The Impact of Human Capital on Non-Market Outcomes and Feedbacks on Economic Development

Walter W. McMahon[1]

This paper develops the rationale and empirical methods for measuring the non-market social outcomes of education, plus their feedback effects on economic growth. It also seeks to identify and measure externalities, some of which are included in these feedback effects. As such, this paper situates human capital in a broader framework of measures of social outcomes generally desired for broader economic development and sustainability. Finally, the paper develops the conceptual framework for tracing and measuring the interrelations among these social outcomes, including those social outcomes which are also inputs and are aspects of social capital.

The *direct* effects of education on each social outcome and on economic growth will be distinguished from the *indirect* feedback effects. The indirect effects are externalities because the effect on the outcome in question of a relatively small investment in education by one household is expected to be negligible and, therefore, is not taken into account by the individual or his/her family as they invest in education. Furthermore, the benefits of these indirect effects are not enjoyed by the individual as the direct result of how much he or she invests, but are freely available to all. Beyond this, if one assumes that there is not perfect information, a number of these indirect effects are very unlikely to be known by the average investor, and, therefore, cannot be taken into account as investment decisions in education are made. The feedback effects are also externalities freely available to others because the lags are very long so the benefits are frequently only enjoyed by

[1] University of Illinois at Urbana – Champaign.

future generations. It is reasonable to assume that most individuals do not act on the basis of largely unknown and minuscule effects over infinite planning horizons far beyond their own life cycles and those of their children.

These feedback effects and externalities play a very important role in recent endogenous growth models (e.g. Lucas 1988). However, there they are a broad category identified as “the level of education in the community” and are not identified, broken up into a number of separate education impacts, and measured, as they are here.

Throughout what follows the conceptual framework for estimating non-market returns controls for per capita money income in order to avoid double counting the market returns to education. The market returns increase money income which in turn can be spent to produce final outcomes such as better health which is part of the market returns and not of the *net non-market* returns to education. Although these direct and indirect non-market returns can and will be quantified and measured (to a first approximation), as will their interaction, this does not include an economic valuation as is done for increments to earnings and to GDP due to education since they do not pass through the market. In the special case of feedback effects from the non-market social outcomes on economic growth, however, there is a market valuation of these feedback effects that will be explicitly identified and measured as a percent of the total monetary returns to education. It is this component that feeds into a computation of a social rate of return that is market based. This has been done by McMahon (1998c) and also by Mingat and Tan (1996), resulting in a narrowly defined social rate of return that still excludes the direct and indirect effects of education on non-market outcomes. Non-market outcomes are estimated by Haveman and Wolfe (1984) and Wolfe and Zuvekas (1997) to be about 50% of the total benefits of education.

1. Introduction and Overview

This section will consider first the overall conceptual framework for identifying and measuring the net market and non-market returns to education. The framework for the net market returns in Section II is based on the new endogenous growth and augmented-Solow models represented here by the Lucas (1988) production function, and the framework for measuring the non-market returns is based on the theory of household production of final satisfactions as represented by Becker's (1965) household production function augmented with externalities. Section III then will turn to the identification of separate specific non-market returns to education related to increments in the average education level in the community, and will explain the rationale for estimating the net contribution of education to each outcome.

The measurement of the net impacts of education as well as the feedback effects, some of which occur only after appreciable lags, are measured using a structural model that traces the logic of each of these impacts and their interactions. This structural model is then used for simulations that extend 45 years into the future, about the time each new graduate is in the work force or still alive. The measures of the net impacts are the increments (or decrements) in relation to a base line scenario over the time period in question following a policy change: an exercise in comparative dynamics. The policy change chosen is an increase of two percentage points in the rate of investment in education as a percent of GNP which operates through the estimates of typical behavior of the education sector in the structural model to increase enrollment rates by about 10 percentage points at secondary and 2- and 4-year college levels in most OECD member countries. Larger, or smaller, policy changes could be chosen but these seem reasonable given the time frame being considered in relation to national education programs that have been implemented recently in some OECD countries (e.g. Greece, Portugal, South Korea). Larger or smaller increments can be interpolated as proportions of the net outcomes chosen for illustration here.

The social outcomes traced are those that are of primary interest to comprehensive economic development with sustainability. All are rather standard goals of economic development. They are health impacts including greater longevity and reduced infant mortality; increasing democratization, human rights, and political stability, impacts of these on rates of investment in physical capital with feedback effects on economic growth; impacts on poverty reduction and reduction of inequality, implications for environmental sustainability, and implications for homicide and property crime rates. Indirect and delayed effects are taken into account in the structural model.

The empirical estimates of both market and non-market outcomes of education then are based on simulations of this model. A simulation approach is necessary to capture the feedback effects and the lagged impacts. The parameters of the model are estimated from worldwide data, generally for 78 countries that include the original 22 OECD member nations. The starting points for the prediction of each net outcome in the simulations use data specific to each OECD member country, data that is shown in the Technical Appendix[2]. This worldwide perspective for estimation of the parameters is believed to be the wisest strategy given the nature of the long-term processes under study here and the fact that the variation within the OECD subset of nations alone is not sufficiently wide to lead to very meaningful results. A glance at a few scatter diagrams reveals that most (but not all) of the OECD member nations are toward the upper end of the range, with a range of variation among them that is too narrow to get sufficient variation for valid parameter estimates since they are almost all at a similar stage of economic development. The resulting sample size is also too small. Comparing the Africa, East Asia, Latin America, and OECD means for each

[2] The Technical Appendix is not published in this volume but can be viewed online at http://www.hrdc-drhc.gc.ca/stratpol/arb/conferences/oecd/home.shtml or at http://www.oecd.org/els/conferences/quebecity.htm.

outcome (as in McMahon 2000) reveals a broad sweep of these long-run processes that is quite revealing. It is reasonable to assume that these processes are continuous at the upper end of each range. Only the stage each nation worldwide is at in each process is “different” and that difference is taken into account by fixing the starting points. There are minor non-linearities as the upper end of the regression line fit to a worldwide scatter diagram is approached that lead to some loss of precision in the estimated impacts, but there are other non-linearities that occur in the middle ranges as well. Other factors contribute to potential variation in outcomes; each structural equation can undoubtedly be refined by others as time passes; there are impacts from the strong personalities of particular leaders (e.g. Nehru’s influence makes India an outlier on democratization); and some of the variation is always unexplained. So 100% precision in the estimated empirical outcomes should not be expected of first approximations, and a standard analysis of the residuals in particular cases is revealing.

This said, a whole new approach to measurement of the non-market outcomes of education and of the social benefits including externalities is offered. The structural model also endogenizes the key constants of the classic Solow (1956) model (e.g. population growth, saving rates, dissemination of technical change, and political stability), as well as poverty and aspects of sustainability. It is hoped that new insights are offered by this new approach and some idea of the direction and general magnitude of each outcome.

2. Market Returns, Non-Market Returns, and Externalities

The overall conceptual framework for measuring market and non-market returns will be considered briefly. This should also clarify the role of externalities as they relate to both.

Market-Based Measures of Net Returns to Education

The theory of knowledge-based economic growth, and the central role of education in disseminating this knowledge including the development and dissemination of technology, has been given an enormous stimulus by the new endogenous growth theory (e.g. Romer 1986, 1990; Lucas 1988) and human-capital-augmented Solow models (e.g. Mankiw, Romer and Weil 1992) accompanied by empirical tests (e.g. Barro 1992, 1997; Kim and Lau 1996) which all give human capital a central role. This role of human capital in the OECD nations has been studied empirically recently by Healy et al. (1998) and also surveyed by Psacharopoulos (1999). Technology also is very important, including its development which occurs largely in the OECD countries. But it has very little practical effect on economic growth processes unless it is disseminated by education which creates the simple basic capacities to utilize the technology and learn on the job, a bitter lesson learned years ago by international economic development and lending agencies.

The Lucas (1988) production function shown in Eq (1) captures these effects nicely. It is a useful vehicle for explaining the role of human capital in the growth equation that will appear later as part of the structural model and for explaining the role of education externalities. Lucas identifies the average level of education in the community, H^{α}, as generating externalities that augment the economic growth process. It is these externalities that we propose to identify and measure as feedback effects from the non-market returns to education that augment economic growth. Although the focus of this paper is on non-market returns and not on economic growth per se, it is necessary that growth be considered briefly in order to explain the role of externalities (or increasing returns) and feedback effects which the paper does seek to measure. Mingat and Tan (1996) have also recently addressed the size of these feedback effects as a proportion of market-based growth. Specifically, the Lucas (1988) production function specifies inputs in the economic growth process that are used within the firm (i.e. inside the parentheses) including inputs of human capital used on the job, μH, (1-μ, the fraction of time this human capital is used in the home in household production of non-market satisfactions will appear shortly), and raw unimproved labor, N, as measured by the number employed, all contributing to output, Y. The productivity of these inputs by firms is enhanced by externality benefits arising from the level of education in the community:

(1) $Y = Y(K, \mu H, N, A) H^{\alpha}$

The output sold in the market, Y, measured as GNP originating within this firm, is produced using knowledge, technology, and techniques that cannot be used unless the value of the employees' time is enhanced by formal education. This means basic reading, writing, math, and job-related skills embodied in the human capital that workers bring to the job for the fraction μ of their total time. Perhaps most important, this human capital enables them to learn on the job, and to make use of new knowledge, A, created by R & D. Human capital, therefore, is not a necessary and sufficient condition but it is one of several causal factors contributing to output. It also contributes to output growth when Eq. (1) is totally differentiated with respect to time, as it is for the specification leading to our growth equation (i.e. Eq. (34) in the Technical Appendix).

Lucas' H^{α}, the average level of education in the community, consists of community effects that are identified as the separate non-market effects of education listed above. They result from the dissemination of knowledge in the community by prior formal education that *directly* aids the firm in increasing productivity, but they also come *indirectly* through education's contribution to other social outcomes. The indirect effects are essentially all externalities and are not taken into account when individual families decide how much to invest in education since the individual's contribution is a very small part of the total, and they are, therefore, "givens" in the community, often the result of investment by past generations. Although the individual may realize privately some of the benefits of investment in education made by others, this is not contingent on his or her private investment decisions. The indirect benefits he or she generates may flow to future generations.

Some of the externalities from education's social outcomes that are components of H^{α} in the Lucas production function are empirically significant but only in specific ways. Democratization, for example, does not appear to impact economic growth directly (Barro 1991, 1997 and Barro and Sala-I-Martin 1995, arrive at the same conclusion), but education does make a significant contribution to democratization (Eq. 8, DEM, in the Technical Appendix) which in turn contributes to political stability (Eq. 10, Technical Appendix). The latter makes a significant contribution to economic growth through its contribution to higher rates of investment in physical capital (Eqs. 38 and 34, Technical Appendix). This is not just true in Sub-Saharan Africa, but also within OECD member countries. One can hardly deny that political instability has contributed to low growth in Northern Ireland, Bosnia, and earlier in Greece, Turkey, and Spain (during the civil war). These are long-term processes we are talking about, and *degrees* of democracy and political stability, not dichotomous variables. This is not inconsistent with Barro and Sala-i-Martin's (1995) finding of a significant contribution to growth by the rule of law, since the latter is a component of both the democratization and political/economic stability indices. Education also contributes to other community factors that have positive effects on economic growth such as lower crime rates (which lower the costs to firms) and the communication of knowledge and technologies useful to firms obtained from libraries and the internet (which is difficult to quantify). Education also contributes to contract dependability and to trust, which are major components of social capital.

Overall Framework for Measuring the Non-Market Returns to Education.

The measurement of the net marginal product of education is based on the underlying theory of household production and the value of non-market time developed by Becker (1965, 1976). Households produce final satisfactions, or Becker commodities, during non-labor-market hours using market goods. A key input is household members' own time whose value has been enhanced by education. Becker's *household* production function is extended here to include external effects:

(2) $Z = Z(Y, (1-\mu)H)\, H^{\beta}$

Here the Z_i's are the final satisfactions produced; $(1-\mu)$, the fraction of time that is non-market; H, the stock of human capital measured by the educational attainment within the household; and H^{β}, the average education level in the community representing external effects but in this case on households. As before, Y stands for all goods purchased in the market as measured by per capita GNP. Since this depends on the household's income, which is heavily dependent on the household's education, Y must be controlled for in measuring the *non-market* marginal product of education if double counting the market returns to education is to be avoided. In the Technical Appendix it will be seen that per capita GNP is included one way or another in every regression that seeks to measure the non-market marginal products of education.

The *direct effects* of education, now on each non-market outcome, are the effects of $(1-\mu)H$ on Z in Eq. (2). Specifically, they are the partial derivatives of the Z_i 's, the various types of non-market outcomes, with respect to $(1-\mu)H$. After differentiating with respect to time, which converts the stock of human capital (e.g. educational attainment levels) to increments in that stock (e.g. enrollment rates which provide updated additions to the nation's stock), these direct effects are measured by the parameters for gross enrollments in education in each regression.

Many of these non-market benefits are private, such as own-health. But some are nearly 100% externalities essentially by definition (e.g. contributions to improvements in democracy that benefit future generations). Still others are partly direct private benefits and partly indirect benefits, in which case the latter indirect benefits operating through intervening variables and usually with lags are largely externalities for the reasons discussed above. For example, lower fertility rates may result in smaller families with each family member being better off, a private benefit, but they also contribute to lower population growth rates which is a social benefit in reducing the strain on maintaining a sustainable environment. These indirect effects are the cross partial derivatives from Eq. (2), e.g. $\partial Z_i / \partial Z_j \; \partial Z_j / \partial\, (1-\mu)H$, where the Z_i's are the social outcomes relevant to social well-being and the cross partials trace their interactions. These cross partial derivatives can be calculated analytically from the regression equations, but they compound in complicated ways and with lags so that it will be much more practical to measure these indirect effects by means of simulations.

3. The Rationale for Measuring Particular Non-Market Returns

Turning now to the measurement of education's marginal product in affecting separate specific types of education's non-market outcomes, the rationale for empirical measurement of each specific direct effect is explained below. The indirect effects also will be noted as they occur through intermediate variables in each equation, although as mentioned, they can become complex so that only the first round will be noted.

The numbering system of the sub-sections that follow corresponds to the numbers of the equations of the complete model in the Technical Appendix which can be viewed at the web address given in Footnote 2. It should be emphasized that there will not be repeated references below to this Technical Appendix, but all of the empirical effects discussed in Sub-Sections 1-17, 34, and 38 corresponding to these equations in the complete model are documented further there. Also the t-statistics, R^2's, specific data sources, comments on multicollinearity, heteroscedasticity, simultaneity, Baltigi and Li tests, comments on alternative specifications and the theoretical and statistical reasons for choosing the particular equation used, and other technical details are reported there. As discussed above and also in the Technical Appendix, all of the regressions estimating the specific net non-market marginal productivities of education (Eqs. 1-17 and 38) are estimated from worldwide data that includes the OECD countries, generally 78 countries. As indicated, in the opinion of the author (and also of Robert Barro in his paper in this volume) this gives much more meaningful estimates of the parameters including occasional non-linearity's given that very long-run processes are involved and the limited variation in some outcomes. The growth equation (Eq. 34), however, is estimated from panel data for five-year periods specific to 15 OECD countries. This is the pattern used in the book for the regions of East Asia, Latin America, and Africa as well (McMahon 2000, Chs. 3-10) to provide for an additional within-country time dimension for the somewhat more volatile economic growth processes given that the primary objective with respect to the growth sector is to estimate the feedback effects.

(1) Health and Life Expectancy. Logically, after controlling for per capita income, life expectancy can be expected to increase as infant mortality falls, and also as secondary education becomes more widespread. Completion of secondary education is not completely universal in any OECD member country, and is still far from universal in many. More secondary education permits wider awareness of potential causes of illness, greater capacity to access information if illness occurs, marriage to better-educated spouses (which the micro evidence indicates is a source of better health), entry into safer occupations, and also encourages adoption of healthier life styles.

Consistent with this, the key empirical determinants of life expectancy in the worldwide cross country data are found to be lower infant mortality rates and higher secondary education enrollment rates, the latter becoming significant after a 20-year lag. Controls for per capita income were used, and other potential determinants were explored. The lag here and elsewhere is necessary to allow a large enough increment in the nation's human capital stock for the effects to become significant, although there may be smaller undetectable effects on health almost immediately.

This result in nationwide data is consistent with microeconomic findings by Cochrane et al. (1980) and by Grossman and Kaestner (1997) who, after also controlling for per capita income, find that those with more education live longer. Life expectancy is to some extent a proxy for good health. Strauss et al. (1993), after controlling for socioeconomic status and location in microeconomic data, find strong positive effects of education on health. This control for per capita GNP appears as a determinant of infant mortality rates, which affects life expectancy, as well as being present in the life expectancy equation by proxy through the dummy variables for Africa and Asia since per capita income is lower in these places than in OECD countries.

(2) Health and Infant Mortality. As larger percentages of mothers have more education in the OECD countries, especially at the secondary or post secondary levels, they are more alert to the way knowledge can be brought to bear to improve their children's health. For example, they are then able to look up health problems in child health books and are more likely to be aware of simple principles such as the need for sterile conditions, the components of good nutrition, the importance of getting help if a child has a fever, and the role of vaccinations. Female secondary education enrollment rates are still far lower in some OECD member nations, such as Mexico and Turkey, than in others and somewhat lower than the average for the OECD in others, such as Italy and

Hungary, (as can be seen in Table 2A in the Technical Appendix). On a gross simple correlation basis, these are the same OECD nations where the infant mortality rates are the highest. In Portugal, where female enrollment rates started rising rapidly in 1990, infant mortality rates fell sharply shortly thereafter.

But this is only a simple correlation. After controlling for per capita income, which also reduces infant mortality, lower infant mortality rates are closely associated with higher female primary and secondary education enrollments in the worldwide data consistent with the rationale, but after a lag of 20 years. Primary enrollment has a smaller and less significant effect than secondary education for females. These nationwide effects are broadly consistent with many microeconomic findings, e.g. McMahon (1998a, 2000) and Grossman and Kaestner (1997). To mention a few, Strauss et al. (1993) find that the strong positive effects of education on adult health just mentioned have multiplier effects on child health including infant mortality. Frank and Mustard (1994) find in their study that education enables individuals to acquire knowledge on better nutrition that is associated with a decline in mortality rates, and also with increased life expectancy, which are both related to infant mortality. The evidence also shows that children who received better nurturing in early life are healthier and do better in adult life.

(3) Fertility Rates. Logically, fertility rates fall as women have more education. The rationale is that women not only want smaller families (i.e. fewer and “higher quality” children), partly because the increase in their job market options makes their time more valuable, inducing a shift away from time intensive activities in the home after they finish their education and toward more human capital intensive activities, but also because their remaining child bearing years diminish as they remain in school longer. There is considerable evidence at the microeconomic level consistent with these patterns of continuous reduction in fertility rates and family size as females finish primary, secondary, post secondary, and PhD levels. See Michael (1982, pp. 113-35), Cochrane (1979, pp. 146), Moore et al. (1993), Schultz (1993), Dasgupta (1995), Grossman and Kaestner (1997), Greenwood (1997), and McMahon (1998a).

In the worldwide data, consistent with this rationale, fertility rates are significantly lower where female primary and secondary enrollment rates are higher, all with a lag of 20 years. Furthermore, these have a significant interaction with the family planning expenditure in the country. That is, increased education for females reduces fertility rates, but this effect in Eq. (3) is strengthened by family planning programs.

(4,5,6,7) Net Effects of Education on Net Population Growth Rates. The net effects of education on population growth rates follow directly from the above, but with lag effects that are essential to the understanding of the patterns. In the poorest OECD countries, and in Sub-Saharan Africa, the positive effects of more female education on better health with falling infant mortality and rising longevity are dominant at first. It is only after females achieve about 9 years of education (by our estimate) that the effects in lowering fertility, which throughout operate consistently in the same direction, become dominant, and net population growth rates start to fall (see McMahon 2000 for the scatter diagrams and graphs). So the Malthusian dilemma can reasonably be expected to continue in Sub-Saharan Africa and South Asia for some years to come (although AIDS may reduce the population explosion, and production, somewhat). Most of the OECD member countries are out of this range and are enjoying slowing or zero net population growth rates at sustainable levels.

(8) Education and Democratization. Democratization is measured by the Freedom House (1997) index, inverted here so "1" represents purely authoritarian, or "not free", regimes and "8" represents full democracy. The level of democratization (i.e. "Political Rights" in the index) is measured annually by Freedom House's evaluation of whether or not there are free elections for the head of government and legislative representatives, fair access for and presence of opposing candidates who have equal campaigning opportunities and the right to organize different political parties, freedom from domination by the military, and so forth (see Freedom House 1997, p. 531). OECD member countries low in this index include Turkey (3), Mexico (4), and Korea (6), with most of the rest near the top at (7). Improvements in the way democracy works (e.g. in the 7 to 8 range) might include continuing expansion of the franchise (percent of population registered, actual voter turn out, etc.), freedom from distortions of the electoral process by political campaign contributions, equal access of all candidates to the airwaves, and reduced corruption. The Freedom House index does not measure these improvements at the top of the OECD spectrum very well, but it is reasonable to assume that they can continue to occur in a continuous fashion, and the ceiling placed on the index at 8 in the simulations described later is somewhat arbitrary.

The rationale is that rising per capita income is associated with a broader middle class, not tied to rural land tenancy arrangements, that seeks broader participation in the political process. Education, particularly at the secondary level or above, contributes to broader awareness and understanding of the issues at stake and facilitates rising participation and refinement of the process over time as was stressed by Thomas Jefferson long ago when he sought to make education the primary constitutional responsibility of the State.

Since a larger than average military can contribute to military coups and a restoration of authoritarian political structures, it is wise to control for this when seeking to measure the net contribution of education to democracy. Consistent with this rationale, after controlling empirically in the worldwide data for per capita income which is clearly a major empirical determinant of democratization, and military expenditures as a percent of government budgets, high military expenditure as a percent of government budgets makes a significant negative contribution to democratization. Secondary education enrollment rates lagged 15 years make the next most significant positive contribution after per capita income. The primary flow of causation from per capita income (and education) to democratization is consistent with the opinion of political scientists who specialize in this topic (for surveys see McMahon 1998a, 2000). As mentioned earlier we find no significant direct effects of democratization on per capita growth, but after a lag and through positive effects of democratization on political stability, there are empirically significant effects of democratization on investment rates that feed back on economic growth. These effects could extend over many generations.

(9) Education and Human Rights. Human rights is the Freedom House (1997, p. 531) measure of civil liberties. It reflects the rule of law, including the degree to which citizens are treated equally under the law with respect to access to an independent judiciary, protections from political imprisonment and torture, a free and independent media, freedom of assembly, free trade unions, free religious expression, and so forth. We are cognizant of the fact that human rights are interpreted in some parts of the world to include access to education, health, and some other things, but we choose to stay with the definition used by political scientists in the West as measured by

Freedom House, which also keeps our analysis clean since we are treating education (and health) as endogenous in the complete model and as important aspects of social well-being.

The rationale is that the protection of human rights is the result of democratization and the rule of law. Over and above that, legal education promotes functioning court systems and concepts of statute and case law. Furthermore, education in the humanities makes the population more sensitive to equity issues and the importance of equal access to fair jurisprudence. Again, it seems apparent that there is still substantial room for improvement in these matters, even though most OECD member countries are close to the top of the Freedom House index.

Consistent with this rationale, after empirically controlling for income per capita and for military expenditures as a percentage of the government budget, human rights increase directly primarily with the level of democratization, but also with secondary education enrollment rates lagged 10 years (further details in McMahon 1998c, 2000). Secondary education is only significant at the 10% level. But higher education may be significant also in the OECD member nations. The rationale is also consistent with observations of how authoritarian regimes that lean against human rights also oppose education in political science, law, and the humanities while strongly supporting vocational and technical education.

(10) Political Stability. Political stability (PS) is measured by Political Risk Services (1997, pp. S7-S9) using 13 components of political risk, 5 components of financial risk, and 6 components of economic risk. Political risk, which accounts for over 50% of the index, gives the largest weight to the rule of law or the lack thereof, civil and external wars, political terrorism, corruption, political leadership failures, and economic planning failures. Financial risk includes loan defaults and expropriation, and economic risk includes macroeconomic instability, inflation, and high debt service. In the index, 100 represents high stability, with Greece, Turkey, Italy, Hungary, Poland, and Spain scoring relatively low and Switzerland, the Netherlands, Denmark, Germany, and the US among the highest.

The rationale for education's contribution is largely indirect, through its contribution to democratization and to economic growth. But it is partially direct as education contributes to those reforms that reduce corruption, macroeconomic instability and inflation (via more and better education in economics?), strengthen civilian control of the military, etc. Consistent with this, the empirical determinants of political stability in the worldwide data are per capita income, which is highly significant, and military expenditures as a percent of government expenditure. After controlling for these, secondary education rates after a lag of 20 years contribute positively at the 10% level of significance, as does the degree of democratization.

The importance of this finding is that political stability contributes to higher rates of investment in physical capital in the investment equation, and hence to economic growth. This effect is rather obvious if one looks even casually at the political/economic instability and chaos accompanied by slow growth in many of the countries of Sub-Saharan Africa and Bosnia.

(11, 12) Inequality and Poverty. Inequality in the income distribution is measured by the Gini coefficient. Rising income inequality continues to be a very major problem in the OECD nations, and is shown to be the result primarily of wider inequality in earnings (see Gottschalk and Smeeding 1997, and Sullivan and Smeeding 1997) associated with higher premiums paid to the better educated (see Arias and McMahon 2001). This is to be distinguished from absolute poverty measured as the percentage of income received by the poorest 20% of the population. The focus here, however, will be on inequality which is rising in most OECD member countries.

The rationale for the relation of education to inequality is that *who gets the education,* and particularly good quality education given the inequality within the education system, largely determines inequality of earnings and hence inequality in the distribution of income later on. See Psacharopoulos (1977), for example. To illustrate this, the difference in the education policies pursued in East Asia, where widespread access to education early on was accompanied both by fast growth and falling inequality can be compared to the policies in Brazil where there had not been equal access in rural areas. In Brazil, the Kuznets inverted U path was followed instead, and growth has been accompanied by enormous inequality. This process is analyzed further and illustrated with scatter diagrams in McMahon (2000). Within the OECD context, as secondary and 2-year college enrollment (and completion) rates are increased, inequality in earnings after a lag can be expected to diminish. This makes those who might otherwise have dropped out of high school employable and also reduces the scarcity rent paid to those with some college. (These effects on distribution are different in Africa or South Asia since universal primary education does not exist there).

Empirically, the most important determinants of reduced inequality in the worldwide data are secondary education enrollment rates lagged 20 years and *lower* population growth, both significant at the 10% level, after controlling for faster per capita economic growth which tends to be associated with falling inequality. Many other potential variables were tested without notable results. But it should be noted that the data on the Gini coefficient is not yet as comprehensive as one might like.

This empirical result is consistent with the rationale, as well as with the findings of various studies based on microeconomic data. Sen (1997), for example, in his study of health and poverty in Bangladesh finds that policies geared towards education specifically for the poor have positive effects on poverty reduction and also on better health.

(13, 14, 15) Education and Environmental Quality. A sustainable environment as measured by the arrest of deforestation and maintenance of water and air quality is not only an important aspect of the quality of life in OECD member nations but also a key aspect of social well-being. Deforestation and wildlife destruction for which it is a proxy is measured by the World Bank (1998, p. 206) as the percentage change in forest land (converted so that positive numbers represent increases in forest land in Table 1 below and in the simulations.

The rationale for the relation of education to forestation is through effects that are largely indirect. In particular, high population growth rates can be expected to lead to faster cutting of forests for firewood, building houses, and for agricultural use. Higher GNP per capita can be expected to provide the capacity for more rapid establishment of national park systems, and higher education may even contribute directly to awareness and more effective environmental regulations.

Empirically the direct effects of secondary education were not found to be helpful in reducing deforestation. But consistent with the rationale, the indirect effects through higher per capita income and lower net population growth rates are found to eventually start to reduce the rate of forest and wildlife destruction.

Consistent with this same rationale, water pollution as reported by the World Bank (1998, p. 206, Cols. 7-8), after controlling for GNP per capita, is significantly reduced as population growth rates slow, as poverty is reduced, and as higher education rates increase. The latter represents a direct positive net effect from education, but the indirect effects are more important.

Air pollution is different in that it increases with higher economic growth rates and with the expansion of primary education (which is more relevant in the less developed countries). But after controlling for these, air pollution is reduced as democracy expands and as population growth rates slow.

(16, 17) Education and Crime. Crime rates are measured as homicide rates and as all other crime, which will be loosely referred to here as property crime, both as measured by INTERPOL (1995). The international perspective offers considerable insight, even though the international crime data is poor. Therefore, US data for the 50 states is used to cross check the tentative findings within the context of one OECD member country.

The rationale, consistent with the criminology literature, is not that academic achievement reduces crime but instead that when young men remain under supervision, either in high school or in a job later on, they are not out on the street getting into trouble (see Witte's survey 1997, Speigleman 1968, and Ehrlich 1975). There are also peer group effects. Since we wish to measure the *non-market* return to education, it is important to control for per capita GNP. After this, greater income inequality and/or higher poverty rates are expected to be associated with higher crime rates.

Empirical results are consistent with this rationale. Controlling for GNP per capita, homicide rates are higher with higher inequality in the international data. In US data, homicide rates are lower following higher secondary education enrollment rates (no lag) and lower unemployment rates (*after a lag of two years).* Both of the latter reflect whether or not younger persons are under supervision either in school or by employers in a job. I was unable to test adequately for the net effects of narcotics addiction or of the availability of guns (see McMahon 2000, pp. 144-5).

"Property" crime rates rise with economic growth (in contrast to homicide rates). But after controlling for this, part of which may be a better reporting phenomenon, they are lower with larger percentages of the relevant population in secondary school, with lower inequality, and with lower poverty rates. Both lower inequality and lower poverty rates involve indirect effects from education as indicated above.

Feedbacks on Economic Growth

To measure the feedback effects, the rationale for the determinants of economic growth and investment in physical capital will be considered.

(34) Economic Growth. A growth equation is derivable by differentiating the implicit Lucas production function with respect to time using a few simplifying assumptions as shown in McMahon (2000, pp. 35-8). The one used has been estimated earlier from panel data for five-year periods for 15 OECD countries. The resources were not available to re-estimate this equation for all OECD countries with updated panel data. But the variables that are significant are consistent with those obtained recently by Mingat and Tan (1996) for the 20 highest income countries as shown in the Technical Appendix, although they find more highly significant positive effects from secondary education enrollments in the 19 middle income countries consistent with the results for East Asia in McMahon (2000, p. 39).

These empirical results all suggest that per capita growth of GNP in OECD member countries is dependent primarily on the rate of investment in physical capital as a percent of GNP but also on human capital investment, especially for college education but more significantly for secondary education in the lower income OECD member countries (which are ‘middle income’ in Mingat and Tan’s worldwide data).

GNP per capita in the initial year, 1960, (Y/N_{60} called ‘initial productivity’ in McMahon, 1984) has a negative sign in all regressions including those by Mingat and Tan (1996, Table 3). This suggests convergence within regions if human and physical capital investment rates were the same (which they are not). The negative effects of underutilization of labor suggest that the excess capacity in some countries does not help. It was also found that investment in R & D (although ultimately important) does not contribute alone at least within a 25-year to 30-year time frame unless the capacity to utilize the new technologies is embodied in human and physical capital capital through higher rates of investment in education and in physical capital which appear necessary for its dissemination. This conclusion is consistent with an even stronger conclusion by Kim and Lau (1996) that technology alone without this human capital and physical capital investment has contributed virtually nothing to growth in East Asia. The complementarities and interaction effects between investment in R & D and investments in human and physical capital are explored much more specifically in McMahon (1992). There the estimates suggest larger direct and indirect effects on growth from R&D through higher education in the five largest OECD countries than in a larger group of 11 OECD countries (ibid, Table 2). Revealing more explicitly the complementarity among the different forms of human, physical, and knowledge (R&D) capital, estimates are presented there of Nested CES production functions for the US that reveal a much higher elasticity of substitution between raw unimproved labor and the total capital nest (consisting of physical capital and higher education human capital, both with the R&D-created technologies embodied) than among the different forms of capital within the capital nest. Barro’s paper in this volume also finds interaction effects, as do some other papers published recently.

(38) Investment in Physical Capital. The rationale for the determinants of investment in physical capital as a percent of GDP is that prior investment in human capital is necessary to use the new technologies that are often associated with new investment, and also to offset diminishing returns to physical capital. Education is hypothesized to supports an export-oriented growth strategy that in turn strengthens the balance of payments, thereby facilitating investment from abroad and loosening the limitation of domestic savings rates. Higher school enrollments, furthermore, induce higher total saving via forgone earnings. Political and economic stability also are expected to contribute to higher rates of investment since they are attractive to international investors. On the other hand, social security expenditures as a percent of Government expenditure support consumption and not investment, so their effect on investment rates is expected to be negative. The empirical results, as already suggested, are consistent with this rationale.

4. Patterns of Effects in the Interactions among Social Outcomes

There are interactions among many of these social outcomes, so that most outcomes are also inputs generating increments or decrements in other social outcomes. That is, most also act as intermediate goods as distinguished from their direct effects on final non-market well-being. The final effects include feedback effects from non-market outcomes on economic growth.

The size of each of these interactions is based on the regression coefficients that are estimated from worldwide data for the non-market social outcomes. They are shown in the complete model which is Table 1A in the Technical Appendix. They have technical properties that are discussed in detail there. To interpret them easily for policy purposes they are converted to the elasticities shown below in Table 1. These elasticities are calculated at the OECD-country means, so that a 1% increase in the “social outcomes” listed in rows 1-38 (corresponding to Eqs. 1-38 in the Technical Appendix) leads to the percent change in the social outcomes shown under Cols. 1-34. All of the mnemonics in the column headings are defined in the same sequence in the first column on the left except GER 1,2,&3=Gross Enrollment Rates, primary, secondary, and higher education respectively, and LFPR=Labor Force Participation Rates, and in the first column EDSH=Education’s Share (as a percent of GNP). The lags in years are shown as (-15), (-20), or –2, -5, and so forth. The data sources for each variable as well as more detailed definitions of each are given in the Technical Appendix as well as in the book (McMahon 2000).

Many cells in Table 1 are blank because there are entries only if there is a significant interaction among social outcomes that reaches at least the 10% level (90% confidence level). The research has been extensive in testing for possible cross effects. But many that one might logically be expected were not found to be empirically significant, and others that have no potential causal relationship that can be inferred from the logic of the theory and the lags are also not included. Of course future research by others may detect effects that could not be empirically documented here.

Finally, it is extremely important in interpreting Table 1 to realize that it includes only the direct effects based on the coefficients and none of the indirect or feedback effects. It is for the purpose of including these indirect and feedback effects, which the author regards as the true total effects of education, that the simulations of the model are done and reported later below. The direct effects are *partial effects* somewhat analogous to dynamic impact multipliers. The further feedback effects and interactions are generally considerably larger, but they and the time forms of the lagged responses can only be measured by simulations over a longer 45-year or so time period.[3]

[3] Total elasticities that include these indirect effects can be calculated analytically (just as can dynamic impact multipliers or equilibrium multipliers as time goes to infinity). But the calculation becomes very complex as is shown in the background paper prepared for the OECD (McMahon 1999).

Interactions Among Non-Market Social Outcomes.

Although some of the non-market outcomes are not as susceptible to being changed directly by policy, it is nevertheless suggestive to consider potential response-elasticities to changes in them. Education, however, is a policy variable that significantly affects all of these outcomes, including the indirect feedback effects that are crucial to sustainable growth, a sustainable environment, and the sustainability of other social outcomes. So it will be considered last.

TABLE 1 GOES HERE: “INTERACTIONS AMONG….”

Health Interactions. Improved *health status* in form of a 1% increase in life expectancy (Row 1, Col. 7) is estimated to lead to about a 0.65% increase in population growth rates if life expectancy is 50 years (1/2(1.30), noting that it is measured as an inverse). Life expectancy is also partly affected by reductions in infant mortality (-0.021%, Row 2, Col. 1). Both of these interactions are quite apart from the effect of both health improvements on citizen well-being directly. 1% higher population growth rates in turn (Row 7) are a source of a 0.079 percent increase in inequality (Col. 12), a 0.962% reduction in forest lands (Col. 13) and a 13.7% increase in water pollution (Col. 14). The adverse relation of population growth to inequality and forest land should not be a problem in OECD countries and in Canada where population growth rates are low, but is a very serious problem in Africa and South Asia where population growth rates are higher. In the higher per capita income OECD countries the effects of improved health status on population growth have already been largely offset by the effects of education in lowering fertility rates (-0.52 after 45 years in Row 19, Col. 3).[4]

No significant relation between population growth and economic growth in the OECD countries was found, although there is such a relation in Africa (McMahon 2000, Ch. 5). Consistent with this, Mingat and Tan (1996, Table 3) find no significant effect, and their negative relation of population growth to per capita economic growth in middle-income countries (-0.029) and positive relation in high income countries (0.024) are also offsetting.

The effect of increased female education to reduce fertility rates (Table 1, Rows 20 & 23, Col. 3) is likely to be the most important in those OECD member countries with lower per capita income (Greece, Mexico, Poland, Ireland, Portugal, or Turkey), given its contribution to reduced deforestation, water pollution, and inequality (e.g. Row 7, Cols. 13, 14, and 12).

Democratization, Human Rights, and Political Stability. The estimates in Table 1 suggest that a 1% improvement in democratization contributes about a 0.6% improvement in human rights and about a 0.8% improvement in political stability (Row 8, Cols. 9 and 10). A 1% improvement in political stability is estimated to contribute a 0.154% increase in the rate of investment in physical capital (Row 10, Col. 38), which in turn contributes 0.36% to increased growth [Row 38, Col. 34, 2.44/(1/0.15)]. Another interaction comes from the contribution of higher total enrollment rates in education to 0.084% higher labor force participation rates, particularly among women (Row 19, Col 29), which leads to less underutilization of potential labor (Eq. 32 in the Appendix) raising per capita growth (Table 1, Row 32, Col. 34).

[4] The negative relation of population growth to air pollution in Row 7, Col. 15 should probably be ignored. It is more likely to be a spurious correlation due to high population growth rates in agrarian LDC's where air pollution is low than

Inequality. Expanding access to secondary education by 1% is estimated to contribute to a 0.306 reduction of inequality (i.e. reducing the increases in inequality) in OECD countries (Row 23, Col. 12).

A 1% reduction in inequality (in the Gini Coefficient) is estimated to contribute in turn about a 1.13% reduction in the murder rate and a 5% reduction in 'property' crime (Row 12, Cols. 16 & 17). A 1% reduction in poverty is also estimated to be associated with a 0.78% reduction in property crime (Row 11, Col. 17).[5] A 1% increase in GNP per capita is estimated to be associated however with a 3.25% increase in property crime rates (Row 37, Col. 17), but this may be partly because of better reporting. So the net effect on property crime rates depends on whether the wider access to and enrollment in secondary education and its effects in reducing inequality and poverty are together strong enough to offset the effects on crime from faster growth.

The Environment. Environmental quality has important final outcomes on the quality of life and on forest, wildlife, water, and air quality sustainability. We were unable to detect interactions of water and air quality with health, although there must be some. It is interesting that the worldwide evidence suggests that a 1% improvement in the functioning of democracy including the rule of law contributes a 1.92% reduction in air pollution, presumably through better enforcement of environmental regulations (Row 8, Col. 15). Higher education contributes to lower water pollution, presumably for the same reason (Row 24, Col. 14). But the evidence is that the effects of pure economic growth on deforestation and air pollution (after controlling for human capital) are adverse. That is, the deterioration of the environment is likely to persist unless offset

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a causal factor called for by the rationale.

[5] The size of the coefficients in the Poverty equation should be discounted in applications to the OECD countries given the slightly different way absolute poverty was measured in the regressions.

by investments in education, suggesting that environmental health may not be sustainable without interactions with other forms of social capital.

5. Simulations Estimating Impacts of Education in 22 OECD Countries

Turning now to the estimated impacts of education after 45 years, the results of simulations using the complete model in the Technical Appendix are summarized in Table 1, Rows 18-24, (in the denominators) and even more clearly in graphs for a hypothetical "typical" OECD country and for Canada below. Simulations for 21 other OECD member countries are in the background paper by McMahon (1999).[6]

The results of the simulations *are not predictions*, but instead estimate the *net* effects of a specific education policy change. These *net* effects are the focus here, not the base line scenario which will be referred to as an endogenous development scenario. The pure economic growth component of this base scenario is merely an extrapolation of each country's last 10-year growth record. But the 33 non-market outcomes for which there is also an endogenous development scenario, including education enrollment rates, will continue to grow or decline from current levels as generated endogenously[7]. (See Table 1, Row 37, Cols. 23 and 24 for the continuing growth in enrollments, for example). This endogenous development scenario generates baselines for all social outcomes from which to measure the incremental effects of specific education policy interventions.

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[6] Simulations for a few countries that have joined OECD more recently could not be done because there is inadequate data available on some of the variables.

[7] The economic growth rates for the base scenario path are set to be identical to the actual real rates of growth in per capita GNP for 1985-95 for all of the 22 OECD countries in the model except for Canada and Japan. Looking into the future, the continuation of the unusually low recent growth experience in those two countries was judged to be overly pessimistic. So the base line scenario for these countries was raised to conform to their respective longer-run growth experience. This does not affect the increment above this base path that is attributable to education, which is the focus of this paper.

Policy Changes Increasing Human Capital Formation Through Education

The policy change chosen for the simulations is a 2 percentage point increase in investment in education as a percent of GNP. This gives rise to an increase in secondary education enrollment rates first in those OECD countries where completion of secondary education is not yet universal. Then the increased investment is funneled primarily to the expansion of college 2- and 4-year enrollments. This investment would build schools, train and hire teachers, and provide education for additional students. A 2 percentage point special increase in public investment in education as a percent of GNP may seem to be a relatively large amount for a single year, but in the longer time perspective taken here it is realistic and may be small. For example, poor countries like Indonesia spend about 3.2 percent of their GNP on education, whereas OECD member countries spend 5.4% of their GNP, and the highest per capita income OECD countries spend even more. It is 6.8% in the US, 8.3% in Norway, and 8.4 % in Denmark, for example. The latter is over 5.2 percentage points higher than in most poor countries. Elasticities showing the response to a much smaller 1% increment in education's share (EDSH) (i.e. not even a 1 percentage point increment), or in enrollments, GER, which show the same thing in a different way, are shown in Table 1, Rows 18-24.[8]

Patterns of Response to Human Capital Investment

Panels tracing net impacts of this increased human capital formation on social outcomes graphically are shown for a "typical" OECD country and for Canada, our host country. The

[8] More specifically, the total effect elasticities are based originally on the effects of an increase of 2 percentage points in the percent of GNP invested in education (e.g. from 6.2 to 8.2% for the average OECD member country). This is converted to the effect of a *one percent change* in EDSH (e.g. from 6.0 to 6.0 + 0.06, or to 6.06) by dividing the percent increase in the outcome by the percent increase in EDSH. The same procedure is followed for calculating the effects of a one percent increase in Gross Enrollment Rates. That is, the increase in EDSH brings about a 6.5% increase in GER1, 23% in GER2, and 26.7% in GER3 by 2045, all calculated at the OECD means for each, which averages 25%, and then this is used as the denominator for calculating the approximate effect of a 1% increase in GER (1+2+3).

starting values for this "typical" OECD country are the OECD mean for each variable. The starting values for all OECD member countries are shown in Table 2A in the Technical Appendix. Comparable graphs showing the full simulations for the remaining 21 OECD countries for which simulations were run are in the Background Paper done for the OECD by McMahon in September 1999. They are: 1) High per capita income as measured by PPP, from the World Bank (2000) - Austria, Belgium, Canada, Denmark, Japan, Norway, Switzerland, United States; 2) Middle income - Australia, Finland, France, Germany, Italy, the Netherlands, Sweden, the United Kingdom; and 3) Low income - Greece, Ireland, New Zealand, Portugal, Spain, and Turkey.

INSERT 4 pp of GRAPHS HERE; "OECD SIMULATION and CANADA Graphs 1.1 – 1.16 and 2.1 – 2.16

As investment in education increases, secondary and higher education gross enrollments increase in the 'typical' OECD country and in Canada. The net changes in social outcomes are shown in all graphs by comparing the Endogenous Development scenario (#1) marked with diamonds to the "after the policy change" scenario (#2) marked with black squares. Gross enrollments at the secondary level can be seen to exceed 100% as is frequently the case because they measure the number enrolled as a percent of the high school age group, which includes some overage students. These gross enrollments are what must be financed, and also they are the measure most relevant to the total impacts of education.

Figures 1.3 and 2.3 shows that there are detectable increments to economic growth after a lag of about 25 years. This is consistent with the rationale that suggests that this is due to the greater skill of the labor force and capacity to learn on the job, but it is also due to feedback effects (measured below) from education's effects on other social outcomes. One of these feedback effects comes through the higher rates of investment in physical capital shown in Figures 1.4 and 2.4 that responds to greater political and economic stability (Figures 1.11 and 2.11).

Life expectancy rises in the OECD and in Canada after a lag of 25 years (Figures 1.5 and 2.5). Infant mortality rates fall (Figures 1.6 and 2.6), fertility rates fall (Figures 1.7 and 2.7), and as the net result of all of this, population growth is lower (Figure 1.8). Of the countries studied, these health and population effects are the most pronounced in Canada, Japan, Australia, Italy, the UK, and Greece. In extremely poor countries, population growth rates rise at first, but all of the OECD member countries have reasonably high female secondary education enrollment rates so net population growth is slow in spite of the effects of the higher enrollment rates on better health and increasing longevity.

Democratization is already high in the "typical" OECD country (6.71 in Table 2, Technical Appendix and in Figures 1.9 and 2.9) as well as in Canada (7.0). It rises to 8.0 within 10 years, although it would appear that the Freedom House index is not as yet sufficiently fine tuned to pick up significant improvements in the democratic process at this upper end. Human rights, however, do not start as high in the OECD average (6.3), although they start higher in Canada. They include such things as equal access to the courts and improve with more education and faster economic growth after a lag of about 25 years in both graphs. All three of these (democratization, human rights, and higher per capita income) contribute to increased political and economic stability on average and in Canada specifically (Figures 1.11 and 2.11), which in turn feeds back on the growth process (Eqns. 38 and 34, Technical Appendix).

Inequality is reduced after this investment in education that increases the percent completing high school and enrolling for Associate and Bachelors degrees (see Figures 1.12 and 2.12, OECD average, and Canada). This effect on inequality is important to consider, given the rising inequality in earnings in the OECD countries (Gottschalk and Smeeding 1997, Sullivan and Smeeding 1997).

Environmental impacts are delayed, partly because the effects of more education are indirect. But after about 40 years, the rate of destruction of forests and wildlife is finally reduced (the upward bend in Figures 1.13 and 2.13, OECD and Canada), even though the destruction of forests continues. Water pollution is reduced to below what it would otherwise be sooner. But air pollution is more intractable and it is not until 45 years have passed that a small positive increment is noticeable. In the places where deforestation rates are the worst, Greece and Ireland (Table 2, Appendix), after a shorter lag of 25 years these adverse trends are reversed (Background Paper by McMahon, Sept. 1999).

Finally, the net contribution of increased education to lower homicide rates is apparent in the last panel in the 'typical' OECD country and in Canada. Although they start at 4 homicides per 100,000 in the OECD on average, and 5 in Canada (See Table 2A in the Appendix), they are currently at a very high 8 per 100,000 in the US. So these effects of higher high school completion rates and larger percentages of young men in community colleges are especially significant there.

6. Externalities

The policy significance of externalities is that they offer some guide as to what percentage of education investment must be financed publicly if the non-market and indirect benefits that are externalities are to be realized. Furthermore, since externalities feedback on the growth process, if they are not supported growth is likely to slow down (e.g. Rioja 1999), although if public expenditure becomes excessive, it may be detrimental. If democracy and human rights, for example, are taken for granted as something which cannot be affected by more education of one individual, and if the benefits of education go to others and cannot be secured privately, there is no incentive for individuals or their families to invest in education, and there will be under-investment.

To measure the *indirect effects, almost all of which are externalities,* the model was specially programmed to measure the *direct effects of education* on each social outcome. This was done by letting all other explanatory variables in each equation except education, which is changed, and the dependent variable follow the endogenous development scenario. Then, from the resulting values, the values of the dependent variable given by the pure endogenous scenario (base solution) were subtracted to obtain the net *direct* effects (shown for most social outcomes for all countries in the Background Paper by McMahon (1999). These net direct effects of education were then subtracted from the total effects to obtain the indirect effects. These are externalities, as well as some of the direct effects such as the direct effects on democratization which are a benefit to others and future generations.

Social Outcomes and Feedback Effects on Economic Growth

Some of these indirect effects feed back on economic growth for each country. These indirect effects are shown beside the total effects in Figure 3 below. The backup numerical simulations for each country generating the bar charts in Figure 3 appear in the Background Paper (McMahon 1999).

BAR CHART #1 GOES HERE : "TOTAL AND INDIRECT…."

Figure 3

For the "typical" OECD country shown farthest to the right the externalities as measured by the indirect effects only, and after 45 years, average 40% of the increments in per capita income. This would seem to be pretty typical of the proportion in all of the individual OECD member countries shown, although the total, and indirect, impacts are larger in some countries than in others.[9] In very poor Sub-Saharan and South Asian countries externality benefits show up as a larger percent of the total, due largely to the long-run contribution of education to greater political stability and lower population growth. *The fact that externalities were still growing as a percentage when the simulations were stopped (at t+45), and that some direct non-market effects in addition are externalities, suggests that the 40% estimate may be conservative.* 40% of GNP per capita places an economic value on these externalities.

Non-Market Social Outcomes: Indirect Effects

The tentative estimate is that about 75% of the effects of education on non-market social outcomes appear to be externalities. This is based on Figures 4 and 5 which show the percentage of the effects that are indirect and the percentage that are direct effects.

BAR CHARTS #2 & #3 GO HERE: "OECD SIMULATION & CANADA"

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[9] Portugal simulations started from extraordinarily high 1995 secondary gross enrollment rates (see Table 2A in the Technical Appendix) but these seem to have been corrected in later World Bank (2000, p. 241) data that unfortunately gives only net enrollment rates.

Figures 4 and 5

A full 100% of the indirect effects can reasonably be thought of as externalities, which are the lightly shaded parts of the bars. This is essentially all of the effects of education on POLITICAL STABILITY, WATER POLLUTION, and HOMICIDE, most of the effects on AIR POLLUTION and DEFORESTATION, about 50% of the effects on PROPERTY CRIME and DEMOCRATIZATION (not shown), and about 25% of the effects on HUMAN RIGHTS.

Some of the direct effects, which are the shaded black parts of each bar, are also externalities. In particular, all of the direct effects of education on reducing inequality and expanding democratization and human rights can reasonably be assumed to be externalities either by definition or because most of these kinds of effects of education benefit future generations still unborn. This 75% estimate of externalities as a percent of all 9 non-market social outcomes (8 shown in the OECD simulation, plus DEM) is based on giving them equal weights, lacking more appropriate weights as given by society or by a Bergson social welfare function. This, therefore, must be regarded as a rough first approximation.

The DEFORESTATION and PROPERTY CRIME bars that extend into negative ranges indicate that there are direct effects of education that reduce the acres of land in forests and reduce property crime rates (see Eqns. 13 and 17 in the Technical Appendix). But there are indirect effects of education that increase the land in forests and property crime rates such as rising GNP per capita. This latter is a negative externality of education. But it is offset by positive externalities from potential reductions in poverty and inequality (for PROPERTY CRIME) such that the total effects from education at t + 45, direct plus indirect, improve social well-being in this respect. In the case of air pollution, (AIR), the direct effects of basic education appear to increase it, as does GROWTH, another negative externality. But the indirect effects of this incremental education via slower population growth and democratization are associated with reduced air pollution.[10]

Almost all of the *direct* benefits of education to better health (not shown in Figures 4 and 5) can be regarded as private benefits enjoyed by the family that has done the investing in education, including reduced infant mortality and greater longevity. There are indirect feedback effects from better health through rising per capita income that are also private benefits. There may be some spillover effects from private health on better public health. But there are also feedback effects from lower fertility rates that eventually lower population growth rates that are very important social benefit externalities in the poorest African and South Asian countries. (The direct/indirect health effects are not computed here but are in McMahon, 2000, pp. 237-9).

7. Conclusions: What Is New, Interesting, and Useful?

This has been a first effort to identify and measure comprehensively a range of specific social outcomes from increased human capital formation through education, to distinguish direct and indirect effects, and to identify and make a first approximation estimate of externalities. The latter suggests that education externalities are not a simple matter of a broad sweeping spillover effect from the level of education in the community. They are instead a whole series of different measurable net outcomes, many but not all of which are indirect effects operating through intervening variables, and some of which are direct effects on non-market outcomes. Some of these more specific externality effects are strong and others weak, most are positive and some are

[10] The plotting of this one bar for AIR appears to be reversed on Figures 4 and 5.

negative, and most are only partially realized after initial impacts and are more adequately measured after allowing for sustained lags. We have been vaguely aware of a few of these externality effects for decades, such as Jefferson's stress on the relation of education to democracy, a notion that may even have been around since Socrates. But the nature of some of these effects, both direct and indirect, and the length and nature of the lags are surprising.

There are further interactions among these social outcomes that we have sought to identify and measure in percentage change terms so that they can be put to other uses (with appropriate cautions). And finally, there are feedback effects from these non-market social outcomes on economic growth which we estimate account for about 40% of per capita economic growth. This 40% for the OECD nations which is the estimate in this paper is not far from estimates made for East Asia or Latin America, and a bit lower than for Africa where there is great political instability, each of which are based on region-specific growth equations (McMahon 2000).

Further, a tentative first approximation of the percent of non-market outcomes that are externalities is placed at 75%. If these non-market outcomes are approximately of equal value to the market-based outcomes as estimated by Wolfe and Zuvekas (1997) using the 'cost-based' Haveman and Wolfe (1984) method of valuation, and if indirect feedback effects and hence externalities are about 40% of market outcomes, then externalities can be estimated to be about 57% of total market plus non-market education outcomes [i.e. (75+40)/2]. This has substantial implications for the percent of the financing of all education that needs to be public, and the percent that it is possible to finance privately.

From the point of view of sustainability of the growth and development process, there are several implications. Considering first pure economic growth, within the context of the new endogenous growth theory, human capital (and R&D) investment and the externalities as they are disseminated offset diminishing returns to physical capital. Instead of arriving at a steady state solution with zero per capita economic growth, these externalities (perhaps affecting returns to scale) make possible, in principle, per capita growth without bounds. This is the key to the longer-run sustainability of positive and hopefully reasonably high per capita growth rates.

But the sustainability of improvements in the other social outcomes that constitute true development is also important to consider. The most obvious is the sustainability of the natural environment, the forests and wildlife, air pollution, and water pollution in particular. This paper has shown how further expansion of education contributes, but in about 80% through indirect effects and only after 45 years or so, to significant reductions in the rate of deforestation, reductions in water pollution, and to relatively small reductions in air pollution in the "typical" OECD member country, as well as in Canada. This 45-year period is not sufficient to attain true sustainability (e.g. zero rate of destruction of forests and wildlife, zero water pollution, etc.) without other measures, but it is sufficient to get things headed in the right direction.

Roughly the same is true for the other social outcomes for which the concept of sustainability is relevant. Rising inequality is reversed, for example, and inequality reduced in the simulations following an expansion of the percentage completing high school and 2-year or even 4-year college programs. This is important to the sustainability of a viable community and ultimately to political stability, and also makes a useful contribution to lower homicide rates in the simulations. Finally, a net contribution is made by continuing to expand female education to slowing population growth rates at given rates of immigration, approaching zero population growth in the "typical" OECD country which is surely a sustainable level.

This is a new approach in that it considers *structural feedback* effects that often occur only after lags. It also explains, or makes endogenous in a shorter-run or medium term simulation model in which capital deepening continues to occur the constants in the well known Solow model. The incorporation of variation in these important factors also goes a long way toward taking variation in "cultural" factors among countries into account. That is, the approach offered here has augmented the Solow model with investment in human capital, and endogenized the key Solow constants that depend on human capital formation. They include population growth rates, the rate of technical progress (via investment in higher education and R & D, but most especially the dissemination of technology via education without which technology has little economic impact), domestic saving rates (defined to include forgone earnings, induced as enrollment rates are increased), and political/economic stability.

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