Journal of Economic Perspectives—Volume 24, Number 3—Summer 2010—Pages 81–96

Microeconomic Approaches to Development: Schooling, Learning, and Growth

Mark R. Rosenzweig

Within the field of economic development over the past 15 years or so, particularly significant advances have been made in what can be loosely called micro-development, an area defined principally by the units that are examined, not by a particular methodological approach. The units may be individuals, households, networks, banks, government agencies and so on, as opposed to countries. Within this area, economists use a wide variety of empirical methods informed to different degrees by economic models, they use data from developed and developing countries, and some use no data at all, to shed light on development questions.[1] The best of this work speaks to the major questions of development and even informs, if not provides the foundation for, macro models of development and growth.

I will illustrate the variety of approaches to development issues that microeconomists have employed by focusing on studies that illuminate and quantify the major mechanisms posited by growth theorists who highlight the role of education in fostering growth. For example, Lucas (1988) emphasizes the role of education by stressing the importance of learning externalities. But what evidence do we have for these externalities? Theories of long-run growth that span the pre– and post–Industrial Revolution periods focus on the interaction between technical change and schooling. Lucas (2002) and Galor and Weil (2000) explain the shift from a stagnant world in a Malthusian equilibrium to one of sustained growth as the

[1] The units of empirical analysis may differ from the units of substantive focus. Thus a researcher may study household behavior, say, using aggregate district-level data. Or even study the behavior of politicians by comparing performance across countries.

■ *Mark R. Rosenzweig is Frank Altschul Professor of International Economics, Yale University. New Haven, Connecticut. His e-mail address is ⟨mark.rosenzweig@yale.edu⟩.*

doi=10.1257/jep.24.3.81

result of technical change inducing investments in schooling, which leads to a shift to smaller families. Nelson and Phelps (1966) suggest that a major mechanism by which poor countries develop is through technological transfer and hypothesize that schooling facilitates such transfers because it improves the ability to master technology. Some key questions suggested by these models are: 1) What is the contribution of schooling to productivity in low-income countries? 2) Does technical change raise schooling returns, and for whom? 3) Does learning play an important role in adopting and adapting to technical change? 4) How important are learning and thus schooling externalities? 5) Does schooling investment respond to variation in returns, whatever their source, or are there important barriers to human capital investment when returns are high?

Studies in micro-development have provided credible answers to these questions using new data and a variety of empirical approaches. The methods used encompass structural estimation, exploitation of natural policy experiments and exogenous advances in technology, difference-in-difference evaluation of programs, the examination of a large variety of implications of a single model (a preponderance of circumstantial evidence), and randomized field experiments, among others. Many of these studies have made important contributions to knowledge that satisfy high standards of evidence. Indeed, it is precisely the similarity in findings arising from different methods, data, and contexts that contributes to building confidence in conclusions.

I begin with a basic issue: what are the returns to schooling? A standard approach in economics has been to use regressions with wages as the dependent variable and a measure of education as a regressor to estimate the returns from schooling. I will argue that this approach is problematical for identifying the contribution of schooling to productivity in a development context and is particularly inadequate for exploring the ways in which education might affect conditions for economic growth. I then discuss microeconomic studies that estimate returns from schooling using alternative approaches, looking at inferences based on how education interacts with policy changes, with technology change, and with the marriage market. I then turn to the questions of whether schooling merely imparts knowledge or whether it also facilitates learning, particularly in a setting undergoing technical change, and whether there is social learning that gives rise to educational externalities. I next examine studies that address the question of the responsiveness of educational investments to changes in schooling returns, and whether and where there exist important barriers to such investments when returns appear to justify an increase in these investments. I end with some brief reflections.

The Rate of Return to Schooling and the Productivity of Schooling

A key question in development concerns the contribution of schooling to productivity. Estimates of how schooling augments productivity are informative about the existence of barriers to schooling investment, which have been hypothesized to be a key reason for the low levels of schooling observed in most low-income countries. Growth theorists also suggest that a key issue is under what conditions schooling contributes more and under what conditions it contributes less to productivity. The measurement of schooling returns is not easily obtained from randomized experiments as schooling attainment cannot be randomly assigned, and even if the cost of schooling were randomized across parents of children (as in the initial stages of the Mexican *Progresa* program), one would need a long time frame to assess how adult productivity was affected. Nevertheless, there have been important contributions made in micro-development in identifying productivity effects of schooling.

To appreciate the challenges to identifying schooling returns as well as recent advances in both quantifying and understanding the variation in the returns to schooling, it is useful to sketch a common approach to the question. For many years, development economists and policymakers have relied on (log) wage regressions on years of schooling obtained from data from low-income countries both to support arguments for increased schooling investment as an effective development policy as well as to inform studies of the determinants of growth (for example, Bils and Klenow, 2001; Casselli and Coleman, 2001). The most popular wage function used in empirical studies of wage determination is the "Mincer" wage function, which is:

$$\log W_{ij} = w_j + \beta_j S_{ij},$$

where w_j is an intercept, perhaps specific to country j, S is years of schooling, and β_j is the "rate of return" to schooling in each country. Indeed, an article compiling estimates of β_j from many countries of the world (Psacharopoulos, 1994) is one of the most cited articles in development. However, there are a number of reasons why estimates of β_j tell us little about the contribution of schooling to output or productivity across countries, even ignoring for the moment the standard issues of "ability bias" that arise due to schooling varying with unmeasured pre-school ability.

One problem is that in many low-income countries, most workers do not work for wages. Given heterogeneity and nonrandom sorting across sectors, restricting estimates to only wage workers, as in almost all studies taking this approach, can lead to bias. Including the self-employed in the sample without accounting for how capital and other inputs contribute to earnings also can bias estimates of schooling returns. And, of course, restricting the estimates to earnings overlooks the nonmarket sector altogether. Some have also criticized the Mincer earnings function approach because it does not take into account school "quality" variables (Behrman and Birdsall, 1982)—that is, variations in the inputs to schooling that are the focus of a large research program on the efficacy of school resources (Kremer and Holla, 2009). However, the main problem is that the model justifying the Mincer earnings function suggests that β_j by itself is of little value in understanding the productivity of schooling. And the model also implies that if one adheres to the

Mincer model, the argument that the absence of school quality variables (or even controls for ability) induces bias is misplaced.

The original specification of the wage function derived by Jacob Mincer (1958) was based on a general-equilibrium "equalizing differences" model incorporating the assumption that individuals discount future income and that there are no nonmarket barriers to schooling or occupations—that is, the amount of schooling chosen by individual workers is not constrained by school availability or by access to finance. Under these assumptions, lifetime wages must be equal for all workers no matter what their schooling level. For example, if college graduates had higher lifetime earnings, then more persons would go to college, driving down the wages of college graduates until lifetime incomes were the same. Moreover, since agents deciding on human capital investments would compare the returns to schooling with the returns to capital, the discount rate would be equated to the cost of capital. In the Mincer earnings function given earlier, therefore, the parameters have a structural interpretation in terms of the model: the intercept is the wage a worker would earn in country j who had no schooling, $w_j = W(0)_j$—the "base wage" for country j—and the rate of return to schooling is actually the rate of return to capital in the economy.

Thus, in the Mincer model, differences in the "rate of return" to schooling across countries reveal little about cross-country differences in the productivity of schooling and may equally reflect capital market conditions.[2] Differences in the productivity of human capital or in the schooling production function (school quality) across economies (in equilibrium) will be reflected not in the Mincer β_j, but in the quantities of schooling. The reason is that people will invest in schooling until the marginal product falls to equal the interest rate. Thus, in equilibrium, variables reflecting the quality of schooling will be unrelated to workers' earnings across countries given their quantity of schooling.

Knowledge of the rate of return to schooling β_j is also insufficient to characterize either the marginal contribution of a worker to output or to predict the aggregate quantity of schooling in an economy as both also depend on the level of the "base wage" w_j.[3] And the Mincer model is silent about the determination of an economy's base wage. Indeed, if, as assumed in the Mincer model, factors are mobile, the principal effect of growth lies in raising the base wage. An empirical question is whether cross-country variation in the base wage or in the Mincerian rate of return to schooling accounts for more of the variation across earnings for workers around the world who have the same schooling. In Rosenzweig (forthcoming), I use data on earnings for workers in 120 countries and new information on cross-country school

[2] Within a developed country, where the assumptions of the Mincer model are more credible, an increase in the productive value of high-skill workers might be reflected in a temporary rise in the returns to schooling coefficient, and thus changes in β over time might suggest changes in the relative value of schooling.

[3] The addition to output of a worker in country j who obtains an additional year of schooling, given the Mincer wage specification, is $\beta w_j e^{\beta S}$.

quality (Bartik, 2008) to estimate the Mincer earnings model. I find that the variation in the base wage w_j across countries is substantial and accounts for most of the variation in earnings across workers of the world (as opposed to variation in β_j).[4] Moreover, I reject the Mincer model as I find that school quality variables also are significant determinants of earnings, net of school years.[5]

Thus, in a development economics context, thinking about returns to education or skill by using a cross-country or within-country regression of wages and years of education seems unlikely to yield insights about the determination of schooling and its returns. Instead, the key issues are what determines the amount of and productivity of skill and why does it vary (so much) across countries, as is evidenced not by variation in β_j but by variation in the base wage. That is, why does giving a U.S. resident a college education increase earnings by orders of magnitude more than a similar investment in schooling in a country like Nigeria? The micro-development research agenda goes beyond the Mincer earnings function approach to measuring the returns to schooling in a number of ways: by accounting for the endogenous variation in schooling, by dealing with the selection of workers into sectors, by measuring more directly the productivity of schooling, and/or by assessing directly the productivity of schooling in different contexts so that a better understanding of where and when schooling investments pay off can be obtained. Here, I give the flavor of that research with three examples.

Esther Duflo's (2001) study of the impact of the INPRES program in Indonesia on schooling attainment uses a difference-in-difference technique applied to different birth cohorts across multiple consecutive censuses to show how a school building program applied differentially across areas of the country increased the schooling attainment of the affected cohorts. The empirical challenge to identifying the impact of the program is that the increase in school building was purposively more intensive in low-enrollment areas. Duflo obtains an estimate of the effect of the program by comparing the change in schooling across birth cohorts affected and unaffected by the program in high-intensity and low-intensity program areas.

Because the methodology takes into account endogenous program placement, the variation in the program provides a plausible instrument for schooling variation across birth cohorts and places of birth. Although the focus of the paper is on the effectiveness of the program in improving schooling attainment, Duflo also examines how the earnings of the relevant cohorts were affected. By comparing the earnings gain with the (very modest) schooling gain induced by the program, Duflo is able to quantify the marginal effect of schooling on earnings. She includes in her estimates those workers who were self-employed so as to avoid the selectivity bias associated with excluding such workers (the majority). Interestingly, Duflo's

[4] Cross-country variations in the base wage have been shown to strongly affect the selectivity of the international migration of skilled workers and of students seeking a university education outside of their country of birth (Jasso and Rosenzweig, 2009; Rosenzweig, 2007, 2008).

[5] The coefficients on the schooling quality variables may reflect more than school quality effects on earnings, as such variables may be correlated with imperfections in the capital market.

calculated return to schooling for the most inclusive sample ranges from 7.45 to 3.6 percent, while the Psacharopoulos (1994) reported estimate of the Mincer β_j for Indonesia is 9.4 percent.

In Foster and Rosenzweig (1996), my coauthor and I used data on agricultural profits to estimate the contribution of schooling to profits. We went beyond measurement of schooling returns, however, to test an implication of the Nelson–Phelps hypothesis, that the returns to schooling rise when there are opportunities to adopt new technologies, by examining data characterizing the early stages of the Indian "green revolution" when new high-productivity seeds were first made available to farmers. We employed a structural approach, estimating how the parameters of the conditional agricultural profit function for Indian farmers changed as a result of the introduction of new seed varieties. Using panel data at the household level on profits, input prices, capital assets, and schooling for Indian farmers, we simultaneously estimated the amounts of agricultural technical change across Indian districts due to spatial variation in agro-climatic conditions, and the contribution to profits from primary schooling (additional schooling beyond primary was not important), first, before the new technologies were introduced and, second, as a function of the subsequent rise in technologically induced farm productivity. Our estimates, which allowed for the endogenous accumulation of assets and schooling, suggested that prior to the green revolution, farmers with a primary education exhibited about 10 percent higher profits than farmers without schooling, conditional on assets. However, in states with high technical change, at the end of the eleven-year period of our panel, profits for the same farmers with primary schooling were 40 percent higher than those for illiterate farmers, while the profit differential by schooling remained the same in areas with little or no suitability to the new seeds.

What about payoffs to schooling outside of the labor market? In many low-income countries, women do not participate significantly in the paid labor market, yet women's schooling attainment can be higher than that of men. One common hypothesis is that the schooling of women is complementary to the production of human capital of children; indeed, almost all data sets show a positive correlation between maternal schooling and child schooling. There are many alternative interpretations of this relationship; for example, the intergenerational correlation in schooling might reflect a genetic link in ability, or women who are more educated may have more bargaining power in the household and tend to prefer to allocate resources to children.

In Behrman, Foster, Rosenzweig, and Vashishtha (1999), my coauthors and I took up the challenge of identifying the effects of a mother's schooling on the efficiency of children's human capital accumulation. We examined implications of a model of schooling investment that incorporated productivity effects of maternal schooling, a relationship between maternal schooling and bargaining power, and marriage market selection. We first established that over the same period in India studied in Foster and Rosenzweig (1996), and using the same data, rural women did not participate in the paid labor market, and women's schooling, unlike men's schooling, had no significant effect on farm profits whether or not farms used the high-yielding seeds associated with the green revolution. We showed, however, that the demand for literate wives increased more in areas of India where technological change in agriculture was highest. We also showed that, within extended households, sons of mothers who were literate studied more hours than sons of illiterate mothers.

We ruled out bargaining power as the interpretation of these relationships with two additional pieces of evidence. Literate mothers did not also spend more on children's clothing, which implies no change in bargaining power within the marriage. More importantly, dowry payments paid by the parents of literate women were lower than those for illiterate women. If literacy only increased the bargaining power of women, presumably men would have to be bribed to marry more literate brides and thus female literacy and dowry payments would be positively, not negatively, related. We thus conclude that there are increases in the nonmarket returns to schooling for women that parallel the returns to schooling in the market sector.

As these studies illustrate, one great advantage to microeconometric studies of the returns to education is that they involve thinking through the particular contexts that affect the productivity or costs of schooling investment—such as programs that improve access to schools, or technological advancement, or the role of family investments in the human capital of children. In this way, such studies address key questions about why schooling is productive, what makes it more or less important in various places and times, and what aspects of schooling contribute to its value.

Schooling, Learning, and Social Learning

Schooling can increase productivity in two ways: by imparting specific knowledge and/or by enhancing skill in acquiring new knowledge. In Foster and Rosenzweig (1996), we interpreted the positive association between the profitability of schooling and technical change as reflecting the contribution of schooling to improving the acquisition of new knowledge about the novel technologies. (The primary-educated farmers did not learn anything about the new seeds when they were in school so this inference seems sound.) However, studies have more directly inquired whether there are important information barriers in new technology adoption and whether schooling helps people overcome these barriers. If schooling enhances learning, and the introduction of new technologies in particular provides profitable learning opportunities, then we have stronger evidence for the Nelson–Phelps hypothesis that schooling and technology adoption are complementary. Agents may also learn from others. Evidence of social learning would provide empirical support for the schooling externalities that underlie many endogenous growth models.

Because learning takes time, to assess its presence and effects requires panel data. Thus, studies focusing on learning have 1) exploited the rich panel surveys that have been undertaken in low-income countries, mostly in agricultural settings where technologies embedded in new seeds or crops and inputs and outputs are well-defined and 2) carried out randomized field experiments that introduce new technologies across pre-defined groups. However, while survey instruments exist to assess a person's knowledge, rarely are there direct and well-accepted measures of a person's ability to decode new information. Thus, learning has to be inferred from observed behavior or outcomes, and the development and use of models has been particularly important in shedding light on these phenomena. In most of these studies, models of technology adoption or input use incorporating learning behavior are set out, and then inferences are drawn about the existence of learning effects from the conformity of the predictions of the model to observations on actual productivity change or, when this is absent, on the specific patterns of adoption.

In these models, the outcome from using the new product or input is uncertain and the output is stochastic, so there is an inference problem for the agent. There are two types of information about new products: the (mean) profitability (or efficacy) of the product, and the best use or application of the new product. Information about the mean return to adopting the product or from applying it in a particular way can be inferred from observations on prior use by either the agent or others. Rational, forward-looking agents will take into account that use of the new product has informational value with future payoffs. Moreover, neighbors' experience with the new product also provides information. Given that information from neighbors is essentially free, but own use provides information with a cost (possible loss if the product is in fact unprofitable or misused), the models also predict free riding. Most models adopt Bayesian learning, impose structure on the stochastic variable distributions, and commit to a particular equilibrium concept when there is social learning.

Besley and Case (1993) used five years of panel data on the adoption of a new seed (high-yield varieties of cotton) by Indian farmers to estimate a structural model of adoption behavior that incorporates all of these modeling features but assumes that best use of the seed, whatever its mean profitability, is known. They use their estimates to test whether in fact farmers are forward-looking (they are) and whether farmers cooperate or not in adoption (they cannot tell). Patterns of adoption over time appear to suggest that there is learning. In their data, Besley and Case also show that more-educated farmers are significantly more likely to adopt the new seeds initially, with the educational difference in adoption rates across farmers diminishing over time. They show that this is consistent with their model, which implies that larger and forward-looking farmers (who are also more educated in their sample) will always initially adopt a potentially profitable new technology at higher rates.

In Foster and Rosenzweig (1995), my coauthors and I focus on the problem of inferring optimal input use for a new technology, using three-year panel data on farmers in the initial stages of the Indian green revolution. We use a target-input model of learning. One advantage of focusing on use-effectiveness is that the payoffs to learning can be more directly assessed. If farmers become better-informed about best use with experience, then conditional on adoption, profits should rise over time. In contrast, finding serial correlation in adoption or a correlation between the adoption rates of agents and their neighbors may have other explanations than learning (and are thus more model-dependent). For example, farmers may merely mimic their neighbors in making their adoption choices, or there may be common shocks.[6] The Foster and Rosenzweig model also provides predictions about the way in which profits evolve over time due to learning from own and other's use and about adoption patterns. The structural and reduced-form estimates of the determinants of profit trajectories and adoption behavior, which employ the same game-theoretic equilibria as in the Besley and Case noncooperative model, show not only clear patterns of learning exhibited in the conditional (on adoption) profit functions, but also clear patterns of free riding—specifically, farmers near other farmers with large landholdings (who are therefore more likely to adopt), given own landholdings, are less likely to initially adopt. Simulations of the model also indicated that farmers with more-educated neighbors also postponed adoption initially but their learning was faster overall. This evidence thus provides direct support for the role of positive schooling externalities via social learning mechanisms.

Bandiera and Rasul (2006) employ the same target input model to look at the adoption of new sunflower seeds in Mozambique. They also find evidence consistent with learning: in particular, when a large number of adopters exist in a network, own adoption is diminished (free riding), a finding inconsistent with mimicking or social pressures. They also find that literate farmers are more likely to adopt first.

Munshi (2004), using the same data as in our Foster and Rosenzweig (1995) paper, exploited another feature of the Indian green revolution to demonstrate the importance of learning in adoption. The fact-based premise of his study is that compared to wheat seeds, rice seeds were much more sensitive to agro-climatic conditions and were also more suitable in those areas where such conditions were more variable. He shows theoretically that, because information about own productivity from neighbors' adoption is less informative for rice growers than for wheat growers, the adoption behavior of the former should be substantially less related to neighbor's adoption behavior. His empirical results are consistent with this hypothesis.

As noted, in all three of the settings in these four studies in which learning is evidently important, more-educated farmers adopted the new-technology crops at greater rates, at least initially. This is consistent with two hypotheses: that

[6] Conley and Udry (2010), using panel data on fertilizer use by Ghanaian farmers, make inferences about social learning not by how the adoption by a farmer is related in any particular way to the adoption by another farmer, but by how the adoption by one farmer depends on the new information provided by neighbors on profitability. However, their study contains no estimates of how profits or fertilizer returns varied by farmer schooling.

such farmers initially have more information about a new technology (perhaps because they read more), or such farmers learn more from the same experience. In Foster and Rosenzweig (1996) and Rosenzweig (1995), we estimate directly how the returns to new seed adoption are affected by schooling over time and find that new seed profitability is higher for primary-educated farmers. More interestingly, more-educated farmers in the first period, when no farmer had any experience with the new technology, earned no higher profits than others; the schooling advantage was only observed after some use and then diminished with experience, consistent with enhanced learning.

One issue in inferring the contribution of schooling to the profitability of new seeds is that the choice to use new seeds may reflect factors unknown to the econometrician that are correlated with anticipated profitability. While the studies employ models that explicitly depict purposive and forward-looking adoption behavior and use instrumental variables and other identification strategies based on the models to take this issue into account, an experiment in which farmers are randomly allocated new-technology seeds (perhaps by varying the price) may yield more conclusive evidence on the role of schooling in enhancing the profitability of adoption. Duflo, Kremer, and Robinson (2008) carried out a field experiment in Kenya, randomly subsidizing a pre-specified dosage of fertilizer and then estimating returns from fertilizer variation. They found that neither more-educated farmers nor farmers with previous experience with fertilizer obtained higher profits from increased fertilizer use compared with their less-educated or less-experienced counterparts.

This null result for schooling returns in the Kenyan experiment combined with the findings from the other adoption studies from agriculture that examine education effects together provide a consistent explanation for where and when schooling may have high productivity—at least in the farming sector. At least one of two conditions must be met: 1) a novel technology with potentially high payoffs about which there is some uncertainty that can only be resolved by use; and/or 2) scope for costly misuse of the technology. In the cases of the new Indian cotton, wheat and rice seed varieties, and Mozambique sunflower seeds, this criterion is met, and schooling has positive effects on both the early adoption and profitability of the new seeds. For the Kenya case, as pointed out by Suri (2009), the seeds being used were not new so there was little new to learn with respect to adoption. Moreover, the principal input that affects crop yields for new seed varieties is fertilizer; getting fertilizer amounts correct is the main challenge with most high-yield seeds. In the Kenya experiment, fertilizer dosage was under experimental, not farmer, control and thus the additional scope for allocating inputs to achieve maximum profits, and thus for schooling to be productive, was limited by design and context.

Of course, not all learning effects take place within the agricultural sector. Consistent with both the experimental and nonexperimental findings within agriculture, a recent field experiment (Dupas, 2009) that randomly assigned different prices for new, improved mosquito nets for beds obtained findings showing the combined presence of social learning and schooling effects on adoption. In particular, take-up rates were greater among the more educated, and respondents who had neighbors receiving the lowest prices were more likely to adopt and keep the new nets, given the prices they faced.[7]

Schooling Investment Responses to Changes in the Returns to Schooling

A key building block of macro-growth models that seek to explain the transition to sustained growth is that schooling investment rises in response to increases in its returns. This is also a key assumption of the Mincer model. However, a major hypothesis in development economics is that due to absent or imperfect credit markets, many households in low-income countries will be unable to augment human capital investment even in a setting where such returns are high. Morever, pre-school human capital, a complement to school-produced human capital, may be low in such households so that their return to schooling investment will also be relatively low. Finally, households may not be aware of the payoffs to schooling, particularly if they occur outside of their immediate environment, especially if mobility costs are high.

Micro-development research has shed light on the responsiveness of schooling to changing returns. In general, it is difficult to change the return to schooling experimentally. Two nonexperimental studies examine periods in which exogenous changes in the returns to schooling occurred, brought about by either technical change or by changes in policies that induced relative shifts in occupational demand. A third study, however, carries out a field experiment that induces a change in *perceptions* of schooling returns among students. The picture that emerges from all three studies is that household schooling investment seems to be responsive to local changes in the returns to schooling, but barriers to mobility associated with informal institutions and perhaps credit or income constraints may impede the full realization of the gains for some households.

In Foster and Rosenzweig (1996), we used our district-specific structural estimates of agricultural technical change associated with the Indian green revolution to assess if school enrollments were responsive to local technology advances, which we showed had raised schooling returns. Using data on enrollment rates of children 10–14 in a panel of households in 1971 and 1982, we regressed the change in enrollment rates over the period on the estimated district-level changes in technology, again exploiting the fact that the advances of the green revolution were spread unevenly over India because of the differing agro-climatic conditions. Note that

[7] The Oster and Thornton (2009) experiment, randomly introducing a new menstrual absorption device (menstrual cup) among groups of school-age girls, is notable in showing that those girls with more adopters among their friends were more likely not only to adopt the new device but also to use it more effectively. Their results thus more directly demonstrate that the observed associations between own and neighbor usage reflect at least in part learning rather than only noncognitive peer effects.

this estimation approach assumes that mobility across districts is low, as is consistent with migration data in India. The results indicated that cultivating households did significantly increase school enrollment rates in high technical change areas, net of school presence and wealth effects. However, landless households did not.

The differential response to technical change from cultivators and noncultivators in schooling investment is consistent with the learning-based idea that decisionmakers—farm owners in this context—benefit from augmented schooling in a setting of high technical change. Manual workers do not face the task of applying the new technologies and thus reap no benefit from additional schooling. In this setting, where children from landless households are unlikely to become cultivators, the relevant returns to schooling for noncultivators are thus unaffected by agricultural technical progress. Occupational immobility could then explain this result. Agricultural technical change did increase the wages of the landless, and thus the incomes in landless households, so that there was an increase in school attendance rates for both landless and cultivating households over the period. However, rural landless households remained poorer than landed households, and so the inability to finance human capital investment could still be part of the explanation for the differential schooling response.

In Munshi and Rosenzweig (2006), my coauthor and I studied the schooling investment responses to the substantial changes in the returns to English schooling that occurred in Mumbai in the last two decades of the twentieth century. Our study helps to distinguish between mobility barriers and family resources as constraints on schooling investments when the returns to those investments increase. In the period of our study (1982–2002), there was a substantial shift in demand toward white-collar occupations and industries, brought about by policy reforms opening India's economy to trade and international finance. Post-reform earnings of those workers who had attended an English-medium school rose substantially compared with those who had gone to local-language schools: specifically, for given years of schooling, among men, the earnings differential between English-medium and local-language school alumni rose from 17 to 27 percent at the end of the period; for women, the rise was from 3 to 27 percent.[8]

In Munshi and Rosenzweig (2006), we then looked at the enrollments rates over the 20-year period in the two types of schools stratified by low-, medium-, and high-caste families, which closely correspond to the rankings of parental incomes and schooling attainment. In the decade prior to the reforms, upper-caste children predominantly attended the private, and more-expensive, English-medium schools, with the rest concentrated in public, local-language schools. The high- versus lower-caste enrollment gap was 35 percentage points for boys and 25 percentage points for girls. However, in the second decade, corresponding to the period in which returns to English rose, there was a massive shift of all groups to

[8] The earnings differential by years of schooling remained constant over the entire period, at about 10 percent per year of schooling for both men and women.

English-medium schools, and rates of enrollment between high- and low-caste girls in the English-medium schools diminished to less than 10 percentage points. That is, the response to the new returns to schooling type was even greater among the poorer, less-educated households. The findings for girls seem to suggest that credit and human capital constraints were not insurmountable barriers to schooling investments when payoffs to schooling increased.

However, enrollment rates by school type across caste groups did not converge for boys, and at the end of the second decade there was still a 20–25 percentage point gap in rates of enrollment in the two types of schools. Because boys and girls come from the same households, the lack of convergence for boys cannot be explained by credit constraints or household human capital. In Munshi and Rosenzweig (2006), we examine the hypothesis that network externalities associated with sub-caste networks that dominated the blue-collar jobs held by low- and medium-caste men (but not women) make it welfare-enhancing for the caste networks under some condition to restrict male occupational mobility, at least for lower levels of return differentials across white- and blue-collar occupations.

In both the rural and urban Indian studies, parents were evidently aware of the changes in the returns to schooling. Jensen (forthcoming) carried out a survey to assess how well students in the Dominican Republic were aware of the *level of* income differentials by schooling, and an experiment to assess the responsiveness of schooling choices to changes in perceptions about the returns. Jensen first obtained econometric estimates of earnings differentials for primary and secondary school graduates by estimating the Mincer wage specification using data from a survey of prime-age workers (excluding the approximately one-third of workers residing in rural areas to minimize the problem of accounting for the sources of earnings among the self-employed). He then carried out a survey of students in urban primary schools to discover the students' own estimates of earnings by schooling level. The students' perceptions of schooling returns were generally lower than those implied by the Mincer regressions.

It is not clear whether the discrepancy between perceptions and the estimates can be generalized to conclude that underestimation of returns is a factor contributing to low schooling investment in low-income countries, as it is not clear whose estimates are more accurate and relevant. The regression-based estimates are subject to the usual ability-bias issues, and in addition, the regression sample includes selective rural-to-urban migrants (not representative of the urban-born children) but excludes a not insignificant number of urban-born citizens who out-migrated from the Dominican Republic and tend to be better-educated than the population as a whole.[9] The important contribution of this study, however, does not rest on the correctness of the schooling return estimates, but rather on the findings from the experiment carried out.

[9] In 2000, over 20 percent of secondary school graduates born in the Dominican Republic resided in OECD countries (Docquier and Marfouk, 2005).

Jensen (forthcoming) selected a random subset of the students to be provided the results from the econometric-based estimates. Since in most cases these returns were higher than the returns initially believed by the students, the question was whether this new information would affect schooling decisions. Jensen found that the new information, whatever its veracity, did increase perceived returns to schooling in the treatment group and, for students from families of above-median incomes, actual schooling attainment did significantly increase in the treatment relative to the control group. However, students from the poorer households were not responsive to the change in perceived returns, consistent with the hypothesis that credit-constraints or pre-school human capital deficits are barriers to schooling investments in some, but not all, households in low-income countries.

Conclusion

Of all fields of economics, micro-development is probably characterized by the most variety in the approaches taken, data sets used, and settings studied. This heterogeneity reflects the fact that not all issues can be investigated with one approach, given limitations of time, methodology, and available data. But the eclecticism of micro-development can also contribute to the credibility of findings. As we have seen, a variety of empirical approaches, based on many different kinds of data—including long-term, general-purpose, household panel data sets; focused data sets associated with experiments; and matched cross-sectional administrative data—have produced important and common insights into the role of schooling in development, highlighted in prominent macro models of growth. In particular, these studies have provided improved estimates of the contributions of schooling to earnings that go beyond simple wage regressions; revealed the importance of both own and social learning in technology adoption that is enhanced by schooling; provided insights into where and when schooling will be particularly productive; and showed that schooling investments increase when schooling returns rise or are perceived to rise.

It is not a mystery why the field of micro-development has produced such interesting and important research. Low-income countries often experience bold changes in policies, thus providing sources of variation that can yield interesting insights even in the absence of randomized evaluations. Many low-income countries have also experienced rapid rates of technical change that emanate from forces outside their borders, another source of variation that can contribute to understanding. Finally, the relative cost of collecting data can be especially low in low-income countries, so new field experiments can be carried out that directly test specific hypotheses or general-purpose panel surveys put in place, permitting the study of the long-term consequences of policy or technological change. The corresponding opportunities for further enhancing fundamental knowledge about the process of development are wide and varied.

References

Bandiera, Oriana, and Imran Rasul. 2006. "Social Networks and Technology Adoption in Northern Mozambique." *Economic Journal,* 116(514): 869–902.

Bartik, Alex. 2008. "New International Data on Schools." Yale University Senior Thesis.

Behrman, Jere R., and Nancy Birdsall. 1982. "The Quality of Schooling: Quantity Alone is Misleading." *American Economic Review,* 73(5): 928–46.

Behrman, Jere R., Andrew D. Foster, Mark R. Rosenzweig, and Prem Vashishtha. 1999. "Women's Schooling, Home Teaching, and Economic Growth." *Journal of Political Economy,* 107(4): 682–715.

Besley, Timothy, and Anne Case. 1993. "Modeling Technology Adoption in Developing Countries." *American Economic Review,* 83(2): 396–402.

Bils, Mark, and Peter J. Klenow. 2001. "Does Schooling Cause Growth." *American Economic Review,* 90(5): 1160–83.

Caselli, Francesco, and Wilbur John Coleman II. 2001. "Cross-Country Technology Diffusion: The Case of Computers." *American Economic Review,* 91(2): 328–35.

Conley, Timothy, and Christopher Udry. 2010. "Learning about a New Technology: Pineapple in Ghana." *American Economic Review,* 100(1): 35–69.

Docquier, Frédéric, and Abdeslam Marfouk. 2005. "International Migration by Educational Attainment (1990–2000) – Release 1.1." http://team.univ-paris1.fr/teamperso/DEA/Cursus/M2R/DocM2Rouverturecroissance/DM_ozdenschiff.pdf.

Duflo, Esther. 2001. "Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment." *American Economic Review,* 91(4): 795–813.

Duflo Esther, Michael Kremer, and Jonathan Robinson. 2008. "How High Are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya." *American Economic Review,* 98(2): 482–88.

Dupas, Pascaline. 2009. "Short-Run Subsidies and Long-Run Adoption of New Health Products: Evidence from a Field Experiment." Unpublished paper, August, UCLA.

Foster, Andrew D., and Mark R. Rosenzweig. 1995. "Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture." *Journal of Political Economy,* 103(6): 1176–1209.

Foster, Andrew D., and Mark R. Rosenzweig. 1996. "Technical Change and Human-Capital Returns and Investments: Evidence from the Green Revolution." *American Economic Review,* 86(4): 931–53.

Galor, Oded, and David Weil. 2000. "Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond." *American Economic Review,* 90(4): 806–828.

Jasso, Guillermina, and Mark Rosenzweig. 2009. "Selection Criteria and the Skill Composition of Immigrants: A Comparative Analysis of Australian and US Employment Immigration." Chap. 9 in *Skilled Immigration Today: Prospects, Problems, and Policies,* ed. Bhagwati, Jagdish and Gordon Hanson. Oxford University Press.

Jensen, Rob. Forthcoming. "The (Perceived) Returns to Education and the Demand for Schooling." *Quarterly Journal of Economics,* 125(2).

Kremer, Michael, and Alaka Holla. 2009. "Improving Education in the Developing World: What Have We Learned from Randomized Evaluations?" *Annual Review of Economics,* vol. 1, pp. 513–45.

Lucas, Robert E., Jr. 1988. "On the Mechanics of Economic Development." *Journal of Monetary Economics,* 22(1): 3–42.

Lucas, Robert E., Jr. 2002. *Lectures on Economic Growth.* Cambridge: Harvard University Press.

Manski, Charles. 1993. "Identification of Endogenous Social Effects: The Reflection Problem." *Review of Economic Studies,* 60(3): 531–42.

Mincer, Jacob. 1958. "Investment in Human Capital and Personal Income Distribution." *Journal of Political Economy,* 66(4): 281–302.

Munshi, Kaivan. 2004. "Social Learning in a Heterogeneous Population: Technology Diffusion in the Indian Green Revolution." *Journal of Development Economics,* 73(1): 185–215.

Munshi, Kaivan, and Mark R. Rosenzweig. 2006. "Traditional Institutions Meet the Modern World: Caste, Gender, and Schooling Choice in a Globalizing Economy." *American Economic Review,* 96(4): 1225–52.

Nelson, Richard R., and Edmund S. Phelps. 1966. "Investment in Humans, Technological Diffusion and Economics Growth." *American Economic Review,* 61(2): 69–75.

Oster, Emily, and Rebecca Thornton. 2009. "Determinants of Technology Adoption: Private Value and Peer Effects in Menstrual Cup Take-Up." NBER Working Paper No. 14828.

Psacharopoulos, George. 1994. "Returns to

Investment in Education: A Global Update." *World Development,* 22(9): 1325–43.

Rosenzweig, Mark R. 1995. "Why are there Returns to Schooling?" *American Economic Review,* 85(2): 153–58.

Rosenzweig, Mark R. 2007. "Global Wage Differences and International Student Flows." In *Brookings Trade Forum 2006: Global Labor Markets?* ed. Susan M. Collins and Carol Graham, 57–86. Brookings Institution Press.

Rosenzweig, Mark R. 2008. "Higher Education and International Migration in Asia: Brain Circulation." In *Higher Education and Development: Annual World Bank Conference on Development Economics, Regional*, ed. Justin Yifu Lin and Boris Pleskovic, 59–84. Washington, DC: World Bank.

Rosenzweig, Mark R. Forthcoming. "Global Wage Inequality and the International Flow of Migrants." In *Equity in a Globalizing World*, ed. Kanbur, Ravi and A. Michael Spence. New York: Routledge.

Suri, Tavneet. 2009. "Selection and Comparative Advantage in Technology Adoption." NBER Working Paper No. 15346.