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Volume Author/Editor: Robert T. Michael

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Chapter Author: Robert T. Michael

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Education as an Environmental Variable

CHAPTER 1 INTRODUCED a general model dealing with the manner in which an environmental variable may affect nonmarket production. The analysis was presented in the context of a general human capital variable, and it was shown that such a variable, by altering the productivity of the factors of production and thereby affecting the relative efficiency of the production functions, could change the real income of the individual household and create income and substitution effects. Chapter 2 will further develop this framework by focusing on one particular form of human capital—education—and by examining implications of the analysis that are empirically testable.

The most direct approach to the question of efficiency in production is an investigation of the output per unit of input, but for our purposes this is not feasible. Since the output has not been quantified (or even identified) in the case of most of the commodities considered here, a more indirect approach had to be used. Rather than observing differences in output as efficiency changes, the analysis is developed in terms of changes in market goods inputs that result from productivity shifts. This chapter discusses the changes in expenditures on market goods that productivity shifts would be expected to produce.

EDUCATION AND THE NEUTRALITY ASSUMPTION

Of the environmental variables mentioned in the preceding chapter, the human capital variable is probably the one most directly controlled by the household. So, from the point of view of policy decisions within the household, information about the nonmarket return on formal

schooling, health, and so forth should be the first order of business.[1] Since much of the empirical work on the effect of human capital on market earnings has dealt with formal schooling, it seems likely that in the area of nonmarket effects this form of human capital may similarly be most manageable. Furthermore, estimates of market returns on investments in formal schooling are readily available for comparison with returns through nonmarket activities. Accordingly, the specific variable considered in this chapter and in the subsequent empirical work is the level of formal education.[2]

Since the equations in Chapter 1 are expressed in terms of any environmental variable H, we may apply them directly to an analysis of the effects of formal education on nonmarket activities. Thus, define

$$\tilde{MP}_{i}^{E} \equiv \frac{\partial Z_i}{\partial E}\Big/ Z_i;\ \tilde{MP}_{x_i}^{E} \equiv \frac{\partial MP_{x_i}}{\partial E}\Big/ MP_{x_i};\ \text{etc.},$$

and the effects on relative prices, consumption income, and the demand for commodities and factors will be defined in a perfectly analogous manner. In the interest of making the model empirically viable, a few important assumptions are imposed on the system at this point. First, we shall assume that education has a neutral effect on the productivity of the factors of production. Education will be considered "factor neutral" if

$$\tilde{MP}_{x_i}^{E} = \tilde{MP}_{t_i}^{E} = \tilde{MP}_{i}^{E}. \tag{2.1}$$

This is a Hicksian definition of neutrality. In equilibrium the ratio of a factor's marginal product to its price is equal for all factors. Then, if education raises the marginal product of each factor by the same percentage, there is no induced substitution in production. Since in the case of factor neutrality the percentage effect of education is the same on all inputs, it is also equal to the percentage effect on the productivity of the function.

Further, it will be assumed that education has a neutral effect on the

[1] From the point of view of society as a whole, the return on investments in increased literacy, better hygiene, and so forth is also relevant. But, since the stock of human capital in society is also affected by government policy, it is no less relevant at the macro level.

[2] To the extent that age is considered a proxy for on-the-job experience, this form of human capital is also investigated empirically.

productivity of all production functions. Education will be called "commodity neutral" if

$$\widetilde{MP}_i^E = \widetilde{MP}_j^E = \widetilde{MP}^E. \tag{2.2}$$

This definition is also Hicks-neutral. If the productivity of all production processes is changed by the same percentage there is no induced substitution in consumption. Commodity neutrality and equation (1.8) imply

$$\widetilde{\Pi}_i = \widetilde{\Pi}_j = \widetilde{\Pi}, \tag{2.3}$$

i.e., that there are no relative price effects. Equation (1.13) also collapses to

$$\widetilde{Y}_c = \widetilde{MP}_i^E = -\widetilde{\Pi} \qquad \text{(for all } i\text{)} \tag{2.4}$$

with the assumption of commodity neutrality. This is evident, for if education affects the efficiency of each production function by r per cent, the change in consumption income is also r per cent. Commodity neutrality does not require factor neutrality and vice versa. Only in the presence of both does an increase in education change the productivity of all factors in all production functions by precisely the same percentage.

Although these neutrality assumptions place substantial restrictions on the model and possibly tax its realism, they do not limit its usefulness as severely as it may seem. The neutrality model permits analysis of education's effect on real income and the consequent shifts in consumption patterns as income changes. Certain hypotheses can be tested empirically, and from one point of view we can infer from the empirical findings the extent to which the neutrality assumptions are inappropriate.[3]

The substance of the model as it stands does not tell us whether a particular environmental variable improves or diminishes nonmarket efficiency; it is, rather, a means by which we can analyze the results on prices, opportunities, and behavior of any given efficiency effect.

[3] The restrictions are imposed solely due to limitations in the availability of relevant data, and not to any inability of the model to deal with substitution effects. Dealing with productive activities conducted primarily in the home, we have few quantitative measures of the output and only scant information on the allocation of one of the two major inputs, time. As additional data become available—for example, household time budget studies—some of the assumptions of neutrality may be relaxed.

The working hypothesis pertaining to the direction of education's effect on nonmarket efficiency shall be

$$\tilde{Y}_c > 0. \tag{2.5}$$

That is, education raises nonmarket productivity and thereby increases the household's real full income. The analytical framework developed in the previous chapter does not imply this hypothesis, but it is in the context of that framework that the hypothesis is formulated. If households engage in production in the nonmarket sector, education may affect the efficiency with which that production takes place.

There are at least two reasons for expecting the effect on efficiency to be positive. First, there is the well-documented positive correlation between levels of schooling and wages. From marginal productivity theory we infer a positive relationship between one's education and the productivity of his time in the labor market. Since education is embedded in the individual, if it affects the productivity of his time favorably in productive activities in the labor market, it may be expected to do so in other productive activities as well. If education raises the productivity of one's time in nonmarket production, it thereby lowers the costs or increases the efficiency of nonmarket production, other things held constant.

Second, the level of education may affect productivity in the household for the same reasons that the level of technology affects productivity in the firm. For the latter, technology represents the acquisition and adoption of new knowledge or new productive techniques; for the former, education represents exposure to knowledge and perhaps the development of a receptive attitude toward the use of new information. The household chooses its productive techniques and selects the market goods and services with which it combines its own time to produce commodities, so the level of its managerial skill and the proficiency with which it purchases and uses market goods influence the level of efficiency in its nonmarket production. These skills will be favorably affected by education if the more educated individual possesses more knowledge (including more knowledge of how to acquire, evaluate, and utilize additional relevant information) and is more receptive to new ideas, including improved consumer products.[4] Since the house-

[4] For an excellent discussion of a related point dealing with the way in which education might influence productivity through a "worker effect" and an "allocative effect," see Finis Welch, "Education in Production," *Journal of Political Economy*, January 1970.

hold members both organize and engage in nonmarket production, the effects of education on the productivity of their own time input and on the efficiency with which production is organized are expected to lower the absolute cost of production or raise the real income of the household.

Thus, the hypothesis will be that education increases productivity in the household. This leads to certain predictions about the effect of education on consumption patterns. If the observed effect of education on expenditure patterns were precisely the opposite of the one suggested by the hypothesis, this would be consistent with education having an adverse effect on nonmarket productivity.[5] Again, the analytical framework developed here is not wedded to the hypothesis that the change in consumption income is positive. It would involve no substantive difference in the empirical analysis if the direction of education's effect were reformulated as an open question.

With the assumptions of factor and commodity neutrality, all relative price effects are eliminated both in production and in consumption. Thus, the nonmarket effect on the demand for the commodity Z_i is given by the simplified equation (1.15):

$$\tilde{Z}_i^d = \eta_i(\tilde{Y}_c), \tag{2.6}$$

where the tilde now represents the percentage change per unit of education. The effect of education on the demand for the commodity will be positive if Z_i is "superior," under the hypothesis that $\tilde{Y}_c > 0$.[6] The effect of education on the demand for Z_i will be greater the larger its consumption income effect and the larger the income elasticity.

Similarly, the equation for the derived demand for a factor of production (1.18) can be simplified given the assumption of factor neutrality. Since $\tilde{MP}_{x_i} = \tilde{MP}_{t_i}$, we get [7]

[5] The results can also imply that education has *no* nonmarket effect on efficiency ($\tilde{Y}_c = 0$). This would be the case, for example, if education had no effect on expenditure patterns.

[6] A commodity is "superior" if its income elasticity, η, is positive; "inferior," if $\eta < 0$; a "luxury," if $\eta > 1$; and a "necessity," if $\eta < 1$. The terms are used according to these standard definitions and no value judgment or normative connotation is implied.

[7] Since $\tilde{Y}_c = -\tilde{\Pi}$ and $\tilde{\Pi}_i = -\tilde{MP}_i$, equation (2.7) can also be expressed as

$$\tilde{x}_i = \tilde{Y}_c(\eta_i - 1) + (\tilde{\Pi}_i - \tilde{\Pi})(\epsilon_i + 1),$$

which indicates that if the price elasticity of the commodity is unity, there is

$$\tilde{x}_i = \eta_i \tilde{Y}_c - \tilde{MP}_i + \epsilon_i(\tilde{\Pi}_i - \tilde{\Pi}), \tag{2.7}$$

or, from (1.15),

$$\tilde{x}_i = \tilde{Z}_i^d - \tilde{MP}_i^E. \tag{2.8}$$

Equation (2.8) suggests, for example, that if the percentage effect on the demand for Z_i were 6 per cent and the productivity effect for Z_i were 4 per cent, the change in education would induce a 2 per cent change in the quantity of x_i and t_i demanded.

Combining (2.6) and (2.8), and noting that under the commodity neutrality assumption $\tilde{MP}_i^E = \tilde{Y}_c$,

$$\tilde{x}_i = \tilde{Y}_c(\eta_i - 1). \tag{2.9}$$

Thus, the prediction of the neutrality model would be that

$$\tilde{x}_i \gtrless 0 \quad \text{as} \quad \eta_i \gtrless 1. \tag{2.10}$$

If the commodity Z_i is a necessity, $\tilde{x}_i < 0$, i.e., the consumer will reduce his expenditure on x_i; if the commodity Z_j is a luxury, $\tilde{x}_j > 0$, that is, the expenditure on x_j rises and is "financed" partly from the reduced expenditure on x_i. Since the consumer's money income is held fixed in this discussion, his total expenditure is fixed.[8]

Education's effect on the demand for commodities and market goods is interpreted here in terms of changes in relative prices and in real income through a reduction in the price level. An alternative way of expressing the same model is to suggest that by increasing the output of the various commodities, education raises total utility (by the sum of the additional amounts of each Z_i expressed in utility-equivalent

no induced effect on the demand for the factor, even if the relative prices of the commodities are affected.

[8] Multiplying each derived demand equation (2.9) of the household by its expenditure share and summing over all goods:

$$\begin{aligned} s_i\tilde{x}_i &= s_i(\tilde{Y}_c\eta_i - \tilde{Y}_c) \\ \sum_i s_i\tilde{x}_i &= \tilde{Y}_c \left(\sum_i s_i\eta_i\right) - \tilde{Y}_c \sum_i s_i \\ &= \tilde{Y}_c - \tilde{Y}_c \\ &= 0. \end{aligned}$$

units) and thereby shifts the relative demand for Z's toward those with higher utility elasticities.[9]

While the latter interpretation views the model in utility terms, it is not an alternative model in any essential way but simply a translation into another language. An alternative can be developed, however, that can lead to the same predicted behavior pattern and is couched in terms of a change in tastes. Suppose that education, for whatever reason, directly increased one's total satisfaction or utility, not through any productivity effects but by simply altering the utility function (i.e., by changing tastes). In this case, education indirectly alters the relative marginal utilities of the Z's in a specific manner if the utility function is not homogeneous.[10]

Since relative prices of commodities are not affected in this "tastes" interpretation, in equilibrium the ratio of the marginal utilities would be the same as initially. Consequently, by diminishing the marginal rate of substitution in consumption, education induces shifts toward items with higher utility elasticities and away from those with lower elasticities—the same qualitative effects as the productivity model implies. Notice, though, that in order to get the same predicted response in behavior, the presumed effect of education on the utility function involves a fundamental and specific change in the indifference map.[11]

EMPIRICAL IMPLICATIONS OF NEUTRALITY

Equation (2.9) suggests the empirical test of the model. If real income is augmented by the efficiency effect of education, the term $\tilde{Y}_c$ will be positive. Accordingly, if the income elasticity of a commodity is greater than unity, the equation implies that the expenditure on the market goods associated with that commodity will be positively related to education. Then holding the household's money income constant

[9] For a more detailed exposition of this point, see Appendix A, section 6.

[10] If all utility elasticities or income elasticities were equal, the neutral productivity model would predict no effect on behavior; the corresponding assumption here is homogeneity of the utility function, which would imply no effect on the ratios of marginal utilities. It is the *lack* of homogeneity that leads to the implication of an effect on behavior in both the neutral productivity model and the "tastes" model.

[11] For a more thorough discussion of this point, see the exposition and diagram in Appendix A, section 7.

and raising its level of education will lead to increased expenditure on market goods associated with luxuries and to decreased expenditure on goods associated with necessities.

The economic interpretation suggested by the model for this predicted behavior pattern is the following. Education increases efficiency in all activities in the nonmarket sector and is assumed to have the same effect on each activity. Thus, relative prices of commodities are unchanged, but the price index falls or real income rises, with money income held fixed. The rise in real income induces the household to increase its demand for commodities, the amount of the increase being shown by the income effect $(\eta_i \tilde{Y}_c)$. At the same time the household is "supplied" with $\tilde{MP}_i$ additional amount of each commodity. The effect on the demand for the market input clearly depends on whether the increased demand for commodity i, $(\eta_i \tilde{Y}_c)$, or the increased supply of commodity i, $\tilde{MP}_i$, is greater. If the household is supplied with more of the commodity than it demands (this is the case when $\eta_i < 1$) it will *reduce* its inputs to bring its total production into line with its demand, and conversely, if its demand exceeds its total production it will increase its use of market inputs. It is, then, an implication of the neutrality model that as education rises, with money income held fixed, we expect to observe shifts in consumption patterns *as if* money income were increasing. Since we cannot directly observe the shifts in the consumption of commodities, we observe the resulting shifts in market goods instead.

Finally, from equation (2.9) it is possible to infer the magnitude of the change in consumption income $\tilde{Y}_c$. Multiplying through by the level of education converts the terms in equation (2.9) into elasticities: ϵ_{iE}, the elasticity of expenditure on the market good with respect to education; ϵ_{Y_cE} is the elasticity of consumption income with respect to education. Thus, from observations on the income elasticity, η_i, and the elasticity of expenditure on the market good with respect to education, ϵ_{iE}, the elasticity of consumption income can be computed:

$$\epsilon_{Y_cE} = \epsilon_{iE}/(\eta_i - 1). \tag{2.11}$$

This elasticity, ϵ_{Y_cE}, abstracts from changes in money income and indicates the effect of education on real full income through changes in nonmarket productivity.