19850	rural hospitals income quartile Adults Children lowest -0.47 to -1.34 -0.65 to -2.32 Second -0.44 to -1.27 -0.58 to -1.98 Third -0.41 to -1.18 -0.49 to -1.60 Highest -0.29 to -0.71 -0.12 to -0.48
Sauerborn et al. (1994)	Burkina Faso (1985)	Overall -0.79 Age groups: <1: -3.64 1-14: -1.73 15+: -0.27 Income quartile lowest -.144 second -1.21 Third: -1.39 Highest -0.12
Mwabu, Ainsworth and Nyamete (1995)	Kenya (1980-1981)	government -0.10 mission -1.57 private -1.94
Bolduc, Lacroix and Muller (1996)	Benin (1992)	hospital -4.17 communal health centre -2.48 private clinic -4.27
Lavy and Germain (1994)	Ghana (1988)	public -0.11 private -0.17

Draws up on Table 3 of Reddy and Vandermoortele (1996)

Table 7: Total fertility rates for women aged 15-49 by education

	Year	None	Education Primary[a]	Completed Primary	More than Primary
Tanzania	1991-92	6.5	6.4[b]	6.0	4.2
Uganda	1988-89	7.7	7.2[b]	7.3	6.7/5.1[c]
Burundi	1987	6.8	7.2	-	5.5
Mali	1987	6.8	6.2	-	n.a.
Niger	1992	7.5	6.3[d]	-	-
Nigeria	1990	6.5	7.2[b]	5.6	5.1/4.2[c]
Kenya	1993	6.0	6.2[b]	5.0	4.0
Ghana	1993	6.7	6.1	-	4.7/2.9[c]
Togo	1988	6.8	5.7	-	4.5
Zambia	1992	7.1	6.8	-	4.9
Zimbabwe	1988	7.0	6.0	-	3.8
Senegal	1992-93	6.5	5.7	-	3.8
Cameroon	1991	6.2	6.4	-	4.5
Botswana	1988	6.0	5.2[b]	4.6	3.3

Source: DHS country reports, as presented in Ainsworth, Beegle and Nyamete (1996).
n.a. Not applicable
 - Not reported.
a. Unless otherwise noted, primary refers to any primary schooling, including completed primary.
b. Incomplete primary
c. First figure is for lower secondary school; second for upper secondary school
d. Any schooling (primary or more)