HANDBOOKS IN ECONOMICS

Eric A. Hanushek
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Economics of Education

VOLUME 3

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HANDBOOK OF THE ECONOMICS OF EDUCATION

VOLUME 3

Edited by

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INTRODUCTION TO THE SERIES

The aim of the *Handbooks in Economics* series is to produce Handbooks for various branches of economics, each of which is a definitive source, reference, and teaching supplement for use by professional researchers and advanced graduate students. Each Handbook provides self-contained surveys of the current state of a branch of economics in the form of chapters prepared by leading specialists on various aspects of this branch of economics. These surveys summarize not only received results but also newer developments, from recent journal articles and discussion papers. Some original material is also included, but the main goal is to provide comprehensive and accessible surveys.

The Handbooks are intended to provide not only useful reference volumes for professional collections but also possible supplementary readings for advanced courses for graduate students in economics.

KENNETH J. ARROW and **MICHAEL D. INTRILIGATOR**

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INTRODUCTION

The economics of education has flourished as a research field since the publication of Volumes I and II of this Handbook. There has been a big upsurge in new (predominantly, though not exclusively, empirical) research by economists on education and education policy. This economic research continues to be extremely practical, with an explicit aim to better understand how education is acquired, how it affects economic and social outcomes of interest, and how it can inform public policy. The chapters in this new volume (Volume III), and in the companion Volume IV that is already in preparation, focus upon this new research, and its grounding with past economics of education research.

There are several reasons for the explosion of research in this area. One is the very significant improvement in data availability and quality. There are now more and better data to address core questions in the economics of education. These include international data on test scores, high quality administrative data, and rich register data in the Scandinavian countries. A second, related, reason for the upsurge of work, including publishing in the top journals of the economics profession, is the expansion of research separately accumulating in many countries around the world. The coverage of the new volumes—in terms of choice of topics, authorship, and editorship—is meant to reflect this globalization of research in the economics of education. A third aspect, focused on in detail in a number of the chapters in this volume, is the use of new methodological approaches that overlap with significant developments that have been made in other areas of economics. Finally, there has been a heightened policy relevance attached to economics of education research. Many governments want more evidence-based policy, and this has been particularly true in terms of education.

All of these have resulted in the economics of education being a thriving and burgeoning specialist field within economics. The topics covered by the chapters of the current volume step into some of the most obvious gaps that have become evident with the newly emerging research. While there are antecedents to the work in each of the chapters, recent research has taken the ideas into new and productive areas. The first two chapters cover developments in the econometric methods used and the emerging work with the international test score data. The next two chapters deal with family background and peers as much-researched determinants of educational outcomes beyond the traditional school resource inputs. Next are two chapters addressing specific topics related to the teaching profession: salary setting and licensure. Three chapters address separate institutional features of the school system: educational tracking, school accountability, and the GED as a credential for school dropouts. The final

two chapters relate to valuation of school quality on the housing market and to apprenticeship as a specific combination of formal education with work-based training that is widely used in several countries, respectively.

We are grateful to all authors contributing to the new volume, as we appreciate (from own experience) how much of a task it is to produce a handbook chapter that both covers the existing literature and provides ideas that lead into the future. Their expertise, enthusiasm, and hard work are highly appreciated. We also gratefully acknowledge the professional support in the *Handbooks in Economics* series, especially by the general editors Kenneth Arrow and Michael Intriligator and by Scott Bentley, Kathleen Paoni, Stacey Walker, and others at Elsevier. We also thank CESifo, which provided financial support and facilities to hold the inaugural meeting of the CESifo research network's Economics of Education area in Munich in September 2009 where initial drafts of the chapters of Volumes III and IV were presented and discussed.

Education is widely recognized as an important determinant of a wide range of economic and social outcomes. Through use of rich data and study of issues of high contemporary policy relevance, study of the economics of education is one of the primary areas of research attraction across the economics profession, appealing to new Ph.D. students and experienced researchers alike. The significant bodies of research studied in this volume suggest that it is highly likely that Volume IV will not be the last in this series, as study of education acquisition and its economic and social impact will undoubtedly remain a fertile research ground for the foreseeable future.

Eric Hanushek
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CHAPTER 1

Econometric Methods for Research in Education☆

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Abstract

This paper reviews some of the econometric methods that have been used in the economics of education. The focus is on understanding how the assumptions made to justify and implement such methods relate to the underlying economic model and the interpretation of the results. We start by considering the estimation of the returns to education both within the context of a dynamic discrete choice model inspired by Willis and Rosen (1979) and in the context of the Mincer model. We discuss the relationship between the econometric assumptions and economic behavior. We then discuss methods that have been used in the context of assessing the impact of education quality, the teacher contribution to pupils' achievement, and the effect of school quality on housing prices. In the process we also provide a summary of some of the main results in this literature.

1. INTRODUCTION

The rising return to schooling and growing evidence in support of education as a primary determinant of economic growth has elevated the importance and visibility of research on human capital formation including both the determinants of enrollment and attainment and the determinants of education quality. Such research must address complications introduced by the myriad and inter-related decision-making processes of families, teachers, administrators, and policy makers. A variety of methods have been used to identify causal relationships, ranging from structural models based on utility maximization to experimental and quasi-experimental approaches, yielding a growing body of often contradictory evidence.

Although the various approaches differ in the degree to which theoretical models of decision-making underlay the empirical specifications, the simple dichotomy between structural approaches on the one hand and experimental or quasi-experimental on the other does not hold up in most applications. As we highlight throughout the chapter, the interpretation, the usefulness, and even the identification of estimates typically relies implicitly if not explicitly on a set of assumptions about underlying behavior. Importantly, the introduction of heterogeneity in treatment effects magnifies the importance of such assumptions.

Rather than dividing this chapter by methods, we divide it into two parts largely in parallel to the division of research on human capital formation into quantity (years of schooling) and quality. The first part Section 2 focuses on the estimation of wage equations and the return to schooling, framed by a Roy model of education decision-making, originally suggested by

Willis and Rosen (1979), that incorporates heterogeneity in returns to schooling across both individuals and three levels of schooling and allows for comparative advantage in the sense that individuals need not be best at both education and the labor market. This model not only provides a flexible description of the process through which human capital is acquired through schooling, but it also provides a framework for discussing the identification issues that arise when estimating education effects on wages with empirical methods not based directly on models that articulate the full structure of the process of human capital acquisition.

We then turn to the various methods used to estimate education effects on wages, highlighting the restrictions that must be fulfilled in order to generate consistent estimates of the return to schooling. The natural starting point is the estimation of the full structural model. We describe its estimation based both on maximum likelihood and on newly developed simulation methods.

Next we describe methods that can be used to estimate Mincer wage equations in which education is taken to be a continuous variable. First, we discuss approaches to identification under the assumption that the return to schooling is constant both with respect to the years of education and across individuals. We then permit the wage return to schooling to vary with the level of education and discuss the use of nonparametric IV estimators when the shape of the relationship between wages and years of education is not known. Next we allow for heterogeneity across individuals and consider general nonseparable models with respect to years of education and unobserved heterogeneity. This takes us to the frontier of research as far as this class of models is concerned. Importantly, it becomes clear that identification and interpretation of results depends on the nature of schooling choice. Indeed the implied restrictions on economic behavior, required for identification, are quite stringent and can be interpreted as restrictions on the information possessed by the individual when making education choices.

Following discussion of the Mincer wage equation we return to the Roy model with potentially unordered schooling choices and discuss approaches to identification of the effects of education on wages. There we discuss conditions that allow identification "at infinity", an argument that depends on the availability of enough continuous instruments such that there are sets of values of these instruments where the, individuals facing such values make a choice of a particular education level with probability one. In such sets there is no selection. If the instruments are independent of the unobservables in the wage equation and under some further conditions, identification is achieved. However, it is unlikely that such an identification strategy has much empirical significance. At this point we either need to acknowledge the need for further parametric assumptions, beyond those implied from theory and beyond the standard IV assumptions, or we need to resort to set identification. In this case we focus on bounding

the distribution of wages for each education group, rather than attempting to obtain point estimates. The various assumptions used in the point identification approach, such as instrument exclusion, can be used here; some can even be relaxed to allow for instruments to shift the distribution of wages in one direction (monotonicity).[1] The approach can be very fruitful, because it provides an intermediate position where a number of theoretical restrictions are used, making the estimates interpretable within a broad theoretical framework, while not using auxiliary assumptions that are both controversial and do not follow from theory.

Section 3 discusses the problem introduced by missing wages for labor force nonparticipants. We compare a fully structural approach that in practice will have to rely on assumptions beyond those implied by theory and an approach based on bounds.[2] Allowing for both endogenous education choice and endogenous labor force participation does make identification more stringent. At the same time bounds are also less informative. Of course ignoring these issues poses serious problems with interpretation. Identification will have to rely on exploiting the restrictions from theory as well as further assumptions, such as those specifying the distribution of unobservables. Despite the shortcomings of having to make assumptions that do not relate directly to theory, the approach that ignores these issues leads to results that have limited interpretation. Moreover, although most identification theorems proposed hitherto rely on identification at infinity arguments, it is possible that further progress can be made by exploiting further restrictions from theory; one possibility is to explore the use of restrictions from other related decisions. The potential for this can be seen when comparing the identification of pure discrete choice models with those that combine discrete choice with continuous outcome variables, such as the education and wages model we discuss.[3] Moreover when considering bounds, it is clear that identification can be obtained without an "identification at infinity" argument. Characterizing the underlying behavioral conditions for this would be an important advance.

Section 3.3 justifies the idea of a Roy model of education and wages by suggesting that each education level may correspond to a different input in production, these inputs not being perfectly substitutable for each other. We argued that in an economy with a changing supply of educated workers of differing levels, the relative wages and the returns to education will change over time. We also refer to evidence that demonstrates the importance of such considerations. In view of this, we close this section by discussing the implications for policy of placing education choice and wages within a general equilibrium framework. A number of authors have shown that without such

[1] See Manski (1994).

[2] See Blundell, Gosling, Ichimura, and Meghir (2007).

[3] Contrast Magnac, Thierry, and Thesmar (2002) with Heckman and Navarro (2007) for example.

a framework it is very difficult to design and think of policy.[4] This again emphasizes the need for a model not only for the interpretation of the estimates but also for understanding what the estimates imply for policy.

Section 5 turns to empirical methods used in research on school and teacher quality. Although it begins with the presentation of an education production function model and discussion of the multiple levels of choices that determine the matching of students, teachers, and schools, this model does not provide the unifying framework of the Roy model, discussed in the previous sections. Given the range of issues covered in research on education quality, we believe it to be more productive to focus on conceptual frameworks tailored to specific issues. We do, however, begin this section with general discussions of housing choice and the dynamics of the process of knowledge acquisition.

In Section 5 we look at the different research areas that have received substantial attention in recent years, and within each we juxtapose various empirical and estimation methods. Specifically, we focus on a small number of papers on class size, teacher quality, capitalization of school quality into house prices, and competition, choice, and accountability. The proliferation of administrative and survey data in recent years has facilitated research on these and other education topics, and we have selected papers that vary by both type of data and empirical method. The methods include controls for observables, instrumental variables, regression discontinuity as a special case of IV, use of random lotteries as a special case of IV, difference-in-differences, fixed effects with large administrative data sets, and the use of data generated by experiments.

As in earlier sections we highlight the inter-relationship among the structure of underlying choices, treatment effects, identification conditions, and meaning of the estimates. Estimators differ according to the assumptions required for identification and assumptions concerning the distribution of treatment effects along various dimensions, though most of these estimators do not come from behavioral models that predict the structure of treatment effects. Nonetheless, we focus on the inter-dependencies among underlying behavior, identification conditions, and interpretation throughout this discussion.

In the case of research on class size, we first present a model of education production based on Lazear (2001) that highlights potential dimensions over which the benefits of smaller classes might vary and then evaluate a series of different estimators with that framework as a backdrop. In addition to describing the methods and identifying assumptions, this compares estimators according to the degree to which they capture class-size–related general equilibrium effects on the quality of instruction; some estimators capture cross-sectional differences in teacher quality associated with smaller classes, some capture changes over time in state average teacher quality, while others isolate the *ceteris paribus* effect of smaller classes.

[4] See Heckman, Lochner, and Taber (1998), Lee (2005), Lee and Wolpin (2006), and Gallipoli, Meghir, and Violante (2008).