

# JACOB MINCER

**A Pioneer of Modern Labor Economics**

Edited by

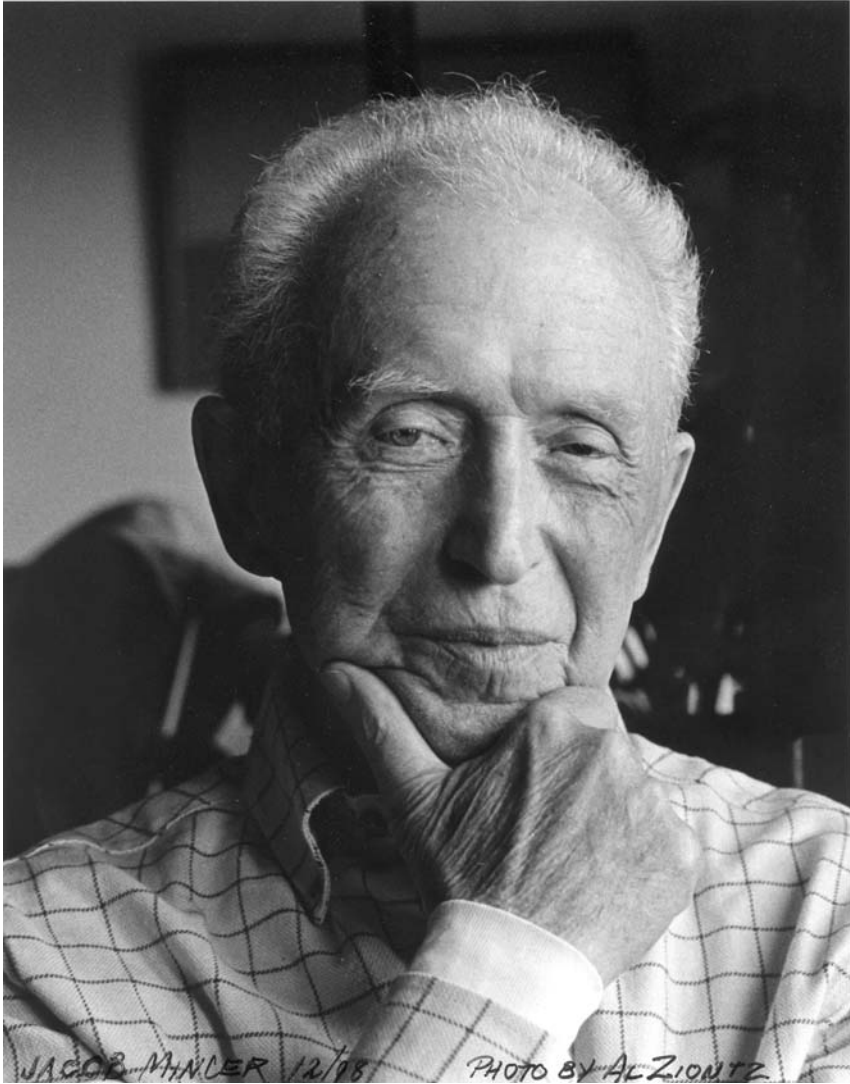
**Shoshana Grossbard**

 Springer

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**Jacob Mincer 12/98**

**Credit: Photo by Alvin Ziontz**

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## PREFACE

BY SHOSHANA GROSSBARD

In 2004, the Society of Labor Economists announced its first Award for Lifetime Achievement in Labor Economics. Jacob Mincer and Gary Becker were the co-recipients. The award was then renamed the Jacob Mincer Award. Two years earlier, Mincer was the first to win the IZA Award in Labor Economics. These awards recognize Mincer's primary role in shaping labor economics, but they only hint at the breadth of his reputation and accomplishments: he is a member of the National Academy of Sciences, and has been appointed a Fellow of the American Statistical Association and the Econometric Society, as well as a distinguished Fellow of the American Economic Association.

Mincer is one of the principal architects of Modern Labor Economics (MLE), a premier application of micro-economics in the spirit of Chicago's positive economics. There are typically three steps to such application: (1) a theoretical model is developed or borrowed, leading to testable implications; (2) empirical work is performed; and (3) the findings are analyzed in light of the theoretical analysis. All of Mincer's work has followed those steps, even when this was a rare occurrence. When he started, in the mid 1950s, labor economics was a sub-field of institutional economics. Labor economics is now a major field of economics. As a result of his work and that of other pioneers, MLE became an example for other applications of economic models.

As noted, Mincer shared the first prize named after him with Gary Becker, another major pioneer of MLE and recipient of the 1992 Nobel Prize in economics. Even though they did not write joint papers, together Mincer and Becker created the labor workshop that became MLE's incubator at Columbia University, from 1959 to 1969.



It was also at Columbia that colleagues—including many of Mincer’s students—gathered on July 15<sup>th</sup>, 2002, to honor him and to celebrate his 80<sup>th</sup> birthday. This book gathers reflections and tributes by Becker, James Heckman, and students who participated in Columbia’s labor workshop during those ‘Golden Sixties.’

Mincer’s contributions to labor economics predate the labor workshop. He completed his Ph.D dissertation at Columbia in 1957, under the guidance of George Stigler, one of the three economists who were his principal sources of inspiration.<sup>1</sup> By 1959, the year that Becker recommended his appointment at Columbia, Mincer had already published a major article on human capital.

Another economist who inspired Mincer’s MLE is H. Gregg-Lewis.<sup>2</sup> In Mincer’s words, reacting to some of us calling him a father of MLE: ‘If I am a father of labor economics, H. Gregg-Lewis is surely the grandfather.’ (Chapter 3). Mincer’s relationship with Gregg-Lewis had developed during Mincer’s post-doctoral fellowship at Chicago in the years 1957–58.<sup>3</sup> Mincer also recognizes a major intellectual debt to Milton Friedman. He was particularly inspired by Friedman’s book (with Simon Kuznets) on income earned by professionals and his research on consumption functions. It is mostly from Friedman that he first learned Chicago-style positive economics.

Mincer and Becker worked as a team. After Becker left for the University of Chicago in 1969, and Mincer turned down an offer to teach at Chicago, their unique collaboration came to its end. Mincer continued to lead Columbia’s labor workshop for many more years. In 1979, Columbia University appointed him Bottenwieser Professor of Economics and Human Relations. He retired in 1991.

This Festschrift honors not only Mincer. It also honors the labor workshop at Columbia during the 1960s, a workshop I wished I had attended. My fascination with that workshop started when I became a student of Becker’s at Chicago in 1973, soon after he had left Columbia. Mincer and many of his and Becker’s former students at Columbia participated in Becker’s workshop at Chicago in the 1970s. I detected something very special about Mincer and all those who had been part of Columbia’s labor workshop in the 1960s.

Thirty years later, the conference that led to this volume made clear to all participants, regardless of their own experience, that Mincer, Becker, and the labor workshop at Columbia in the sixties were extraordinary. The display of affection that flowed at Jacob’s 80<sup>th</sup> birthday conference was overwhelming, particularly from workshop participants in the ‘Golden Sixties.’ Most students from the ‘Golden Sixties’ were there, including Jean Claude Koene from Belgium, Reuben Gronau, Ruth Klinov and Jacob Parush from Israel, and Masatoshi Kuratani from Japan. Many of Mincer’s later students came as well.

#### **MINCER AND COLUMBIA’S LABOR WORKSHOP IN THE 1960s**

Chapters 1 through 7 of this volume contain essays that explore the nature of Mincer’s and Becker’s labor workshop. In addition to essays by each of them, this part includes chapters by James Heckman, the 2000 Nobel Prize laureate, and Solomon Polachek, who studied with Mincer and Becker in the 1960s. These essays, and an

interview with Mincer by Pedro Teixeira, provide a clear sense of the circumstances that gave birth to Modern Labor Economics. Most of these materials are original to this book.

Chapter 4, contributed by Gary Becker, offers a unique and personal perspective on the cooperation between two outstanding minds. The chapter is based on comments, originally presented at the 2002 Conference at Colombia and previously unpublished. Becker's reminiscences moved the audience to tears. Becker describes this period as possibly the most exciting and fruitful in his life. Numerous elements seem to have contributed to the highly productive Mincer-Becker collaboration.

First, the two men shared intellectual interests. A number of subjects—including the economics of human capital, time allocation, and household economics—were at the center of each man's research. Mincer and Becker had very few disagreements, maybe none on fundamental issues. In particular, they both were strong believers in the need to blend theory and empirical work, and in that sense they each identified with the methodology of Milton Friedman's positive economics. Mincer learned from Friedman mostly by reading his work; Becker was Friedman's student.

Second, the two men had a very strong personal friendship that continues to this day.

Third, these two researchers are highly original thinkers (they were engaged in research that was not done anywhere else at the time).

Fourth, their perfectionism led to well trained students and high quality research (see Chapter 5).

Fifth, their complementarity led to fermentation and cross-fertilization: Mincer empirical, Becker theoretical; Mincer self-contained, Becker outspoken (see Chapter 4).

Sixth, a dedication to their students, whose presentations were the primary focus of the workshop, a dedication apparent throughout this book. In their own chapters, Mincer and Becker credit the outstanding students who attended their workshop during that time. However, from Sol Polachek's chapter it appears that the quality of the students was not exogenous. Outstanding students joined the labor workshop thanks primarily to the qualities of Mincer and Becker as leaders of the workshop. More information on the students attending the workshop can be found in Chapter 7.

#### **TECHNOLOGY, HUMAN CAPITAL, AND THE NEW HOME ECONOMICS**

One book can't possibly offer a comprehensive tribute to an economist as influential as Jacob Mincer. The topics that are included here are among the closest to Mincer's heart: technology, human capital, children, women's labor supply, the distribution of earnings, and health.

Part III consists of Mincer's latest economics paper, which deals with technology and the labor market. Part IV offers new perspectives on Mincer's contributions to the topic of human capital. These perspectives are offered by two students of his in the 1960s, Barry Chiswick and Solomon Polachek, and by a younger economist, Thomas Lemieux, who focusses on Jacob Mincer's most famous contribution to this area of research: the Mincer equation. That equation also plays a central role in

Chapters 8 and 9 by Chiswick and Polachek. Chiswick also discusses the distribution of earnings, and Polachek also deals with Mincer's concept of 'overtaking point.'

Finally, Part V addresses Jacob Mincer's contributions to the New Home Economics. Each of the chapters was written by one of Mincer's students from the 1960s: Reuben Gronau (on labor supply), Michael Grossman (on the household production of health), and Arleen Leibowitz (on household production and children). Excepting Lemieux's article, all chapters in Parts IV and V were presented at the 2002 Conference at Columbia. Chapters 8, 10, 12 and 13 were previously published in a special issue of the *Review of Economics of the Household* (REHO). Chapters 9 and 14 are adaptations of articles in REHO.

#### NOTES

1. Telephone conversation with Jacob Mincer, May 30, 2005.
2. Becker has also publicly recognized his intellectual debt to H. Gregg-Lewis.
3. Mincer has more ties to Chicago: he was a visiting professor there in the mid 1970s and holds an honorary Doctorate of Law from the University of Chicago.

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## ACKNOWLEDGMENTS

Preparing this volume has been an outstanding experience. It has given me numerous opportunities to get to know Jacob better. The more I know him, the more impressed I become with his extraordinary combination of talent and modesty, and the more honored and thankful I feel for having had the opportunity to organize this book. It was a pleasure consulting with him about every aspect of this work's preparation. In the process, a great friendship with Jacob and Flora, his wife, has ensued. I thank Jacob for his patience when answering my numerous questions and I thank both of them for all their assistance with this book, including helping me get the bibliography and Jacob's picture.

I thank everyone else who participated in this volume as well. I am very grateful to my Chicago professors, Gary Becker and Jim Heckman, for trusting me with their articles. Jim Heckman also facilitated this book's editing process. It has also been gratifying to learn from the students who participated in the labor workshop at Columbia and to get to know them better. The former students who contributed to this volume join me in thanking Jacob Mincer for the intellectual gifts he bestowed upon us.

Thanks also go to Marilea Fried of Springer for her support for this book, Jim Heckman for asking me to help him organize the conference that inspired this book, Nachum Sicherman for helping organize the conference, Barry Chiswick, Reuben Gronau, and Arleen Leibowitz for helpful comments on the preface, and Jennifer Boobar and Howard Yourow for their editing contribution throughout. I also thank Kristin Ruscetta and her staff for getting the manuscript into book form.

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**PART I. JACOB MINCER IN PERSPECTIVE**

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## 1. SOME BRIEF REMARKS ON THE LIFE AND WORK OF JACOB MINCER

BY JAMES J. HECKMAN

In July 2002 a group of colleagues and students of Jacob Mincer gathered on the occasion of his 80<sup>th</sup> birthday to celebrate his accomplishments. This occasion offered an opportunity to reflect on the achievements of Jacob Mincer and the legendary Labor Workshop at Columbia which he helped found and which he conducted with Gary Becker and alone for many years.

In order to place the contributions of Mincer and the Labor Workshop in perspective, it is helpful to look back briefly to the state of labor economics in the early 1950s. At that time, most economists viewed the study of the labor market as the province of labor relations experts, institutionalists and sociologists. The dominant Keynesian paradigm in macroeconomics ignored labor supply, incentives and skill formation entirely and focused on problems of demand management. With the exception of H. Gregg Lewis at Chicago, and Melvin Reder at Stanford, the labor economists of the day did not know or apply price theory to the study of the labor market. Bodies of “facts” were accumulated which were difficult to interpret within any coherent intellectual framework.

In the mid 1950s, this began to change. Gary Becker’s work on discrimination and wage differentials, H. Gregg Lewis’s work on unionism and the time series of labor supply, Melvin Reder’s work on the occupational wage structure and Jacob Mincer’s work on human capital-induced wage differentials were the first major efforts to apply basic price theory to understand aspects of the labor market.

Building on this work, labor economics was transformed into analytical labor economics in the period 1955–1975 largely through the efforts of Gary Becker, Jacob Mincer and the participants and affiliates in the Columbia Labor Workshop, many of

whom gathered to honor Mincer's birthday. An entirely new field of household economics was created by the early efforts to understand female labor supply and fertility that were centerpieces of workshop discussion. A theory of earnings determination and wage inequality emerged.

This enterprise was enriched by, and stimulated, the production of microdata that were becoming available to the economics profession on a wide scale in the 1960's. The challenge of using the new theory and the new data helped spawn the modern field of microeconometrics. The Columbia workshop attracted and produced some of the best minds in the profession who responded to the intellectual challenges and opportunities created by its pioneering research.

Central to the success of this entire enterprise was Jacob Mincer. Mincer emphasized the importance of using economics to understand data from households and the labor market. He used clearly formulated economic principles to explain the "facts," and he thought broadly and deeply. His relentless application of theory to evidence and his careful attention to the evidence makes his work both distinctive and influential.

Mincer's contributions fall into two main bodies of work. Mincer was a leading member of a group of economists at Columbia University and the University of Chicago who systematically developed the empirical foundations of human capital. His 1958 *Journal of Political Economy* article (Mincer 1958) showed the power of the concept of equalizing differences in explaining earnings inequality due to educational differences among people. His 1962 *Journal of Political Economy* paper (Mincer 1962b) presented the first systematic empirical analysis of learning on the job as a determinant of life cycle wage growth. His magisterial *Schooling, Experience and Earnings* (1974) showed the power of the human capital investment concept in accounting for diverse patterns of earnings inequality and wage growth over the life cycle. He demonstrated the empirical importance of complementarity in skill formation – that skill begets skill- and that more educated people do more post-schooling investment in learning than less educated people. This research established the Mincer earnings function as a widely used and widely replicated cornerstone for interpreting earnings data in many fields of economics. His subsequent work on job turnover, on the measurement of firm specific training, on investment responses to technology change and in accounting for the recent rise in wage inequality within an economic framework, enriched the basic Mincer model and showed its analytical and empirical power.

Mincer also pioneered the study of female labor supply and the economics of the household. His seminal 1962 paper on the labor supply of married women (Mincer 1962a) showed that accounting for the influence of the price of time – the market wage – explains why female labor supply increased at the same time that the real wealth of society (and that of the women's husbands) was increasing. It reconciled apparently contradictory time series and cross section evidence. That work, and a subsequent 1963 paper (Mincer 1963), showed the importance of accounting for the household choices women face in explaining female labor supply and fertility. This research helped to foster the emergence of household economics as an independent field within the larger discipline of labor economics. Mincer's insights on labor

supply, human capital and fertility laid the foundations for understanding how economic development transforms the role of women and the family.

I conclude with a few personal notes. First, a personal note about Jacob Mincer himself. It is an amazing piece of good fortune that Jacob Mincer ever made his seminal contributions. Born into a Europe ravaged by war and persecution, Jacob Mincer survived captivity in the Holocaust only through chance. His memoirs reveal the incredible obstacles he overcame before he arrived in America in the late 1940's. He more than caught up for the time he lost in concentration camps by his extraordinarily productive stretch from age 35 to the publication of *Schooling, Experience and Earnings* (1974), at age 52.

Second, on a personal note of my own, I owe Jacob Mincer an enormous debt. As a graduate student in economics at Princeton, I was very discouraged by much of the economics that was taught there and was considering leaving the field. As a prospective development economist, I came to realize that the computation of shadow prices for project evaluation was a sterile and unproductive activity, and that the models of economic development I was reading had little contact with the real world.

My whole vision of economics changed when by chance I read Mincer's (1963) fundamental paper on female labor supply. It's concise, insightful analysis of the theory of female labor supply and its brilliant interplay of simple theory and econometrics excited me and led me to become a labor economist and work on many of the ideas and open problems that appear in that paper.

On a final personal note, my years as his junior colleague both at Columbia and the New York NBER expanded my horizons and educated me in labor economics, the economics of the household and in empirical economics. From him, and the first rate people who congregated around him as students and colleagues, I learned much. My interactions with him and his group shaped my lifetime research agenda.

We are all grateful to Jacob Mincer for illuminating the study of empirical economics.

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## 2. AN INTERVIEW WITH JACOB MINCER

BY PEDRO TEIXEIRA

This interview was held on July 16, 2002, in Professor Mincer's apartment in New York City.

### 2.1. EARLY YEARS AND THE CHOICE OF ECONOMICS

Q – Can we start by talking about your interest in studying economics?

A – Let me start at the beginning. My life was disrupted by the war in 1939, but in 1948 I was able to resume my studies, in the United States, thanks to a Hillel Foundation Scholarship. Before the war, my studies were in engineering, not because of any special interest, but because it was an applied field in mathematics. After the war, I did not go back to engineering because I decided that the social sciences held more promise for the future. To my mind, technology as a means of progress had failed; it contributed to the bloodbath of World War II. That was a simplistic idea, but it led me to look at the social sciences, which I found very interesting, a kind of 'entertainment', something one likes to read outside of work. The one field that mystified me, and therefore attracted me, was economics. It was appealing because its structure was analytical and because it used mathematics.

Soon after arriving at Emory University, in Atlanta, Georgia, I studied with Professor Ernst Swanson, who had earned his Ph.D. in economics from the University of Chicago. He advised me to do graduate work there as well. As a matter of fact – and this is interesting – he said, "At Chicago you will meet a young economist named Milton Friedman, who is not yet well known but soon will be. You should study with him. If you don't go to Chicago," Swanson continued "you should go to

Columbia, not because there are great teachers there, but because they are associated with the NBER (National Bureau of Economic Research), and that is the only place that does empirical work in economics.”

As it turned out, I followed both pieces of his advice. I went to Chicago to do graduate work (unfortunately, Friedman was on sabbatical). That year, I also met my future wife, and she had a job offer in New York. That is why I came to Columbia to finish my Ph.D.

Q – That was in the early 1950s?

A – That was academic year 1951-2. The first thing that I did was visit the NBER. At work there were some professors at Columbia. Others were full-time at the NBER. I was hired by a woman economist, Ruth Mack, who was sitting there on the floor smoking a pipe (laughter)... The floor was strewn with a bunch of graphs, and I asked her ‘what are you studying?’ and she told me she was studying business cycles. But all I saw were long lines with very small wiggles. Those were long-term trends. Anyway, she hired me. Once I was at the NBER, I met a number of other young people, among them Bill Greenwald who taught at City College and who made me an offer to teach there. That’s how my academic career started.

## 2.2. RECOLLECTIONS FROM COLUMBIA IN THE 1950s

Q – When you arrived at Columbia the Department of Economics was still largely influenced by institutionalism, wasn’t it?

A – That’s right. I tried various courses, and the ones that appealed to me most were the theory courses.

Q – Was there anyone who became a strong influence on you, a kind of mentor? You were very fond of George Stigler...

A – Of all the people at Columbia, some of whom were important figures in economics, George Stigler and Arthur Burns were my greatest teachers. Stigler had a tremendous sense of humor and I got closer to him when I was already writing the dissertation.

Q – But he did not sponsor your dissertation?

A – Right, in fact he was away the year I organized my thesis committee.

I did not take courses in labor economics. I once sat in a lecture course on labor economics for a week or two, and all I heard was history of labor unions. That was not sufficiently interesting to me.

Q – Who was teaching labor economics at that time at Columbia?

A – Leo Wolman. He was associated with labor union activities.

I decided on the topic of my dissertation: wage differentials. I didn’t think of that as labor but as price theory.

Q – You saw it as applied microeconomics?

A – Yes, that is what it is called today. I was looking at various comparisons: by occupation, education, industry, age, sex, all possible characteristics; and I calculated the wage as available in Census data. The thing that struck me after a while was that, no matter what kind of cut I took, education and age were the most important variables affecting wages. It occurred to me at that time that one should use one principle rather than hundreds of contrasts. That sent me back to Adam Smith. I then developed what was later called the schooling model, where I show the importance of education and post-education activities in the labor market.

Q – Another work that seems to have also influenced your work was Milton Friedman’s doctoral dissertation. However, in the years following its publication this work had not managed to stimulate many researchers to explore the link between education and personal income.

A – I was just about to mention that. The way I approached my topic was inspired by Friedman and Kuznets, after I went back to Adam Smith. Smith did not really have an explicit model, but Friedman and Kuznets had just come out with their book on professional income in which they calculated the capitalized value of an expected income flow conceived as earnings from capital, using implicit rates of return. At that time I asked myself ‘why can’t I apply this to the entire labor force?’. And that’s basically what I did.

Q – That’s interesting because at that time, the debates on personal income distribution tended to emphasize either sociological explanations or matters of luck, exogenous to individual choices. Both Friedman and Kuznets and your work tend to emphasize the capacity of an individual to improve his own condition.

A – Right.

Q – Moreover, reading your dissertation and your further work, it seems that you became increasingly convinced of the importance of education in this respect. From its status as a partial explanation, education had become the major theoretical explanation for the personal income distribution. How did this happen?

A – In my dissertation, schooling is something one can define and use data for. But, as I already mentioned, age seems to be important too. I had a vague idea that it was not age by itself that mattered, but activities. I later called it experience and distinguished it from age. The theory of what happens over time to an individual over his life cycle was something that came after the dissertation, because I felt that this aspect of earnings could not be due only to age.

Q – Or seniority?

A – Or seniority. So there is a need to generalize. It was not just about education, but about human capital. I did use human capital analysis in the dissertation, but I did not extend it sufficiently. At that time I was already very close to Gary Becker. He too

thought that age phenomena are not exogenous, that something happened in the meantime. People make job decisions after completion of formal schooling, people continue to increase their human capital by means of learning/training on the job. This is a major topic of the book that came out in 1974.

### 2.3. RECOLLECTIONS FROM CHICAGO

Q – After you have finished your dissertation, at a time when there were very few people working on human capital (basically you, T. W. Schultz at Chicago, and Gary Becker who had just started his project at the NBER), you go to Chicago with a post-doctoral fellowship. How did it happen?

A – Let me explain. Ted (T.W.) Schultz was focusing on economic growth, so he was looking at growth differentials over time, on an aggregate level, whereas I was interested in wage differences on a cross-section level, in the distribution of those differentials. My sponsor at Columbia was Harold Barger, and he knew that Schultz was interested in that subject, so he sent a draft of my dissertation, and almost by return mail I got an invitation for a post-doctoral fellowship at Chicago. I did not know anything about Ted Schultz at that time, and I was not focusing on economic growth, although I realized there was a similarity in analyzing the issue in one case across people and in another across time.

Q – A kind of complementarity?

A – Yes. But they were basically very different topics. When I got to Chicago I was advised to attend the Labor Workshop led by Gregg Lewis. Gregg Lewis told me that I was a labor economist, which sounded as an insult to me. (laughter)

Q – Because of your recollections from Columbia?

A – Well, in general Labor was a wilderness. It was well known that what people were talking about in labor economics was institutional, sociological, all things but economics. In fact, Samuelson at that time said that ‘labor economics is the last refuge of the scoundrel’...

Q – Friendly words...

A – It didn’t really exist. But Gregg Lewis at Chicago was a very fine economic analyst, and he was teaching a course in labor that was entirely different from the kind of things that I had encountered at that time. Once I sat in his course, I realized he could not be insulting me.

Q – And he was trying to apply price theory to labor issues, something very unusual at that time.

A – Exactly. I started writing the article based on my dissertation for the JPE (1958), which Gregg Lewis and Albert Rees helped me finish. When I sat on their courses, I found out that Gregg Lewis, as well as Albert Rees, were at that time very much interested in the labor force participation of women. A book by Clarence Long had

just come out. Clarence Long worked at least ten years on that book published by the NBER. The basic question was ‘why is it that while in cross-sections in families where husbands are doing well, wives don’t work; over time wages have been rising and instead of women dropping out of the labor force, their participation in the labor force increased?’. Neither Lewis nor Rees had an answer to that. They tried all kinds of approaches... but it occurred to me that a simple price-theoretical approach could do. I still don’t know why they didn’t think of that before me... At the end of the year I went over to Gregg Lewis and told him that I had an idea on how to approach the subject. He was very excited, and said ‘you’re invited to a conference!’ (He was organizing a conference on Labor Economics). That was the conference where the paper on labor force participation of women came out.

Q – That was the famous 1960 Conference of the NBER on Labor Economics?

A – Right. In fact Clarence Long was my discussant and he expressed great excitement at the solution of the problem, which had escaped him and many others.

#### 2.4. BACK TO COLUMBIA AND WORKING WITH GARY BECKER

Q – After that time in Chicago you came back to NY. Not to Columbia yet.

A – You’re right. I had first one more year at City College, and then to Columbia. Gary was already here, and his reputation preceded him (because of his dissertation on discrimination), in applying economic theory to unconventional subjects, which attracted me. Neither he nor I taught labor, in fact nobody did, but when I got an offer to come to Columbia we combined forces to organize a Labor Workshop. A lot of things developed in that Workshop.

Q – At that time you started teaching statistics.

A – I taught statistics for about six or seven years, but then I realized a) that I was more interested in labor economics, b) that statistics was ‘passé’, one needs econometrics. That was when they started hiring people in econometrics.

Q – Apparently you became more comfortable with the labor economist label.

A – Oh, yes.

Q – That inaugurates a very exciting and fruitful period at Columbia. What sort of recollections do you have from those times? Did you feel that you were contributing to something that important?

A – We knew that we were doing things that nobody else was doing. We had a mission that we pursued in the Workshop, in seminars, in conferences. There was never any doubt in our minds that we were really moving the subject forward. The two main angles had to do with two contributions, namely labor supply and human capital. These were the basic ideas that we then applied to a variety of topics.

Q – An important part of your work and of human capital research was developed at the NBER. Why do you think that the NBER became increasingly interested in Labor research at that time?

A – The presence of Gary Becker, and of myself, enabled the NBER to acquire a number of talented young economists who were interested in the same subjects.

Q – What are your recollections from those times at the NBER? How was the relationship with the rest of the researchers at the NBER, a very heterogeneous group of economists at that time?

A – Whether heterogeneous or not, the group at the Bureau was lively, sociable, and eager – both on the job and off – to discuss their work.

Q – At a certain point you were coordinating research projects in that area. How did it happen?

A – There was no formal coordination except for periodic seminars.

Q – At that time I gather there was a close interaction with Chicago, with people such as T. W. Schultz, Gregg Lewis, and even with Albert Rees who was still at Chicago until 1966.

A – Rees was at Chicago. He was not an analytical economist, he was still of the old tradition, but he tried to combine both approaches. Gregg Lewis was the real father of modern labor economics, but he published very little, being a perfectionist. (As is well known, most of the dissertations in labor economics at Chicago were basically products of Gregg Lewis).

Q – Beyond those circles was there significant resistance to those new applications?

A – Yes. But that was exciting.

Q – Did you feel animosity at professional meetings, for instance?

A – Both Gary and I always felt very secure with what we had to say, and we did not hesitate to say it. And gradually the field changed. I think our students did a good job in that respect.

Q – Do you think that was already visible by the end of the sixties?

A – By the time my book came out, in 1974, there was a general acceptance of the human capital approach. I remember I showed a draft to Orley Ashenfelter, and he was very excited and said ‘This is going to become the standard approach in labor economics’. He was right.

Q – What explains the vitality of the research on human capital at that time (late 1960s – early 1970s)? A strong network of researchers, novelty of applications, institutional support?

A – All of those factors were important.

## 2.5. HUMAN CAPITAL AS AN AGENDA FOR LABOR ECONOMICS

Q – As human capital becomes an organizing principle for your research, one gets the feeling that there is a persistent exploration of human capital as a general explanation of various issues in labor economics,...

A – You are right.

Q – including the role of women in the labor market.

A – Analysis of labor supply goes back to Lionel Robbins and his memorable article. It is geared to the individual, there is no family in his analysis. Both income and wages, income and prices are the same. If you wanted to apply this theory to empirical data, you couldn't get a separate full-fledged supply curve. All you would get is the net differential resulting from the coexistence of these two variables. A number of people were looking at that, such as Paul Douglas and Clarence Long, but they simply looked at wages and found a negative effect on labor force activity. That is because the income and price variables were not separated. So to my mind the whole theory of labor supply must deal with the family. The income variable is not the same as the wage variable: if the family pools its income, you have one income variable, and then each individual has a wage, which is the price variable. That's quite separate.

Q – That change of perspective from the individual to the family is a crucial one.

A – That was the problem that labor analysis had to deal with. The answer to this is: consider the family. Then you are going to get a number of variables that are not tied to one another. There may be powerful relations. Once I got that idea, it took me very little time to get the estimates. Basically at the end of the course I had the ideas in my mind; I told Gregg Lewis and he said "you got it!" That became the standard approach. Of course there are subtleties. My approach was that the family pools its income, nowadays there are theories about bargaining within the family, but it started there.

Q – In relation to the family, you have also been influential in emphasizing the role of human capital accumulated at a pre-school stage, within the family – the so-called home-human capital. Why did you become interested in that aspect?

A – Well, as I told you the family came as a solution to the problem of labor supply that I just mentioned. But of course, the family is of interest by itself. I did not really contribute that much to what is called family economics, except in terms of labor supply analysis. I was interested in labor force participation of women, because of my wife. I knew she had a high-powered profession and it was clear that she would not simply become a housewife. That was our start. That was an example of the role of wages in labor force participation. From the very start I believed that wages have a positive, not a negative, impact over labor force participation. The negative effect came of course because of the residual. If you just relate wages to participation, at that time you would get a negative effect (I'm talking about women), but once you take

income as a separate variable, you will see that the wage has a positive effect that in fact is stronger than the income effect.

Q – You seemed to be interested in exploring the various dimensions of the concept of human capital. However, at a certain point human capital research became very focused, perhaps excessively focused, on the schooling dimension (perhaps for matters of data). You have always pinpointed other aspects of human capital such as On-the-Job Training (OJT), home investments, and migration. Did you feel that it was narrowing too much and missing part of the picture?

A – From the very beginning I focused on education but also on age. The age phenomenon intrigued me. There was a question of development of wages and the labor force behavior over the life cycle.

Q – Human Capital came to dominate the research agenda in Labor Economics by the late 1960s. Why do you think that happened? What was the role in that respect of multiple applications and increasing availability of data allowing econometric testing?

A – The topic of economic growth replaced the previous emphasis on business cycles. Human capital is one of the keys to economic growth. Applications were found in many fields of economics, especially in labor economics. The availability of data on an individual level made empirical research feasible and attractive.

## 2.6. APPRAISING HUMAN CAPITAL RESEARCH

Q – Looking back after so many years of work on human capital how do you appraise its evolution? Which aspects would you like to single out as major achievements?

A – The main contributions of human capital analysis are twofold. One, it is an insight into the wage distribution. Before human capital, people looked at distribution as a functional concept, one part to capital one part to labor... That was because data came that way. Around the time I started, individual data became available, starting with the 1940 Census. One could look at the distribution of personal income and there were all kinds of questions about that: about its variance, skewness, and patterns of personal income distribution. I think human capital contributed a great deal there. It also contributed to the understanding of economic growth, although I did not work on that. I think these are the two major contributions: understanding the personal income distribution and understanding economic growth. These were the contributions at the very beginning and they just kept developing.

Q – What aspects of human capital research should be more explored? Which ones were less fruitful?

A – I shy away from the word “should”. All research is work in progress.

Q – Despite the increasing acceptance of human capital analysis, a series of alternative explanations appeared. Nonetheless, you never seemed too worried about, for instance, the screening approach.



A – The screening approach makes little sense. It assumes that the major product of schooling is a piece of paper requiring many years to achieve. If this were the major or sole benefit of schooling, it would be much cheaper and more efficient to save years and expenditures and simply prepare for an employment test provided by the employer.

Q – Although you accept that employers will use this piece of paper at least initially?

A – Yes.

Q – Why do you think that screening theories became so popular at a certain point?

A – That's always the result of debates and discussions. If somebody comes up with an idea, someone else comes up with a counter argument (laughter)...

Q – And there is a kind of dialectical process?

A – That's healthy.

Q – Do you think that at the end human capital won the debate?

A – To my mind, yes.

Q – In that respect, how important was the empirical evidence?

A – Well, there are some empirical approaches that deal with schooling. There is for example the pattern of the earnings curve over the life cycle, especially in the beginning, where we find a negative correlation between initial levels on the job market and, say, ten or fifteen years later they reverse and that clearly indicates an investment process. What I find most convincing was what I mentioned at the beginning, that it seemed foolish that an investor would spend so many years in education in order to show a piece of paper to the employer.

Q – In the sense that human capital was a better explanation?

A – Yes. Isn't this common sense? You will have a rather narrow or restricted job in most cases, for which one could prepare an examination that it would take you a year or two, but not twenty years. That would be a lot cheaper to the economy.

Q – Textbooks are regarded as an important instrument to consolidate a certain theory within a discipline. Do you agree? Have you ever considered writing one yourself? Do you think it would have helped the dissemination of human capital research?

A – Textbooks give the student an overall view of the subject matter and appropriate references. Since the subject matter evolves over time, constant revisions are needed. I never contemplated writing a textbook.

## 2.7. REFLECTIONS ON THE DISCIPLINE

Q – I would like to talk also about your career as an economist. As a privileged observer, how do you see the evolution of the discipline during the last 40/50 years? Some people point out to excessive formalism. Do you agree with that?

A – I partially agree. On the other hand, I feel that there is nobody who can tell people what to do. So, let a thousand flowers bloom! Whatever is important is going to survive, if it's not important it will be forgotten. But it is difficult to tell ahead of time. So, I would say, I agree that highly mathematical work just requires a lot more work and may not deliver as people think it might. It is interesting, because I was attracted to economics because I could not understand it (I did not know much about it), and at the time there was too little mathematics, too little rigor, too little analysis. Now, it is moving with a vengeance in the formal direction.

Q – You have always placed strong emphasis on empirical research in economics that is driven by theory. Do you agree that there is a low premium for that type of research in economics? Has that situation improved or deteriorated in the recent decades?

A – The style of research matters a lot less than its findings.

Q – Because you taught statistics and econometrics in the early days, but you seemed to regard it very much as an instrument, rather than an end in itself...

A – That's right.

Q – Do you feel that there is the danger that people lose sight that econometrics and statistics are instruments?

A – Well, there was a division of labor, and a lot of people who were very good at mathematics would do either econometrics or mathematical economics. In fact the term mathematical economics does not exist anymore. That is what is understood by economics. It's always very helpful when one knows the technique that furthers the solution of the particular problem you're trying to solve – that I appreciate.

Q – Well, you said 'let a thousand flowers bloom', but how can we select a valuable explanation from one that isn't?

A – We don't select. It's a question of survival.

Q – You always seemed close to the idea that the model should be judged by its predictive power. I gather Milton Friedman and George Stigler influenced you in that respect?

A – That was an idea that I had even before that, but they showed examples. You are right the usual textbooks don't talk about empirical work. That is something that the student acquires after years of work in the field.

Q – You mentioned empirical work, and at the NBER, where you developed an important part of your work, there was a strong empirical emphasis.

A – They almost ran the other way! In 1950, I think, there was an article that came out by Koopmans, ‘Measurement without theory’, that was a review of what he saw as the work of the NBER. In response, Arthur Burns wrote ‘Theory without measurement’. Using theory to get empirical work, or using empirical work to test theories, is something you have to learn by yourself. It is more of an art.

Q – If it is an art it is also important that it addresses issues that are relevant to policy. In relation to that, you never seemed to be very interested in developing policy analysis.

A – Like everyone else I am interested in political aspects of economic behavior, but there is a question of research priorities and there my major efforts were in the positive rather than normative aspects of labor economics.

Q – Another development of the discipline was to expand its scope by addressing topics not previously considered. How do you see those developments, the expansion of the discipline?

A – The question is whether the boundaries haven’t gone too far. Well, I am a laissez-faire man. As I mentioned before, I think ‘a thousand flowers should bloom’. If we can find something of interest economists can tackle the way they are doing it, why not?

Q – You believe that economics has a lot to contribute to social understanding?

A – It has a great deal.

Q – You are one of the foremost economists of your generation. What do you think will be your lasting contributions?

A – The same contributions I made at the very beginning of my career: the one was modernizing labor supply analysis, and the other was human capital. Human capital having priority, actually.

Q – And these are the ones you would like to be remembered for?

A – Well, yes. What I will actually be remembered by is a matter for posterity, and maybe I won’t be remembered at all (smiles)...

Q – That’s your proverbial modesty talking...

A – Posterity is something one has to leave to the next generation...

Q – And how do you think economics will look like in the next generation? Do you think it has a bright future?

A – I am sure it does.

Q – What are your recommendations for young economists?

A – Just follow your instincts as to what is important at a given time, or important in the sense that you are not satisfied with the answers that have been given.

Q – However, you always talked about continuity in the history of economics...

A – All subjects are open-ended and success depends on asking the right questions. The real mark of success is when your contributions are so fully absorbed into the mainstream that your authorship is no longer singled out.

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### 3. ACCEPTANCE SPEECH UPON RECEIVING THE FIRST IZA PRIZE

November 24<sup>th</sup> 2002 in New York

BY JACOB MINCER

I am deeply honored and very happy to be the first recipient of the IZA International Prize in Labor Economics. Although a lifetime of interesting and challenging work is its own reward, a formal recognition of merit, such as the IZA Prize, is most flattering. I agree to accept it.

Being named the first recipient has at least two implications. First, it sets standards for research and teaching in Labor Economics. The standards I always aimed at are simplicity of analysis and of exposition, and robustness of empirical findings. As Milton Friedman phrased it: “I’d rather be simple than right”; and in the words of John Maynard Keynes: “I’d rather be vaguely right than precisely wrong”.

The other implication of being the first recipient regards the historical view of the discipline. On that, my academic experience parallels that of Labor Economics; you may call it “from insults to praise”, or “from backwater to mainstream”.

This reminds me of the late Professor H. Gregg Lewis, who, if I am a father of Labor Economics (note “a”, not “the”), H. Gregg Lewis is surely the grandfather.

It was he who invited me to a post-doc at Chicago in 1957, upon reading my Thesis before the defense. In my first conversation with him, he called me a labor economist, which deeply embarrassed me, since I had never had a course in labor economics, and for good reasons (viz. Samuelson’s view at that time).<sup>1</sup>

H. Gregg Lewis’ seminars and lectures during that year caused me to revise my opinions and indeed opened up an opportunity for pioneering in a subject that was “tabula rasa”; every filled blank was pioneering. My ambition was strengthened a year later when I joined Columbia and my office was next door to Gary Becker. And the rest is history, as they say.

Today, Labor Economics is a model of applied economics attracting talented students and institutional support, such as the IZA.

**NOTE**

1. “Labor Economics is the last refuge of a scoundrel”. Samuelson

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**PART II. COLUMBIA'S LABOR WORKSHOP IN THE 1960s**

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#### 4. WORKING WITH JACOB MINCER: REMINISCENCES OF COLUMBIA'S LABOR WORKSHOP

BY GARY S. BECKER

Permit me to spend some time elaborating upon my reminiscences of the years during which I worked closely with Jacob— I must say that the decade Jacob and I spent working together was surely one of the most, if not the most exciting and fruitful in my life.

People ask how it is that Jacob and I never wrote a paper together. In fact we did—but we never published it. We did a paper on a forward-looking, perfect foresight model of the relation between consumption and income. At that time, time-series analyses were all backward-looking, in the sense that consumption was based on some form of weighted average of past and present income. Jacob and I thought that the right way of looking at consumption was by assuming people are forward-looking. We wrote a paper on the subject that is closely related to the major paper by Robert Hall (1988), but we assumed perfect certainty. We had a theoretical model, and did some empirical work. Why did we not publish this? That is a good question. We should have! I am sure that it would have become an influential paper. We thought that the empirical relationship predicted by the theory between consumption and income was not quite right, and we did want to work further on that, but never did. I had a look at the paper a year ago or so— I still think it is quite a good paper!

Although we did not write much together, the intellectual collaboration and interaction was continuous, so it is hard to know what was his contribution and what was mine. We were engaged together in an exploration, an intellectual venture, that took us to a number of areas. We accomplished an enormous amount together, and that was far more important than what we might have written together.



This intellectual co-operation led to a great workshop—the labor economics workshop at Columbia. Several factors contributed to its success. First of all, it had a continuing input of first-class students. Ultimately, the quality of the students determines the success of a workshop, and I would give our students number one credit for the accomplishments of the workshop. They were hard-working, able, extremely interested in the subject, and they were ready to take criticisms of their work. All these were important characteristics—a kind of survival training for the real intellectual world. We tried to have an open intellectual discussion that raised important economic questions.

These students were engaged in what is now recognized as often path-breaking work, far ahead of the profession at the time. Consider some of the topics on which they worked: human capital; family economics; household economics and allocation of time; crime; discrimination.

Jacob's dissertation on compensating differentials in education was a pioneer analysis of human capital. I remember that he explained his dissertation to me when I first met him. I was also interested in human capital because of my dissertation on discrimination. I told him that I was going to New York shortly to work at the NBER (the National Bureau of Economic Research was then located in New York) on a project on education and human capital. He said that he was going to Chicago on a post-doctoral fellowship partly because he thought I would be there. I replied that I was going to New York assuming that he would still be there. Jacob went to Chicago that year, and I came to Columbia and the NBER. He sent me a copy of the Ph.D. dissertation he had written at Columbia. I was immediately impressed by its first-class originality, even though he did not have anyone at Columbia, with the possible exception of George Stigler, who was interested in education and earnings. So I concluded that he was a very unusual young economist, with a lot of independence and creativity.

He did come back to New York, and within a couple of years we got him to Columbia. I had started a study at the NBER on rates of return to education. Jacob and I had become increasingly interested in On-the-Job Training since once you begin to discuss the relation between human capital and earnings you can't stop at education. Earnings are not constant after people start working, so something else is going on. You could do what labor economists traditionally did before the human capital revolution, which was to attribute increases in earnings with years in the labor force to unions or seniority, but that seemed far from the real story. One had to realize that investments in human capital do not stop with schooling, but continue in post-schooling activities, either on-the-job, or elsewhere in training programs. We were both working on post-school investments, as reflected in the articles published in the 1962 JPE Annual Supplement, that important volume edited by Ted Schultz, one of the pioneers of human capital analysis, and a great friend of both of us (Becker 1962, Mincer 1962a). We continued to analyze education and post-school investments in the workshop. One major output was Jacob's outstanding book (Mincer 1974).

Jacob published his paper on labor force participation of married women after it had been presented at a 1960 conference (Mincer 1962b), and everybody there

immediately agreed that it was very important. I had read Clarence Long's book on labor force participation of women for the NBER, probably the most important work on that topic until that time. Jacob's paper cleaned up and extended the analysis by showing how one could use income and price effects in a way that would not only explain cross-sectional evidence, but also much of the time-series change in women's participation. Most of the time, successful analysis of cross-section evidence does not do very well in analyzing changes over time. Jacob succeeded about 60 percent of the way in reconciling the two types of evidence, which was a large advance compared to earlier work on this subject.

I was also working on the family, starting with my paper on fertility at an NBER Conference (Becker 1960). Hence, we had a common interest in studying family behavior, including women's labor force participation and fertility.

Jacob and I also both worked on time allocation. Some of our students did very good dissertations on this subject. I was involved in time allocation through my work on human capital. I had a long footnote in my human capital theory paper (Becker 1962), which showed how the discussion of foregone earnings could be extended to a general full-income framework. I expected that analysis to come out shortly – it took a few years (Becker 1965). Initially, our interests in this topic were independent, but they became increasingly connected. It was really a joint venture, the purpose of a workshop. Together with the students we created an atmosphere of intellectual cooperation and fermentation on this and other subjects.

The workshop consisted mainly of student presentations of their research in progress – we always tried to give first priority to our students. The temptation often is to invite known faculty speakers from elsewhere because they attract a larger audience. However, the purpose of a workshop is to train students. That is why Jacob and I started ours – to give students the opportunity to present, preferably at an early stage of their dissertation work. But Jacob and I also presented our work at their early stages, so that students would see that they were not asked to do something that we were not ready to do ourselves. In early presentations of our work, we also received valuable comments.

Jacob and I invited to participate in the workshop young economists who were at the NBER either as visitors (such as Sherwin Rosen, who spent a year visiting at the NBER) or as NBER associates (such as Victor Fuchs). Visiting professors at Columbia also participated, including Assar Lindbeck and Stephan Linder from Sweden. Both spent a year at Columbia and participated regularly in the workshop. Labor economics in Europe was virtually dead at that time. There was some literature on industrial relations, but that made little use of economic analysis. Assar took back to Europe many of the ideas discussed at the workshop, such as human capital. It took Europe a while before it caught up with the level of the Workshop discussions on these topics.

Nowadays there are many economists doing important work in labor economics. But at that time, outside of Chicago and Columbia, human capital, time allocation, household economics, and labor force participation of women were mostly ignored. I believe, and I can also speak for Jacob on this, that most of the profession was not interested in these topics until much later. However, we felt confident enough to

keep working on these subjects, hoping that someday this work would be appreciated by the economics profession. Fortunately, that eventually did happen. But in Jacob's case I would say not sufficiently, and this celebration and his IZA prize announced today are part of the professional appreciation that is due him.

Jacob was crucial to the workshop. I was much more aggressive, more critical. Jacob spoke less frequently and more quietly, but I do not remember his making a comment that was not relevant. Jacob's comments were thoughtful and helpful, for his goal was to help students do everything they could to get the maximum amount out of their analyses, and in tackling interesting empirical questions. Jacob has always been an ingenious empirical analyst, clearly among the most outstanding empirical analysts of his generation. In those days the data available was very limited, yet Jacob would find ways of making the most out of the limited data available for the many pioneering papers presented in the workshop. Although data are always limited, one of the most important challenges in social science is to get the most out of existing data. Jacob was wonderful at that, and he conveyed that genius to the students and other participants in the workshop.

We supervised many dissertations together. He was the first supervisor on some of them, I on others. I cannot say who was more dominant, since most of the time we were both dominant, hopefully not contradicting each other. I had a reputation for being tougher, but after a few drafts I would tend to give up. Not Jacob! He would force students to extract the maximal number of empirical implications, and then test them extensively. Students often had to struggle to finish, but the dissertations and subsequent careers of these students were far better because they were pushed hard. Sometimes, when working on a complex topic, like women's participation in the labor force, you want to give up, and you need someone who pushes you further. Jacob did it, more than I, especially with the empirical analysis. That made the dissertations substantially better, which had an important impact on the careers of many of the students.

We met weekly at the workshop in which most of those present today participated as students, but Jacob and I also had contact beyond the workshop. We were both at the NBER, where we would spend a part of each week in seminars and projects. Many of our research assistants there were our Columbia students, going through a research apprenticeship, and interacting with full-time staff such as Anna Schwartz, Victor Fuchs, and a number of others. Some, unfortunately, are now deceased, such as Arthur Burns and Sol Fobucant.

Let me return to how much I learned from Jacob. Our talents were extremely complementary—I was more theoretical, he was more empirical. But we both recognized that empirical work needs good theory, and theory needs to be tested because it cannot exist in a vacuum. I was more outspoken, he was quieter. I personally feel that I benefited so much from this complementarity. To be complementary, you need strong agreement on the basics. If researchers are too different, there will be little interaction between them. Jacob and I agreed practically all the time. We had very few disagreements, maybe none on fundamental issues. But we had different strengths and weaknesses that were complementary. Certainly, I felt this.

I decided to leave Columbia mostly because of the way the faculty—not Jacob!—dealt with the student unrest of the late 1960s. It was a very difficult decision, since I had to leave many close associates and friends. But as I remember those times, I am driven to salute a great economist who combines originality, insight, impeccable honesty, modesty, generosity, and stubbornness in a unique way. Jacob, it has been a great pleasure to interact with you over many decades, and an even greater pleasure to work so closely with you. Thank you so very much.

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## 5. LABOR ECONOMICS MINCER-STYLE: A PERSONAL REFLECTION\*

BY SOLOMON W. POLACHEK

### ABSTRACT

*Between 1957 and 1974 Jacob Mincer pioneered important new approaches to labor economics. In the years since these seminal discoveries, he, as well as generations of his students and colleagues at Columbia University and elsewhere, adopted these innovations to reach important conclusions about human well-being. In 1967 I was lucky enough to arrive as a graduate student at Columbia University, just at the peak of this research revolution. In this paper, I detail some of my recollections concerning Jacob Mincer and the hospitable research atmosphere at Columbia University that sparked so much of this path breaking research.*

In the spring of 1967 when I first contemplated graduate school, I visited Columbia University just the day Reuben Gronau presented his Ph.D. dissertation research. His topic entailed a time- allocation model to estimate SST travel demand based on saving hours from faster speed. The Economics Department was in Fayerweather Hall, but the seminar took place a half dozen blocks away in a dingy drab second floor room of an old building on 114th Street. Gronau was seated at the head. Gary Becker and Jacob Mincer, the seminar leaders, were perpendicular to him on each side.

\*This constitutes the first section of the paper "Mincer's Overtaking Point and the Lifecycle Earnings Distribution" I presented at the Columbia University Conference Honoring Jacob Mincer's 80<sup>th</sup> Birthday, July 2002. I feel honored to be one of Mincer's students. This paper acknowledges the intellectual debt I owe him for the superb training I received and for the continued interactions and collaborations since. I thank my fellow graduate students at Columbia University (many of whose names are mentioned herein) for helping create a stimulating yet fun intellectual environment during difficult political times. Also, I thank Shoshana Grossbard for encouraging me to split my original paper so this perspective could appear as an independent chapter. Finally, I thank the Industrial Relations Section at Princeton University for providing a conducive environment to revise this paper during my sabbatical there.

Becker and Mincer were both brilliant, but both different; and the differences were stark.

Becker was outgoing, asking lots of questions and continually calling on students. By comparison, Mincer seemed taciturn, relatively reserved and introspective, questioning Gronau only sparingly and picking on students infrequently. I believe also at the seminar were Linda Edwards, Isaac Ehrlich, Victor Fuchs, Gil Ghez, Mike Grossman, Giora Hanoch, Masanori Hashimoto, Marjorie Honig, John Claude Koeune, Arleen Leibowitz, Bob Michael, Dave O'Neill, June O'Neill, Beth Niemi (now deceased), John Owen, Mike (Carl) Rahm, and possibly Victor Fuchs and Finis Welch. I realized those present were the world's best, brightest and most talented young labor economists, whose brand of labor economics differed from the simple institutional approach I had seen and dismissed as an undergraduate. Obviously exciting major changes were occurring in labor economics and they were happening at Columbia University. Columbia was a place where labor economists ate, breathed, and dreamt economics. That's all they talked about; it was total immersion. By the time the seminar finished I was convinced that I wanted to be a part of that group. I knew Columbia was for me, so I enrolled; and I am glad I did.

Indeed, over the next year or two it got even better. Barry Chiswick and Bill Landes returned, with Bill bringing his wife Lisa. Jim Heckman arrived with immense curiosity and boundless energy. Soon Ann Bartel, Andrea Beller, George Borjas, Cynthia Brown Lloyd, Masatoshi Kuratani, Margaret Ludlum, Haim Ofek, Jacob Paroush, Cordelia Reimers, Mark Rosenzweig, Sue Ross (who unfortunately passed away just weeks before the conference), Fredericka Pickford Santos, Carmel Ulman (later to become Carmel Ullman Chiswick), Harriet Zellner, among others, joined the labor seminar. Columbia had the very best – all in one place. I could see that Becker's and Mincer's advocacy for using the price theoretic approach as a tool to understand many social problems attracted the best of Columbia's students to labor economics. Anyone that was anyone in labor was at Columbia during the 1960's and early 1970's. I was lucky to arrive just at the peak.

Mincer was a perfectionist, both in his own work and in guiding others. He professed solid theory with an eye toward rigorous empirics. As I'll mention later, Mincer's notion of rigorous empirical research was not necessarily sophisticated multi-equation, nonlinear maximum likelihood estimation, but instead to apply a sound specification using a number of data sets so one could assess robustness in what you might call Mincer style. He was reluctant to let a student finish until he was convinced no stone was left unturned to verify a thesis' assertions.

Students, on the other hand, had another idea of rigor. They would introduce Mincer to their spouse and kids, somehow to convince him they needed a job to support their family. This they hoped would gain his approval for a dissertation defense, so finally they could get on with their life. Perhaps then, he would consent that yet an additional regression with still another data set might not really be necessary for the degree, "even though surely, it would be mandatory for publication". Even the paper Jacob and I did together didn't satisfy him until he completely redid the entire draft and reran the entire set of regressions stratified by three different

educational groups. For the extra work, I owe deep gratitude to George Borjas, who served as the final research assistant for this latter stage of analysis.

But Mincer was a perfectionist, especially in his own work. When I first got to Columbia I took the typical core courses: Jacob's statistics course, Gary Becker's micro-theory course, Albert Hart's macroeconomics course and Philip Cagan's monetary theory course. During that first year, I attended a faculty student reception and asked Professor Mincer about labor economics. He said, "It's simple. There are supply and demand." Well, I took his labor course. The first semester we studied labor supply, and the second we studied how employees supply the market with human capital; but we never did get to labor demand. Finally, at Jacob's Columbia University retirement party in May 1990, I got the courage to ask him about labor demand. He said "Wait, there's still time." Well I'm happy to say that in Jacob's 1997 paper on changes in wage inequality (Mincer, 1997), he finally deals with how technology affects the demand for human capital. All I can say is that Jacob is such a perfectionist that it took him over 30 years to get supply in good enough shape to ultimately pursue demand.

Indeed Jacob Mincer was a perfectionist like no other. As I mentioned, his brand of perfection was to devise a theory. (It had to be rigorous, yet parsimonious, since Mincer was an ardent believer of Occam's razor.<sup>1</sup>) Then, Mincer meticulously tested his theory empirically. Unlike a number of today's economists, he thought you really didn't have a viable theory unless you could see its implications *strongly* from OLS estimation. Thus he didn't use fancy non-linear maximum likelihood estimation of the type that made Heckman famous, but instead he tested and re-tested his theory in as many ways as possible. Take *School, Experience and Earnings* as an example. Not only did he derive an earnings function and fit it with data, using a multitude of specifications (e.g. linear and exponential decay functions), but he also looked at the theory's further implications regarding earnings distribution. For this reason, every theory Mincer developed is *robust*. Indeed probably the most frequently estimated equations in the history of economics are the "Mincer earnings equation" and the "Mincer female labor supply function." Both form the basis of all wage and employment studies.

To me, one of Mincer's most illuminating articles was his "Market Prices, Opportunity Costs, and Income Effects". The paper dealt with five topics (transportation costs, labor supply, the demand for domestic servants, fertility and search). Not only did each become a major field of labor economics research; but also when viewed more generally, the paper could be construed as the impetus for much of the empirical labor economics literature. This is especially true regarding all serious research on gender. As such, it would not be unreasonable to consider Mincer a founding father of modern labor economics *and* a founding father of gender economics. As father of modern labor economics, Mincer concentrated primarily on two major areas: labor supply and human capital. But within these major branches of labor economics he also wrote about education, on-the-job training (which he sometimes called post-school investment), wage floors, labor turnover, economic developments, technology, unemployment, and even on the accuracy of economic forecasting models. As father of gender economics, he solved the mystery of why women's labor

force participation rose continuously for at least the last century (probably the most important trend in labor economics) and made important inroads investigating why women earn less than men. His important work on human capital and labor supply is put together in a two-volume set, *Studies in Human Capital: Collected Essays of Jacob Mincer Volume I* and *Studies in Labor Supply: Collected Essays of Jacob Mincer, Volume II* published by Edward Elgar in 1993. But since then, he wrote additional articles, two of which are published in *Research in Labor Economics*.

Working with Mincer was an indispensable experience that changed my research focus. Originally, I was interested in mathematical economics. I thought I'd apply search theory to employer misconceptions of worker quality very much in the spirit of what has become known as statistical discrimination. However, I didn't develop keen empirical implications testable using an earnings function approach.<sup>2</sup> So instead of doing research in search theory, I worked on a supply-side human capital model which led to what I like to think was a novel theorem proving that women's human capital investment need not decline monotonically as was the case for continuously employed males (Polachek 1975). This led to a most valuable collaboration, resulting in the development of the "segmented earnings function" designed to get at the impact of women's discontinuous labor force participation (Mincer and Polachek 1974). For this association and the resulting slew of interactions from which I learned so much, I owe Jacob a great deal more gratitude than a student usually bestows upon his professor. Hopefully, this chapter as well as my later one in this volume, recognizes this intellectual debt to a most esteemed scholar.

## NOTES

1. Occam's (Ockham's) razor is the principle that a model's uncontested propositions should be minimal. William of Ockham first formulated this principle in the fourteenth century. Ockham had several forms for the principle. The most common is: *Pluralitas non est ponenda sine necessitate*. See Philotheus Boehner (1958), p. 155.
2. Only much later in joint work with Bong Yoon (1987) was I able to modify Mincer's earnings function specification to develop a "two-tiered earnings function" incorporating incomplete employer and employee information in a way I believe can shed light on employer statistical discrimination.

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**6. REMARKS FOLLOWING THE FINAL SESSION  
OF THE CONFERENCE IN HIS HONOR, HELD  
AT COLUMBIA UNIVERSITY ON JULY 15, 2002**

BY JACOB MINCER

Never in my life have I gotten so many compliments per hour. But I want to reassure those of you who know me better that it was not a sudden attack of vanity that prompted the event that has brought us all together.

The idea of a conference was originally conceived by Jim Heckman, who expressed this to me on a visit almost a year ago. What I had in mind was a reunion of the legendary labor workshop at Columbia – not a celebration of my birthday. Others decided to combine both purposes. Whatever its pretext, today’s gathering has been an outpouring of affection to me and to all those who participated in the workshop that changed significantly the course of labor economics.

Of course, no assessment of the workshop can ignore the initiating and dominant role played by Gary Becker. His words about our complementarity are most generous. Another complementarity to which Gary gracefully alluded is the 50-year one between me and my wife, Flora. My career had a lot to do with her, as she inspired many of the topics I studied; women’s participation in the labor market was just one.

Although the notion of scientific legacy sounds pompous to me, when it is applied to our group it seems to be appropriate. Ultimately, one’s legacy is a matter of shared posterity; and success arrives when one’s ideas become part of the common mainstream and references to authorship are no longer necessary.

My thanks and love to all of you who came today, including close friends and family members.

I would also like to thank Columbia University, where I spent almost all of my career and where I had the privilege of spawning many others’.

Thank you.

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## 7. THE NEW HOME ECONOMICS AT COLUMBIA AND CHICAGO\*

BY SHOSHANA GROSSBARD

### ABSTRACT

*This paper studies forty years of New Home Economics (NHE), a school of household economics started by Jacob Mincer and Gary Becker at Columbia University in the early sixties. Household economics is defined as economic research concerning decisions that household members make regarding any allocation of resources. These decisions may regard consumption, labor supply, transportation, fertility, or health. From studying the history of the NHE we learn that its growth benefited from the concentration of talent at Columbia, the diversity of a student body that included many talented men and women, a relatively high concentration of married students who tended to be more interested in household production, the proximity of research organizations in New York, an avoidance of political controversy, and a pleasant workshop atmosphere.*

During the 1960s, a number of economists made the study of home production a central topic of interest, applying theoretical and econometric methods of analysis that had been developed for the study of production by firms. This research became known as the New Home Economics (NHE), a term emphasizing the contrast between new applications of economic analysis and the discipline of home economics

\*This is an abbreviated and corrected version of an article published in *Feminist Economics*, Vol 7, Number 3, November 2001, [copyright symbol] International Association for Feminist Economics 2005. Reprinted with permission from IAFFE. The original article can be accessed at [www.feministeconomics.org](http://www.feministeconomics.org). I am grateful to Jacob Mincer and Gary Becker, two extraordinary teachers and mentors. Their uncompromising and spiritually uplifting demand for truth continues to inspire me. I thank Mincer, Becker, James Heckman, and some of their students at Columbia (Andrea Beller, Linda Edwards, Marjorie Honig, Sol Polachek, and Cordelia Reimers) for answering some of my questions; and Bina Agarwal, Andrea Beller, Barry Chiswick, Linda Edwards, Nancy Folbre, Andrew Foster, James Heckman, Evelyn Lehrer, Diana Strassmann, and Howard Yourow for useful comments.

established a few decades earlier by Hazel Kirk and Margaret Reid (see Evelyn Forget 1996, Yun-Ae Yi 1996, and Elizabeth Kiss and Andrea Beller 2000). The NHE transformed household economics by widening its application in the areas of labor economics, demographic economics, health economics, transportation economics, and public economics.

This chapter presents an account of the growth of the NHE in the sixties, when Columbia was the hub of NHE activity, and discusses some aspects of the development of household economics after 1970. This account is based on interviews and correspondence with Jacob Mincer, Gary Becker, James Heckman, and many of their students at Columbia, and is influenced by my experience as a household economist trained principally by Becker at Chicago in the 1970s.<sup>1</sup> One of my goals is to show that the NHE had two fathers: Mincer and Becker. This chapter's main goal is to list the factors that help explain why the NHE grew so rapidly in the 1960s.

### 7.1. THE SIXTIES: THE GOLDEN AGE OF THE NEW HOME ECONOMICS

The sixties was a Golden Age, not only for rock music and student revolutions. It was also a period of rapid growth for the NHE. In 1960, both founding fathers of the NHE, Jacob Mincer and Gary Becker, first publicized their ideas about applying microeconomic theory to explain household behavior. The NHE's first publication is Becker's (1960) economic analysis of fertility. For the first time, modern price theory was applied to the study of fertility. That same year, Mincer presented an enthusiastically received paper on women's labor supply in a family context at a NBER meeting. Mincer's (1962) contribution (reprinted in Mincer 1993) was a significant improvement over previous analyses of women's labor supply (see Chapter 13 by Gronau).

Mincer's other major contribution to NHE is his "Market Prices, Opportunity Costs, and Income Effects" published in 1963 (reproduced in Mincer 1993), a precursor of the models of allocation of time by Becker (1965) and Kevin Lancaster (1966).<sup>2</sup> Mincer (1963) and Becker (1965) recognized that opportunity costs of time affect fertility, demand for transportation and domestic servants, labor supply, and search behavior, and that wage effects differ from (pure) income effects.

By their own account, Mincer and Becker had been inspired by earlier Chicago economists T.W. Schultz and H. Gregg-Lewis.<sup>3</sup> What distinguished the NHE from previous research was not that it recognized the role of home production (Reid, Kyrk, and others had recognized that earlier), but that they applied the tools of microeconomic analysis, which had been developed in the context of firms, to model home-based decisions such as labor supply and fertility. It is principally as a result of Mincer's and Becker's contributions to the NHE, that labor economics now includes the study of the opportunity cost of time, demographic economics, health economics, and other considerations related to household production.

One of those deeply affected by Mincer's writings on women's labor supply was James Heckman, who eventually contributed important further innovations to research on women's labor supply.<sup>4</sup> Heckman notes, "When I was a graduate student

at Princeton, reading Mincer's paper on the labor supply of married women completely altered my interests in economics. I was so impressed that a simple model of such beauty could predict data so well that I decided to become a labor economist."<sup>5</sup> Other influential labor economists inspired by Becker's and Mincer's NHE include Victor Fuchs, Mark Killingsworth, and Sherwin Rosen (see Fuchs 1994).<sup>6</sup>

The NHE models of Mincer and Becker assumed family decision-making rather than individual decision-making, an assumption later challenged by many household economists, starting with Marianne Ferber and Bonnie Birnbaum (1977). Note that Mincer's specifications contain implicit functions that are consistent with a variety of assumptions regarding decisionmaking about consumption or production.<sup>7</sup>

Although Mincer and Becker never published a joint paper, their mutual cooperation has been rated as very productive by themselves, colleagues, former students, and other participants in their joint labor workshop. All the participants in this 'Golden Age' of the NHE at Columbia to whom I talked reported a unique sense of excitement around the labor workshop led by Mincer and Becker. It is in this workshop that Mincer and Becker developed Modern Labor Economics (MLE) as we know it, NHE being a major aspect of MLE (other major aspects of MLE developed by Mincer and Becker being economic analyses of human capital and wage determination). According to Jim Heckman, "it was a great workshop. Mincer believed that you could learn about the world from looking at data. He believed that economics was a science and he made us all enthusiastic about the great empirical venture called modern labor economics: price theory used to interpret evidence." Chapters 4 by Becker, 1 by Heckman, and 5 by Polachek offer more evidence on how exciting this workshop was, especially when both Mincer and Becker were heading it.

The workshop's success helped attract some excellent doctoral students.<sup>8</sup> This process was facilitated by Mincer and Becker's systematic tandem operation to attract the brightest students to their seminar and labor courses.<sup>9</sup>

Then, as now, American women were more attracted to by the study of study household economics (including labor supply) than were men. Heckman was impressed by the number of bright young women participating in the workshop.<sup>10</sup> The ratio of women to men in the labor workshop jointly directed by Mincer and Becker was around 1, a very high ratio even by today's standards (see Shulamit Kahn 1995). I suggest that the relatively large number of talented and creative women students who became involved in NHE was partially the result of a talent pool of women whom marriage had brought to New York City. Then, as now, few married women initiated family moves to another city. In the sixties, the average age at marriage was considerably lower than it is now, and Ph.D. students, especially women students, were more likely to be married than they are today.<sup>11</sup> Many of the women who worked on NHE-related research at Columbia in the sixties were married before they started their doctoral studies.<sup>12</sup> Others married while they were students, including a number who wed fellow economics students or faculty at Columbia.<sup>13</sup> Also, generous criteria for admission to graduate studies in economics facilitated the entry of students with a wide range of intellectual interests who were attracted to the novelty of the NHE.

Mincer and Becker have different temperaments and personalities. Becker is more charismatic than Mincer, which helps explain why he became the NHE's leader (Fuchs 1983, 1994). The following story by Jim Heckman captures the great respect given to Becker at Columbia's labor workshop in 1971<sup>14</sup>: "By the time I attended the workshop the room was filled up. There was one chair at the head of the table and I sat there. As soon as I sat down a howl went up from the senior faculty. They said 'That's Gary's chair—you can't sit in it.' Becker had just left that year to go to Chicago and a vacant seat was kept to honor his presence. The next year the seminar moved to a new room and the honorary chair was abandoned."<sup>15</sup>

While both Mincer and Becker tried to minimize the role played by political and ideological considerations, they differed in their adherence to strategies aimed at separating politics from academic pursuits. Mincer was and remains very adamant about avoiding political discussions during professional interactions.<sup>16</sup> The supply of smart students to the NHE benefited from a policy of avoiding discussion about politics around the labor workshop. This policy, which Mincer continued to enforce until his retirement, facilitated fruitful cooperation among people—men and women—with diverse political opinions and personal lifestyles. In turn, a large number of students chose to study NHE.<sup>17</sup>

As a result, even though it was known that both men were politically conservative, students and faculty inclined to different views felt comfortable working with them at Columbia.<sup>18</sup> Some of the students who ended up working with Mincer or Becker on NHE-related research at Columbia in the late sixties and early seventies were women sympathetic to feminist causes.

Although men and women were equally represented in the labor workshop at Columbia, they tended to differ in their research interests. Women were generally more interested in dissertation topics dealing with labor supply,<sup>20</sup> whereas men were more likely to write on such subjects as marriage and health production in the home.<sup>21</sup>

The growth of the NHE in New York in the sixties and early seventies was not limited to Columbia. A group of high caliber researchers from the City University of New York also entered the field of household economics during that decade, including Finis Welch and James Smith, who contributed to research on women's labor supply, and Victor Fuchs (1983), who contributed to health economics and a number of other topics related to the NHE. The fact that the NBER was then located in New York facilitated communication and collaboration between NHE scholars on different campuses, thereby lowering the costs of empirical research. Mincer and Becker spent much time at the NBER during this period.<sup>22</sup>

## 7.2. THE NHE AND HOUSEHOLD ECONOMICS AFTER 1970

Becker's move to the University of Chicago necessarily weakened the quality of the collaboration between Mincer and Becker and led Columbia to lose its prominence in household economics. While gaining prominence in the field, Chicago

never played as crucial a role in the development of household economics as the role Columbia had played in the sixties. Both Mincer and Becker continued to contribute to the NHE as its influence spread. The transformation of traditional home economics departments into human ecology departments facilitated this process, and part of their subject matter became integrated into economics. The excitement of the creation of a new field of economics wore off, possibly leading Mincer, Becker and potential students towards other fields of application.

Another factor influencing the development of household economics in the U.S. after 1970 was the success of feminism in raising women's awareness of their economic interests as women, which in turn led men to become more aware of their own interests. Given that men have been the predominant practitioners of economics, their perspectives have, until recently, dominated the analysis of family interactions. In the 1970s, household economists influenced by feminism (typically women) began to question models that assumed stereotypical gender roles, as was the case with the early models developed by Mincer and Becker.<sup>23</sup> The result was a polarization of household economics, with most NHE contributors influenced by Mincer and Becker on one side, and feminist economists on the other.

### 7.2.1. Chicago

Starting in 1973, Becker published his theory of marriage, which he had begun writing while at Columbia (Becker 1973, 1974a; see also 1981). Becker's theory of marriage differs significantly from the model of household allocation of time that he had published earlier (Becker 1965) in that it assumes maximization of individual utility (rather than household utility) and includes the assumption of competitive marriage markets. Becker's insight that individual women and men face an indeterminate distribution of consumption in marriage, depending on marriage market conditions, opened the door to new theories of intra-household allocation, theories that assume that allocation of income inside the household involves individual agency.<sup>24</sup> Although bargaining theories are often presented as alternatives to NHE, they are in fact compatible with Mincer's (1962, 1963) econometric specifications and with Becker's theory of marriage.<sup>25</sup>

In striking contrast to the relatively large number of American-born women at the labor workshop at Columbia in the sixties, after 1970 very few women came to work on NHE topics with Becker at Chicago. This dearth may be related to the small number of women Ph.D. candidates there, given women's tendency to be interested in household economics. Although more women entered Chicago's Ph.D. program in economics in the 1980s, the number of women interested in writing dissertations on household and labor economics at Chicago did not grow much. This is especially the case for women born in the U.S.

The proportion of male students interested in researching household economics with Becker did not diminish as much as that of female students. Men who performed NHE-related research under Becker's guidance at Chicago in the 1970s include U.S.-born Michael Keeley (1979), Lawrence Kenny (1983), and Richard Burkhauser, and U.K.-born Chris Robinson and Nigel Tomes. One of Becker's

NHE male students in the 1980s was Laurence Iannaccone, a specialist in the economic analysis of religion (see e.g. Iannaccone 1998). Among the students specializing in household economics at Chicago in the 1990s were Michael Brien and Kermit Daniel. In his dissertation, Daniel set out to prove that marriage does not make men more productive, but ended up recognizing that it does (see Daniel 1995). Of these men, most of those who stayed in academics quit NHE research. Others left academic life altogether.<sup>26</sup>

That relatively fewer women wrote dissertations on household economics with Becker at Chicago than at Columbia does not seem to be due to a lack of female role models at Chicago. It is true that for most of the period 1970–2005, Becker's workshop at Chicago did not include a tenured or tenure-track female faculty member.<sup>27</sup> However, there were no female professors at the labor workshop at Columbia either, and nevertheless a large proportion of the participants were female. It is also difficult to explain this fact in terms of lack of exposure to household economics. Courses on household and family have continued to be offered, including courses by Becker, Chiappori, and Heckman, although the NHE did not continue to receive the same emphasis: it had been central to courses taught at Chicago by H. Gregg-Lewis, Gilbert Ghez, and Jacob Mincer, between approximately 1970 and 1975. (The cohort who took their preliminary examination in labor economics in 1974 was the last one to be taught courses heavily influenced by the Mincer/Becker style NHE.) Since 1975, labor economics at Chicago has principally been taught by Pierre-Andre Chiappori, James Heckman, Edward Lazear, Kevin Murphy, Derek Neal, Sherwin Rosen, and Robert Topel, labor economists who generally did not place as much emphasis on NHE models.<sup>28</sup>

A possible explanation for the decrease in the proportion of women studying with Becker after his move to Chicago is that some women opposed some of the materials that he published after the move. For example, Bergmann (1995) and Woolley (1996) have criticized Becker's (1976) use of examples of male altruists and female egoists. Furthermore, there have been critiques by feminist economists and bargaining theorists of marriage of Becker's (1976) model of altruism as a justification for the unitary utility models of the household characteristic of NHE articles published in the 1960s (see Pollak 2003). Bergmann (1995) and Woolley (1996) have also been critical of some ideas found in Becker's *Treatise on the Family* (1981) and Becker (1985), such as his attribution of higher divorce rates to gains in women's earning power relative to men's. Another explanation is that Becker moved on to other topics, which then became of more interest to students.

The supply of foreign-born women Ph.D. candidates to Becker-style NHE did not decrease until later. In the early and mid 1970s a few foreign-born women wrote NHE-related dissertations with Becker at Chicago, including Ivy Papps, Michele Riboud, Indian-born Indra Makhiya (1977), and the author, who had come from Belgium and Israel.<sup>29</sup> Papps returned to the U.K. and made a number of contributions to household economics, e.g. Papps (1980). Riboud returned to France and has written on women's labor supply (e.g. Riboud 1985). It is possible that foreignborn women were less aware of the gender politics at work in the US



and were less exposed to feminism at the time, and therefore did not feel the same hesitation about NHE research.<sup>30</sup> By the mid-1980s, more women (both American-born and foreign-born) came to study economics at Chicago, but few of them specialized in household economics. One of the few female students at Chicago in the 1980s who specialized in household economics is Elizabeth Peters, who wrote on the economics of divorce under the principal guidance of Robert Michael (see Peters 1986).

While the NHE, with its core set of household decision-making models developed by Mincer and Becker, lost some of its influence at Chicago, other household decision-making models were taught and made their way into students' dissertations. For example, Heckman taught a course on household production that included many models other than the NHE models, and Chiappori taught courses on collective models of household decision-making.

### 7.2.2. Columbia

Becker's move to Chicago not only decreased the number of students drawn to study NHE with Becker at Chicago, it also led to a decline in the number of students entering the NHE at Columbia, where Mincer remained at the helm of the labor workshop. During his short stay at Columbia in the early 1970s, Heckman helped Mincer recruit students with an interest in the NHE and served as adviser on a number of NHE dissertations.<sup>31</sup> At Columbia, a number of women who had studied at Columbia and took jobs in the New York area continued to be regular participants in Mincer's workshop. They include Linda Edwards, Marjorie Honig, and Cordelia Reimers. Prospective female students at Columbia would not have gotten the impression that NHE is for men only. However, Mincer never co-authored any papers with (former) female students. On NHE research, he has collaborated with Solomon Polachek (Mincer and Polachek 1974) and Haim Ofek (Mincer and Ofek 1982). The fact that, since 1970, very few women entered the NHE production lines either at Columbia or Chicago suggests that a 'women as role models' hypothesis does not explain much about the flow of students entering the NHE.

Would household economics have developed differently had Mincer and Becker stayed together at Columbia? One can speculate that the physical distance between the two researchers who had been so productive together hurt the development of their school of household economics.

### 7.3. LESSONS FROM COLUMBIA AND CHICAGO

Some of the factors that explain Columbia's success in the sixties can't possibly be reproduced. The personalities and talents of Mincer and Becker are totally unique, and so was the synergy surrounding them when they were colleagues. The low age at marriage leading to large proportions of married students, another ingredient in the success of the NHE, is also impossible to reproduce. However, the following factors that help explain Columbia's success could be reproduced.

### 7.3.1.1. *A Concentration of Scholars*

The geographic concentration of economists interested in researching the household was an asset that benefited the development of the NHE at Columbia. During the sixties, household economics was concentrated not only at Columbia, but also in the New York area, in part thanks to the presence of the NBER in New York. Any attempt to reproduce the rapid growth that household economics experienced in the sixties requires concentration of talented researchers with an interest in household economics. The field can be promoted through a hiring policy that places emphasis on specialization in household economics and related areas of research. While the advantages of geographical concentration may have dwindled in an age of global communication, these advantages continue to exist, as can be noted from the tendency of major research departments to concentrate on just a few fields of application.

One reason Columbia's NHE program grew fast is that it attracted scholars of various backgrounds: men and women with and without strong training in mathematics. Also, at that time Columbia's economics department was among the top 10 in the U.S. and it had a workshop system offering students opportunities for more active participation in the development of ideas than is usually offered to students. The workshop system had been introduced not long before at Chicago (by Milton Friedman), and was not widely used at that time. This gave Columbia's labor workshop an edge over the competition.

### 7.3.1.2. *Organizational Support*

The presence of the NBER in New York in the sixties not only increased the geographic concentration of scholars interested in the NHE; given the influence that Mincer and Becker had at the NBER at the time, the agency also contributed organizational support. After the NBER moved to Cambridge, household economics lost advocates in high positions.<sup>32</sup> Harvard and MIT have not shown much interest in household economics.

### 7.3.1.3. *Motivated Researchers*

A successful research program in household economics aims at attracting all the talent it can get, male or female, conservative or liberal. Encouraging entry into the field implies taking advantage of the idealism that can lead people to research in household economics. The household economics program at Columbia benefited from the availability of researchers interested in studying household decisions. This was partially the result of the relatively large presence of married men and women participating together in courses and workshops. The theories of home production that Mincer and Becker developed were more likely to appeal to people with first-hand experience of marriage and family than to people lacking such experience.<sup>33</sup>

By the seventies, few students entering graduate programs in economics were married. That the flow of married foreign students entering household economics at Chicago decreased less than the flow of entering married U.S.-born students is one of the explanations for the high percentage of foreign-born students among

those entering the NHE at Chicago in the seventies. Since the 1980s, this ‘marriage effect’ influencing entry into household economics has weakened as graduate students are increasingly single and childless, regardless of their country of origin.

The motivation to enter household economics can also come from personal exposure to lifestyles that are alternatives to the traditional lifestyles assumed in the early NHE models. In recent years, the development of household economics has benefited from the work of economists motivated to some degree by a desire to change household-related institutions. Many of these economists have written critiques of Becker’s work, including feminist economists.<sup>34</sup>

#### *7.3.1.4. Diversity*

Diversity is a side-effect of opening doors to a large pool of talent. In this instance, as in many others, diversity may create positive externalities. Researchers who take very different approaches to questions posed in household economics may benefit more from working together than scholars who share the same background. Diversity among researchers in the same department is likely to lead individual scholars to refine the presentation of their ideas. However, it may not be easy to achieve collaboration and professional interaction between people who have very strong and divergent opinions. Differences in personal lifestyles may create tensions and impede collaboration. Nonetheless, whether the perspectives compete with or complement each other, interaction among researchers with different perspectives is likely to be productive. One justification for the existence of research institutions is that they generate productive scholarly interactions. While diversity of perspectives on household economics is not solely a matter of gender, gender differences in individual interest in the subject matters of the NHE are likely to be a major source of differences in perspective on household economics. As was the case with the NHE at Columbia in the sixties, a program is likely to benefit from the presence of diverse perspectives on household decision-making, including the diversity of points of view usually taken by men and women. When an academic program in household economics includes male and female economists, a stimulating degree of diversity is more likely to be present than if the environment is all-male or all-female.

Today, departments of economics produce insufficient opportunities for intellectual cross-fertilization and debates among diverse specialists in household economics. Most departments include few economists of the household, and if they do, they tend to hire fellow economists with similar training. Even where there is a group of household economists, it is typically too homogeneous to produce much cross-fertilization. That homogeneity occasionally takes the form of gender homogeneity.

#### *7.3.1.5. Policy De-emphasizing Gender-related Politics*

Columbia’s NHE benefited from Mincer’s strict insistence that politics—including gender politics— not be discussed in the hallways and conference rooms at Columbia.

This policy may have facilitated cooperation among a diverse group of scholars. It is possible that had Becker been away from the influence of his outspoken conservative colleagues at Chicago, Milton Friedman and George Stigler, he may have continued to adhere to Mincer's policy of strict avoidance of political discourse, and more students would have been drawn to household economics.

#### 7.3.1.6. *Workshop Atmosphere*

Collaboration requires an atmosphere of acceptance of different opinions and respect for other ways of thinking. In Chapter 4, Becker recognizes the importance of shared values among the two leaders of the labor workshop that gave birth to the NHE and other applications of Modern Labor Economics.

### 7.4. CONCLUSIONS

Household economics benefited greatly from the contributions of Mincer, Becker, and their students at Columbia in the 1960s. This chapter has identified factors explaining the success of Columbia's labor workshop started by Mincer and Becker, the birthplace of the NHE, and other applications of Modern Labor Economics. More research is needed on the history of household economics and on the role played by Mincer, Becker, and their students in the development of this sub-discipline of economics.

### NOTES

1. These students include Andrea Beller, Barry Chiswick, Linda Edwards, Marjorie Honig, Michael Grossman, and Cordelia Reimers.
2. Lancaster was also at Columbia at that time.
3. After he completed his doctorate at Columbia in 1957, Mincer held a post-doctorate at the University of Chicago.
4. A good part of the research for which he was awarded the Nobel Prize in Economics in 2000 is NHE related.
5. Personal communication from Jim Heckman.
6. Personal communication from Jacob Mincer.
7. Assumptions of combined household consumption and production functions as in Becker (1965), Dennis DeTray (1973), Robert Willis (1973), Arleen Leibowitz (1974), and Robert Cherry (1998); assumptions of individual consumption and individual production functions as in Grossbard (1976), Grossbard-Shechtman (1984), Frances Woolley (1988) and Shelly Lundberg and Robert Pollak (1993); assumptions of individual consumption and household production functions as in Marilyn Manser and Murray Brown (1980) and Marjorie Mc Elroy and Mary Jane Horney (1981); and assumptions of individual consumption and no household production as in Pierre-André Chiappori (1992).
8. The students who attended the labor workshop at Columbia in the 1960s include Andrea Beller, Barry and Carmel Chiswick, Linda Edwards, Alan Freiden, Gilbert Ghez, Reuben Gronau, Michael Grossman, Masanori Hashimoto, Marjorie Honig, Shirley Johnson, Ruth Klinov, Jean Claude Koene, Elizabeth Landes, Arleen Leibowitz, Cynthia Lloyd, Robert Michael, Beth Niemi, Haim Ofek, June O'Neill, John Owens, Jacob Parush, Solomon Polachek, Frederika Pickford-Santos, Cordelia Reimers, Mark Rosenzweig, and Harriet Zellner.
9. Personal communication from Jacob Mincer.
10. Personal communication from Jim Heckman.
11. In 1970 the average age at marriage for women was 21.8 years. By 1988 it had climbed to 25.1 years (see John Weeks 1999).
12. This includes Arleen Leibowitz and Cordelia Reimers.
13. This includes Barry and Carmel Chiswick, Bill and Lisa Landes, and Dave and June O'Neill.

14. This occurred in 1971, the year that Becker left Columbia permanently and Heckman arrived as an assistant professor. Becker had been in Chicago as a visiting professor in 1969.
15. Personal communication from Jim Heckman.
16. Personal communication from Jacob Mincer.
17. In accordance with his strategy of not letting politics interfere with professional interactions, Mincer was unaware that any of his former students might have been feminists.
18. Personal communication from Jacob Mincer and former students at Columbia.
19. In accordance with his strategy of not letting politics interfere with professional interactions, Mincer was unaware that any of his former students might have been feminists.
20. As in the cases of Andrea Beller (e.g. Beller 1979), Cordelia Reimers, and Marjorie Honig. More recently, Beller has switched to topics more obviously related to household economics, such as Beller and John Graham (1993).
21. They include Alan Freiden, who wrote an analysis of marriage (1974), and Michael Grossman, who examined health production in the home (1976). Other students who helped expand the scope of the NHE were Reuben Gronau (1973, 1977), Robert Michael (1973), Arleen Leibowitz (1974), and Fredericka Pickford-Santos (1970).
22. Personal communication from Barry Chiswick.
23. See, e.g., Bina Agarwal (1997), Lee Badgett (1995), Barbara Bergmann (1987, 1995), Ferber and Birnbaum (1977), Julie Nelson (1995), Janet Seitz (1991), and Diana Strassman (1993).
24. See, e.g., Grossbard (1976), Manser and Brown (1980), McElroy and Horney (1981), Grossbard-Shechtman (1984), Frances Woolley (1988), Chiappori (1992), Shelly Lundberg and Robert Pollak (1993), and Grossbard-Shechtman (1993).
25. It is no coincidence that Marjorie McElroy published her bargaining theory of marriage soon after a post-doctoral fellowship at the University of Chicago upon Becker's invitation (personal communication from Gary Becker).
26. Keeley and Brien became consultants, Tomes disappeared from academic life to become a Protestant minister, and Kenny became a public choice theorist.
27. In the seventies, the only exception was Margaret Reid, who attended Becker's workshop regularly. However, by then she had long passed retirement age and had little contact with students.
28. Lazear, who started the *Journal of Labor Economics* in the 1980s and the Society of Labor Economists in 1995, and stayed in Chicago until the mid-nineties, has done much to promote business-oriented labor economics. (Most labor economics that is not household economics can be viewed as part of personnel economics.)
29. Chilean-born Evelyn Lehrer also entered the field in the seventies and studied at Northwestern with Marc Nerlove, who had just left Chicago.
30. For instance, I came to Chicago from Israel, where feminist ideas were less popular among professional women in the early 1970s than was the case in the U.S. Foreign-born women were also more likely to be married than US-born women.
31. Including the dissertations of Andrea Beller and Fredericka Pickford-Santos.
32. Nevertheless, a NBER program in health economics directed by Michael Grossman remained and continued to grow in New York.
33. For instance, Arleen Leibowitz, one of the most successful women who entered the NHE at Columbia, was writing on home production of childcare while she and her husband were raising their own children. Fredericka Pickford-Santos wrote about the decision to marry around the time she married a fellow student in economics. Reuben Gronau and Chaim Ofek were married fathers while engaged in their studies.
34. For instance, Barbara Bergmann, an active promoter of egalitarian marriage; and Lee Badgett, concerned with the neglect of same sex and blended family in the social science literature.

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**PART III. JACOB MINCER ON TECHNOLOGY**



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## 8. TECHNOLOGY AND THE LABOR MARKET

BY JACOB MINCER

### ABSTRACT

*Economic developments of the past 3 decades posed new questions to economists: What are the causes of fluctuations in rates of return to human capital? What is the relation between the changing skill-wage structure and changing overall wage inequality? Does the widening of the wage structure produce an equilibrating supply response? What are the causes, dimensions and implications of the “technological cycle” for wages, unemployment, and its “natural rate”? Why is the long term trend of human capital formation relentlessly upward?*

*My research of the past decade, among that of other economists, attempted to provide answers to these questions, as described above. In the course of the analysis several misconceptions are clarified: (1) The view of an increasing “wage gap” as a worsening “social divide” misses the incentive effects of the increased rates of return on furthering investments in human capital. These are empirically documented. (2) Growing overall wage inequality can conceal a declining inequality of opportunity as it did in recent decades. (3) Technological unemployment as an aggregate phenomenon appears to be a myth. (4) The concurrent supply response to increasing demand for human capital applies to investments, not to the stock. The accumulation of investments (such as enrollments) over time produces a lag in the response of the human capital stock. This lag is a basic cause of the “technological cycle”.*

*Finally, it is worth noting that a positive skill bias is not inherent in technological changes. These may sometimes carry a negative effect on the demand for human capital. The implications of “deskilling” (the assembly line is an example) would be the opposite of what we found for the recent decades (1970–2000). However the long-term growth of human capital suggests a positive skill bias in the long run.*

### 8.1. INTRODUCTION

Much of my research in the past decade was an exploration of the impact of technological change on the labor market. Findings of this research reveal effects of

technical change on the demand for human capital, on changes in the skill structure of the wage distribution, as well as on overall wage inequality. The analysis was guided by and applied to empirical developments in the U.S. economy between the 1960's and 1990's.

Sporadic data available between 1950 and 1970 showed no significant changes in rates of return to education. Measured by the “educational wage premium” –the percent gain in wages resulting from an additional year of schooling– returns to education fell in the 1970's but turned upward very steeply in the 1980's reaching a high plateau in the 1990's with a slight intimation of an incipient decline.

The course of total wage inequality followed the increases in the wage differentials by skill after 1980. In the 1970's: “wage premia” declined, yet wage inequality increased. The contrasting movements in the 1970's were noted by economists, but remained unexplained<sup>1</sup>. My resolution of this apparent puzzle is shown in section 3 below.

The series of questions prompted by these developments are stated in the section headings. The findings and conclusions are summarized in the last section 7.

In section 8.2 I describe an analysis of changes in the skill structure of wages –the inter-group component of wage inequality. The other, intra-group “residual” component, is taken-up in section 8.3 as part of the analysis of total wage inequality. Inequality is measured by the variance of logarithms of wages, that is of relative (percentage) wage differentials across workers.

By and large, there is a consensus in the literature analyzing changes in wage inequality about the importance of shifts in supply and demand for human capital and the technological origin of the skill biased increases in demand.<sup>2</sup> There is less agreement on the importance of other factors in the changing wage structure, such as the growth of international trade, of immigration, and of the decline of unionism.

In section 8.3 I use the human capital definition of wages (as return on the stock of human capital) to decompose the total variance into “between” and “within” group differentials.

Following Gary Becker (1967) the key to understanding changes in the within group or “residual” variance is a disaggregation of human capital demand ( $D_i$ ) and supply curves ( $S_i$ ) to the individual level. It shows that the skill structure (between group wage differentials) is affected by shifts of the two sets, while the residual variance is affected by the changing spread (vertical distances) among individual ( $D_i$ ) and ( $S_i$ ) (see Fig. 8.2).

Did the supply of human capital respond to changes in rates of return? Section 8.4 is devoted to that question. The answer is sought in investments in human capital (in education and training) and not directly in supply of the total stock. The latter is accumulated by investments over a long period.

Section 8.5 looks at effects of technology other than those on wage differentials. Unemployment rates are smaller at higher levels of skill. Skill differentials in unemployment are affected the same way as wage differentials: Skill biased increases in demand widen the unemployment structure. The ratio of unemployment rates of unskilled to skilled workers increases in the short run, but declines in the longer run when time for a supply response (mainly in training) is allowed. Compared to wage

dynamics, the relative unemployment changes are faster: they take about half the time compared to wage changes.

Section 8.5 explores also the effect of technology on aggregate unemployment and on inflation. Other factors, such as maturing of the labor force, and growth of international trade are factors working in the same direction as technology. A question mark applying to the “natural rate of unemployment” is noted.

Section 8.6 considers secular trends in levels of human capital as distinguished from long technological cycles, which are superimposed on the trends. Rates of return to human capital appear to fluctuate around a roughly horizontal trend, but volumes of human capital, persistently trend upward, educational attainment being the clearest example. The reasons for trending are explored in this section as effects of economic growth.

Nothing in these analyses contradicts the proposition that growth of human capital is not merely a consequence of economic growth, but also a determinant of it, in two senses: Scientific knowledge provides the basis for technological innovation, and an educated, skilled labor force can handle the innovations efficiently. As both cause and effect, human capital ensures sustained economic growth.

## 8.2. WHAT EXPLAINS CHANGES IN THE SKILL STRUCTURE OF WAGES?<sup>3</sup>

Data on earnings and their relation to education were scarce prior to 1950 (but see Claudia Goldin and Lawrence Katz, 1999, for this period). Available evidence for the period 1950–1970 indicated stability in wage inequality<sup>4</sup> and in the skill structure of wages. Aside from research into the incidence of poverty, interest in the subject of wage inequality disappeared from view prior to the 70’s. Reasons for stability were not questioned. As Jan Tinbergen (1975) maintained, stability of rates of return to human capital (therefore of the skill structure of wages) despite the growth of human capital was understood as the outcome of an evenly matched race between technology (the source of demand) and education (the main supply). Hypotheses of complementarity of human with physical capital (Zvi Griliches, 1969) and with technological innovation (Richard Nelson and Edmund Phelps 1966, Finis Welch 1970, Theodore W. Schultz, 1975) explained the demand side. Growth of income, including educational subsidies, moved the supply side.

The assumed stability reflected in fragmentary data before 1970 did not invite empirical research. It was not until the late 70’s when narrowing of the skill wage structure suggested “overeducation” as a cause (Richard B. Freeman, 1979). The widening of the skill wage differentials thereafter, all visible in annual data, posed a challenge for human capital analysts, especially labor and education economists. The U-turn in the rates of return to education and the growing inequality in wages became major topics of research starting in the early 90’s.

On closer examination “educational wage premia” grew somewhat (from 7% to 9%) in the 1960’s, declined to 5% in the 1970’s, and rose dramatically in the 80’s reaching a high plateau of around 15% in the 90’s.

**Table 8.1.** Time series regression of rates of return

	Logs	Levels
Intercept	-7.52 (0.97)	-0.025 (0.010)
RDE <sub>-2</sub>	0.88 (0.15)	7.9E-5 (1.1E-5) *0.96*
RSG	1.03 (0.22)	0.033 (0.005) *1.07*
RSY <sub>-2</sub>	-0.70 (0.16)	-0.003 (0.0006) *-0.71*
Adj R <sup>2</sup>	0.69	0.81
Period	1957-90	1957-90

Notes: (standard errors in parentheses; elasticities in asterisks)

VARIABLES

Dependent  $r_t$  = for workers with 6-10 years experience, the log of the ratio of the average real wage of those with schooling years equal to 16 over those with schooling years equal to 12; March CPS tapes for 1963-1990; patchwork backwards using Mattila to 1995

RSG ratio of service employment to goods-producing employment; US; Economic Report of the President, 1993

RDE<sub>-2</sub> per-worker expenditure on research and development; lagged two years; 1982 dollars

RSY<sub>-2</sub> percent of population 25-29 years old who have 16 or more years of schooling

By now a consensus has emerged that the decline of the rate of return to education in the 1970's was mainly due to the rapid influx of the baby boom generation of college graduates into the labor market, and the steep rise of the rate of return in the 1980's was due primarily to increases in skill-biased demand for labor, while supply (educational attainment) remained stagnant in the 1980's. International competition in low skill intensive products, the growth of unskilled immigration, and the decline of union density played some, though apparently minor parts in the changing wage structure. Inferences about the technological origin of increases in the demand for skilled labor were mainly of a residual sort. More direct empirical work was provided by Ann Krueger (1993) who estimated the contribution of computerization to the growth of educational wage differentials in the 1980's. My own work (1991, 1993) utilized information on R&D intensity as the demand shifter covering the period 1955 to 1990. This variable grew in the 1960s, stagnated in the 1970's and grew rapidly in the 1980's.

Table 8.1 shows the results of regression equations which best performed in explaining the variation over time in the college "wage premia". As shown in Figure 8.1, these premia were closely tracked by relative supplies of college graduates (RSY) with negative sign and positively by changes in relative demand for educated workers. The latter was indexed by annual research and development expenditure per worker (RDE) as well as by trends in relative service employment (RSG). RSY and RDE are lagged two years. Of all the factors, RDE accounts for most of the

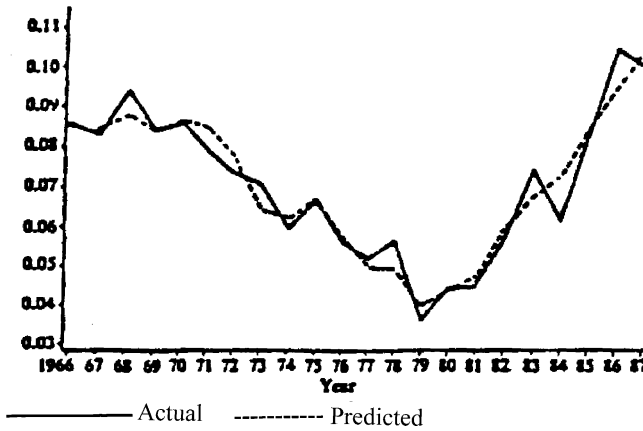


Figure 8.1. Actual and Predicted Rates of Return to College.

explanatory power. According to auxiliary regressions, other variables exerted minor effects, if any. Some regressions attribute skill-biased growth of demand to complementarity of skill with capital (Griliches 1969). But, the skill-bias of new equipment may not represent anything different than the effects of new technology embodied in the equipment.

### 8.3. WHAT EXPLAINS CHANGES IN WAGE INEQUALITY?<sup>5</sup>

Between-skill-group inequality, analyzed in the previous section, is a part of overall inequality. The other part due to within skill group differentials must be considered in order to understand the course of overall wage (interpersonal) inequality. This total grew since 1970, despite the decline in the skill wage premia in the 1970's, though in consonance with their movements after 1980. This is not surprising as the residual (within group) variance is observably larger than the variance in the skill structure (between group). The puzzle noticed earlier but not resolved, is the contrasting movement of the two-variance components in the 1970's.

A human capital decomposition of wage inequality, is helpful in resolving the puzzle. Define wages (in logarithms) as the return on the stock of human capital (Jacob Mincer 1974):

$$\ln w_{ij} - r_{ij}K_{ij} = r_i(s_i + K_{pij}) \quad (1)$$

Here  $i$  denotes individual,  $j$  his working age.  $K_{ij}$  contains schooling ( $s_i$ ) in time units, and post-school investments ( $K_{pij}$ ) measured in "time equivalents", which are ratios of investment costs to earnings.  $r_i$  is the individual rate of return on the accumulated human capital stock.

At a particular working age ( $\hat{j} \cong 1/r_i$ ) called the “overtaking age”, post-school investment costs are exactly offset by returns, so  $(r_i K_{pij}) = 0$ . Consequently eq. (1) becomes

$$\ln w_{ij} = r_i s_i \quad (2)$$

At that stage wages are a function of education only (Mincer 1974).<sup>6</sup> Here the variance of log wages is the variance of the product  $r_i s_i$ , and according to Leo Goodman (1960):

$$\begin{aligned} \sigma^2(\ln w_{ij}) &= \sigma^2(r_i s_i) = \bar{r}^2 \sigma^2(s) + \bar{s}^2 \sigma^2(r) + \sigma^2(s) \sigma^2(r) \\ &= \bar{r}^2 \sigma^2(s) + \sigma^2(r) [\bar{s}^2 + \sigma^2(r)] \end{aligned} \quad (3)$$

The expression (3) holds when  $r_i$  and  $s_i$  are independent. If they are correlated the variance is augmented or reduced depending on the sign of the covariation (bars denote averages). The correction factor  $\rho$  is the added (or subtracted) term in (3):

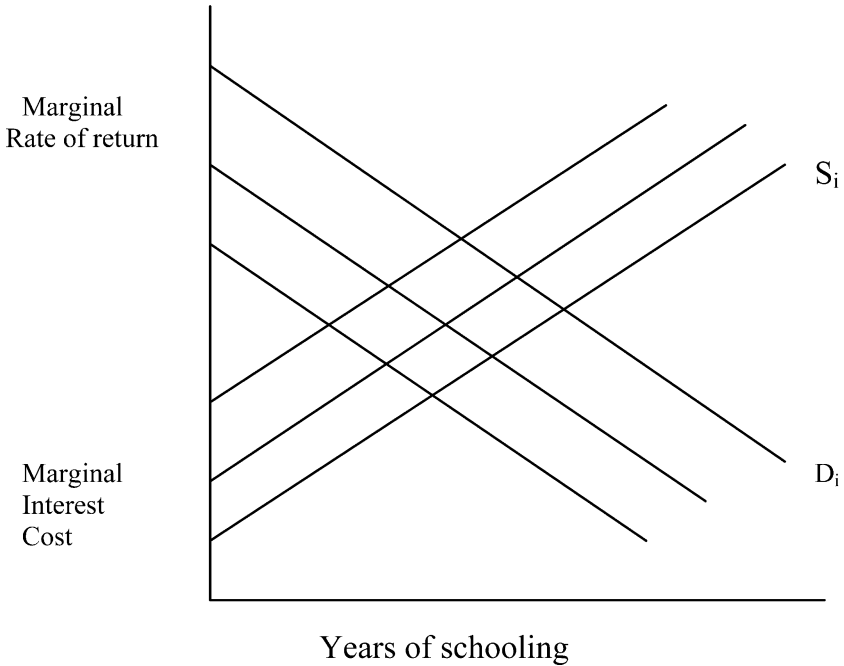
$$\sigma^2(r_i s_i) = \bar{r}^2 \sigma^2(s) + \sigma^2(r) [\bar{s}^2 + \sigma^2(s)] + \rho \quad (3a)$$

The first term in (3a) is the variance between groups differing in schooling ( $s_i$ ) which can be calculated or estimated by a regression of  $\ln w_{ij}$  on  $s_i$  for workers at the “overtaking stage.”<sup>7</sup> The remainder is the residual variance, or variance within schooling groups,  $\sigma^2(u)$ .

$$\sigma^2(u) = \sigma^2(r) [\bar{s}^2 + \sigma^2(s)] + \rho \quad (4)$$

Note that the group average “wage premium”  $\bar{r}$  enters only the “between group” variance  $\bar{r}^2 \sigma^2(s)$ .  $\sigma^2(s)$  was rather stable over the 1970–1990 period. Hence, there is no arithmetical reason to expect the movements in the two component variances to be in the same direction. In the 70’s  $\bar{r}$  declined and increased thereafter, while  $\sigma^2(u)$  increased in the ‘70’s because  $\bar{s}$  and  $\sigma^2(r)$  increased. In the 80’s  $\sigma^2(u)$  continued to increase because  $\sigma^2(r)$  and  $\rho$  increased (Mincer, 1997).

Sources of the U-shaped changes in between-group inequality were spelled out in section 8.2 as skill-biased technology and demographic change (the “baby boom”). The sources of growth of the residual variance, its components in eq. (4) can be explored by disaggregating the sets of demand curves ( $D_i$ ) and supply curves ( $S_i$ ) to the individual level (as in Becker 1967). Fig. 8.2 portrays the sets (simplified to parallel straight lines). Intersections of individual  $D_i$  and  $S_i$  determine the values of  $r_i$  and  $s_i$ . The intersection of averages of  $D_i$  and  $S_i$  yield  $\bar{r}$  and  $\bar{s}$ , and from the individual intersections we can read off  $\sigma^2(r)$  and  $\sigma^2(s)$  as well as  $\rho$ , the latter proxied by the linear covariance, as shown in Mincer (1997). One or more of these components had to grow over time in order to account for the growth of the residual variance, according to eq. 4. (The growth of  $s$  accounted for a small part of it.)



**Figure 8.2.** Sets of demand curves ( $D_i$ ) and supply curves ( $S_i$ ) at the individual level.

$$\sigma^2(r_i) = (1 - \gamma)\sigma^2(d_i) + \left(\frac{\gamma}{2}\right) [\sigma^2(d_i) + \sigma^2(c_i)] \quad (5)$$

$$\sigma^2(s_i) = \left(\frac{\gamma}{b}\right)^2 [\sigma^2(d_i) + \sigma^2(c_i)] \quad (6)$$

$$\text{cov}(r_i; s_i) = (\gamma/b)[\sigma^2(d_i) - (\gamma/2)[\sigma^2(d_i) + \sigma^2(c_i)]] \quad (7)$$

Here  $\gamma$  and  $b$  are constants with  $\gamma < 1$  reflecting slopes of  $D_i$  and  $S_i$ ;  $d_i$  and  $c_i$  are the vertical intercepts of sets of  $D_i$  and  $S_i$  respectively. The stability of  $\sigma^2(s_i)$  over time makes  $\sigma^2(d_i) + \sigma^2(c_i)$  also constant according to (6). So  $\sigma^2(r)$  grew only if  $\sigma^2(d_i)$  grew (by eq. 5), in which case  $\rho$  grew as well (by eq. 7), while  $\sigma^2(c_i)$  declined (by eq. (6)). Since  $\sigma^2(u)$  grew observably, as did  $\rho$ , but at a much lesser rate, the growth of  $\sigma^2(r)$  is a confirmed change due to widening among demand curves (growth of  $\sigma^2(d_i)$ ). This despite the narrowing among supply curves (decline in  $\sigma^2(c_i)$ ) implied in (6), which by itself would have caused a decline in the residual variance, contrary to fact.

Reinterpreting the changes we may conclude that the between group wage inequality is caused by the shifts of the whole set of demand and supply curves moving the average  $D_i$  and/or  $S_i$  (hence  $\bar{r}$ ) without necessarily widening or narrowing among individual  $D_i$  and/or  $S_i$ . The latter however, affect the residual variance, even without

shifts of the complete sets, that's even without changes in averages  $D$ ,  $\bar{s}$ , or  $\bar{r}$  (up or down). Empirically rightward shifts in the set of  $S_i$  in the 70's which narrowed the (between group) wage structure, were accompanied by widening among individual  $D_i$  which increased the residual (within group) variance. After 1980  $D_i$ 's moved up and widened, increasing both components of inequality.

Overall inequality increased in the 70's because residual inequality is the larger of the two component variances. Note that the stability of  $\sigma^2(s_i)$  implies (by eq. 6) that the variance among  $S_i$ 's narrowed,<sup>8</sup> reflecting increased equality of opportunity (as defined by Becker, 1967). This was masked by the observably increasing overall inequality.

#### 8.4. SUPPLY RESPONSES TO CHANGE IN DEMAND: REVERSAL OF WAGE GAP?<sup>9</sup>

As "wage premia" fell in the 1970's, the concurrent growth in inequality was a puzzle to analysts, as was more generally the apparently perverse behavior in the supply of human capital relative to changes in demand. Supply of human capital (as reflected in educational attainment) grew in the 1970's while rates of return to education fell during the decade. In the 80's wage premia started their steep climb, but educational attainment stopped rising.

Declining wage premia in the 70's are explainable by the largely exogenous increases in the supply of human capital due to the influx of better educated "baby boomers" into the labor market. But there has been no increase in attainment in the 1980's, while it appears that the need for a more highly skilled labor force accelerated as suggested by rising rates of return to human capital.

Economic theory predicts a positive supply response to increases in demand. What explains the non-response? A closer look at the data on education reveals a positive response as soon as we keep in mind the distinction between stocks of human capital (attainment) and investment flows (enrollment). It is the flows that *respond* to profitability, while the stocks accumulated over a number of years *affect* the profitability later on. Increased supply of human capital depresses rates of return, hence enrollment, while increased demand for human capital raises the rates and enrollments. So an increase in supply generates a subsequent decline (or deceleration) in supply while increased demand produces a subsequent increase in supply. Two implications follow: we can find the supply response empirically by observing the relation between rates of return and investment in education (enrollment), we can also estimate the lag between changes in demand and effective changes in supply.

Declines in the wage premium during the 70's resulted in declining college enrollments, and a barely moving level of attainment in the next decade, that is in the 80's. Large increases in the rate of return in the 80's produced strong increases in enrollments that led to growth in attainment in the 90's. The lag between enrollments and attainment of the entering labor force (age 25–29, or up to 10 years of work experience) is explainable by the long pipeline from high school graduation to college graduation plus a number of years in the labor force to build an impact on the labor market. The lag is estimated by the years it takes to maximize the statistical fit



**Table 8.2.** Enrollment rates (1967–1990)

Independent variables are 3-YR moving avgs	% of HS Graduates Enrolled Next Oct	% of HS Grads Enrolled Age 18–24		% of Population Age 18–24 Enrolled	
College Wage Premium	2.9 (5.1) *0.45*	1.3 (3.2) *0.31*	1.3 (4.3) *0.31*	0.77 (2.8) *0.23*	0.77 (3.6) *0.23*
Parental Education	3.7 (3.7) *0.84*	1.2 (1.7) *0.42*	1.2 (2.3) *0.43*	1.6 (3.4) *0.73*	1.6 (4.5) *0.74*
Tuition	-0.007 (2.9) *-0.81*	-0.002 (0.96) *-0.29*	-0.002 (1.1) *-0.26*	-0.0004 (-0.3) *-0.08*	-0.0003 (-0.3) *-0.06*
Intercept	27.7 (3.1)	18.8 (3.1)	18.8 (4.1)	3.2 (0.7)	3.2 (1.0)
Residual from first regression			0.46 (3.9)		0.32 (3.9)
R <sup>2</sup>	0.75	0.69	0.82	0.79	0.88

Notes: (t-statistics in parentheses; elasticities in asterisks)

Dependent variable sources:

Column (1): Condition of Education, 1992, Table 7–1

Columns (2–5): School Enrollment–Social and Economic Characteristics of Students: October 1992, P20–474

between enrollment and attainment. A close to a decade lag fitted best. A decade after the demand stimulus the effective increase in supply of young workers begins to exert a downward pressure on the wage premium.

The supply response is not perverse, it shows up almost a decade later after a sufficient accumulation of investments builds up the human capital stock. Following the steep climb of rates in the 80's supply kept growing in the 90's, and wage premia levelled off at very high rates (15%), reflecting continued shortages of supply.

The empirical evidence on the response of investment (enrollments) to the educational wage premia is shown in the results of three regressions in Table 8.2. The regressions are shown for three enrollment periods: % of HS (high school) graduates enrolled October after graduation, percent of HS graduates enrolled at ages 18 to 24, and enrollment as a percent of the population age 18–24. Investment in education responds positively to prospective rates of return, as well as to parental education and income. Income matters because of consumption aspects of education and because of imperfect capital markets for human capital. Parental education is an index of income as well as of preferences for educational investments. Net tuition costs (gross minus subsidies and earnings of students) are omitted in the “wage premia”. But they moved over time similarly to gross tuition costs, used in the regressions. The prospective profitability of education is best gauged by the wage premium of college graduates about 10-years older than the decision making high school graduates: The income stream at that working age (6–10 age of experience) is the expected permanent income due to investments in schooling alone. This is the “overtaking” stage

of work experience, which is minimally affected by job training (Mincer, 1974), on which I report below.

At all stages shown in Table 8.2, the enrollment response to wage premia is positive and significant, tuition has a weak negative effect, and parental education is positive. As the  $R^2$  indicate together the 3 variables track the time series of enrollment quite well. As already reported the accumulation of enrollments (investments) to attainment of the same cohort takes close to a decade. So enrollment growth in the 60's responding to growing rates of return produced the growth of attainment in the 70's, while the static (or declining) enrollments in the 70's (responding to declining rates of return) led to the plateau in supply (attainment) in the 1980's. In turn the growth of enrollment in the 1980's (responding to rapidly growing rates of return) led to increasing relative supplies of educated workers in the 1990's. In the late 90's the growth of relative supplies halted the growth of wage premia, at very high levels, indicating continued (but not growing) shortages of skilled labor.

#### 8.4.1. Job Training Responses

In the 1980's the growth of demand for human capital resulted in increased rates of return to schooling and induced positive supply responses in enrollments. Do we find corresponding changes in profitabilities and volumes of job training?

Several pieces of evidence yield affirmative answers: Indirect evidence on the growth of profitability and of volumes of job training is provided by the analysis of changing wage profiles over the 1964–1990 period. Direct evidence on the volumes (incidence) of job training is available in two comparable BLS Bulletins (1985, 1992).

Two basic factors affect the slope of the (cross-sectional) wage profile, that is, the magnitude of age (work experience) differentials in wages: (1) Increased profitability and/or volumes of job training steepen the profile over the early decade of experience. The slope equals  $rK_0$  where  $r$  is the profitability rate (rate of return) and  $K_0$  the annual fraction of time spent in training during the early years in the labor force (Mincer 1974). If demand for skill training increases, the coefficient of work experience ( $X$ ) should rise, reflecting increases in  $r$  and  $K_0$ . (2) Demographic changes (“baby boom and bust”) also resulted in changes in relative wages by age. As studies by Freeman (1979) and Welch (1979) have shown, the influx of large numbers of “baby boomers” into the labor markets of the 1970's steepened the slopes of the wage profiles: Increased relative numbers of young workers reduced their wages relative to older workers. However as the diminished “baby bust” cohorts entered the markets of the 1980's the profiles did not flatten. They remained steep for college graduates and steepened further for high school graduates. Empirical evidence in Table 8.3 shows (Mincer 1998) that both the growing profitability and/or use of job training, as well as demographic change affected the slopes of the profiles.

But the slope coefficient  $rK_0$  does not distinguish between profitability ( $r$ ) and volumes ( $K_0$ ) of training. Increases in rates of return  $r$  are clearly suggested by the increased educational wage premia. Direct evidence in Table 8.4 on volumes of training in the 1980's is available from two BLS surveys (1983 and 1992). Two

**Table 8.3.** Slope of wage profile\*\*

	High School	College
Intercept	-0.0165 (-2.9)	n.s.
r <sub>1</sub>	0.31 (7.8) *0.68*	0.12 (3.6) *0.27*
DR	0.06 (5.1) *0.61*	0.06 (6.0) *0.76*
U	0.0011 (5.2) *0.17*	n.s.
R <sup>2</sup>	0.91	0.60

Notes: (T-stats in parentheses; elasticities in asterisks)

All endogenous and exogenous variables are for males only. Two sets (one each for the two different columns above, corresponding to high school and college) of each of the endogenous and exogenous variables are used  
r<sub>1</sub> – rates of return to schooling

DR – ratios of number of workers of 1–10 yrs experience to all workers 1–40 yrs experience

u – unemployment rates for recent grads

\*\* rk at experience = 10 years, where r is the rate of return on post-school investments and k is the time-equivalent fraction spent acquiring those investments

**Table 8.4.** Skill improvement: sources

Year	All	School	OJT	Company	Other
1983	35%	12%	14%	11%	4%
1991	41	13	15	16	7

## Skill Improvement: Education and Age

Year	Education			Age		
	HS	SC	Coll	20–24	35–54	55–64
1983	26%	41%	54%	28%	41%	31%
1991	29	46	61	31	48	37

Source: Paul E. Barton, "Training to be Competitive", ETS Report, 1993

purposes of training were distinguished in the surveys: (1) Training needed to qualify for the current job, and (2) training to improve skills on the current job. While training requirements for job changed little, except increased preference for higher levels of education in 1991, training for skill improvement on the current job increased from 35% in 1983 to 41% for all workers in 1991. A major change was the relative increase in incidence and duration of formal company training programs. According to Ann Bartel and Nachum Sicherman (1998) formal company training programs are more closely related to technological change than are other forms of training.

### 8.5. OTHER CONSEQUENCES OF SPREADING NEW TECHNOLOGIES: UNEMPLOYMENT AND INFLATION<sup>10</sup>

The growth of skill-biased demand for labor which widens the skill structure of wages should for the same reasons affect the structure of unemployment, as measured by the ratio of unskilled to skilled unemployment rates. While growth of skill biased demand would at first widen the unemployment differentials, the supply response in skill training should subsequently tend to reduce these differentials, after some lag, which is due to increases of skills due to training of initially less skilled workers.

The unemployment rate ( $u$ ) can be expressed as a product of the incidence or probability of experiencing unemployment within a given period  $P(u)$  and of the fraction of the period spent in unemployment ( $D$ ). In turn  $P(u) = P(s)P(u|s)$ , where  $P(s)$  is the separation rate, while  $P(u|s)$  is the unemployment incidence among job changers, or the conditional probability of unemployment, given separation. The reduction in unemployment of trained workers is channeled through these components. We can expect a shorter duration of search ( $D$ ) as a result of increased opportunities, and a lesser incidence of unemployment  $P(u)$ , via reduction of turnover  $P(s)$  and/or  $P(u|s)$ . Firm or industry specificities in acquired skills reduce turnover. The conditional probability declines if layoffs decline more than quits do. This happens in business upswings, and also when a larger share of training costs is borne by employers rather than workers, a plausible case if technology changes rapidly, discouraging workers from investing in training soon to become obsolete, while firms prefer to invest in training when new hires of skilled workers become too costly.

Evidence in Micro Data:

We use the PSID (Panel Study of Income Dynamics) for micro data in which we can distinguish 38 2-digit industry sectors. Technology indexes are constructed for each, annually from 1980 to 1993. The full equation is

$$P(U) = \left( Tech, X, X2, Ed, \frac{NW}{Mar}, Nu, Eg, Union \right)$$

The same equation is used for each component of unemployment. We utilize two technology indexes (alternatively): Total Factor Productivity (TFP) and Computer per Worker ( $C/W$ ) for each of the 38 sectors. The independent technology variable is augmented by other variables that affect unemployment in order to estimate the net effects of the pace of technology. The first 5 independent variables are the “core” equation. The extended equation contains 4 additional variables. Here  $X$  is years of work experience,  $Ed$  years of schooling,  $NW$  race,  $Mar$  marital status,  $NU$  –national unemployment rate,  $EG$  –employment growth of the sector,  $Union$  –membership,. The equation uses lags of technology up to 9 years.

In Table 8.5 both the core and extended equations show negative effects of the pace of Total Factor Productivity (TFP) and of Computer per Worker ( $C/W$ ) on turnover  $P(s)$  and on the incidence of unemployment  $P(u)$ . Peak effects are 3 to 5 years following TFP growth, but longer lags are shown by the computer ( $C/W$ ) variable. The conditional unemployment variable  $P(u/s)$  is negative for the TFP

**Table 8.5.** Effects of technology on unemployment males, 1980–1993, in PSID cross-section

	<b>P(u)</b>	<b>P(s)</b>	<b>P(u s)</b>	<b>D</b>		<b>P(u)</b>	<b>P(s)</b>	<b>P(u s)</b>	<b>D</b>
<b>TFP, core</b>					<b>C/W, core</b>				
<b>Lags 0</b>	-0.31 (2.2)	n.s.	-1.36 (2.1)	-47.2 (2.1)	<b>Lags 0</b>	-0.76 (4.0)	-0.86 (3.5)	n.s.	n.s.
<b>3</b>	-0.38 (2.6)	n.s.	n.s.	n.s.	<b>3</b>	incr.	Incr.	n.s.	n.s.
<b>5</b>	-0.34 (2.2)	-0.49 (2.5)	n.s.	n.s.	<b>5</b>	incr.	Incr.	n.s.	n.s.
<b>7</b>	-0.39 (2.4)	n.s.	n.s.	n.s.	<b>7</b>	-1.2 (3.3)	-2.2 (4.6)	n.s.	n.s.
<b>9</b>	n.s.	n.s.	n.s.	n.s.	<b>9</b>	-1.4 (3.1)	-2.4 (4.1)		n.s.
	<b>P(u)</b>	<b>P(s)</b>	<b>P(u s)</b>	<b>D</b>		<b>P(u)</b>	<b>P(s)</b>	<b>P(u s)</b>	<b>D</b>
<b>TFP, ext.</b>					<b>C/W, ext.</b>				
<b>Lags 0</b>	n.s.	n.s.	n.s.	n.s.	<b>Lags 0</b>	-0.58 (2.9)	-1.02 (4.1)	n.s.	n.s.
<b>3</b>	-0.33 (2.3)	-0.45 (2.4)	-1.72 (2.0)	n.s.	<b>3</b>	incr.	Incr.	n.s.	n.s.
<b>5</b>	-0.47 (2.9)	-0.36 (1.8)	n.s.	n.s.	<b>5</b>	incr.	Incr.	n.s.	n.s.
<b>7</b>	-0.59 (3.5)	n.s.	n.s.	n.s.	<b>7</b>	Incr.	-2.2 (4.7)	n.s.	n.s.
<b>9</b>	-0.46 (2.6)	n.s.	n.s.	n.s.	<b>9</b>	-1.2 (2.6)	-2.4 (4.2)	n.s.	n.s.

Notes: t-statistics in parenthesis. n.s. = not significant. incr. = increases with length of lag

The core equation contains the variables Tech, X, X<sup>2</sup>, Ed, NW. The extended equation contains in addition MAR, NU, EG, Union

Not shown in Table 1:

Effect on P(u|s) not significant for young workers (X ≤ 12). For X ≥ 12: it is -2.6 (2.5)

Effect on D n.s. for less educated ed < 12 strong for more educated (ed > 12): -101.3 (2.4) at 5-year lag

Effect on P(u) n.s. for young workers (X ≤ 12), but -0.89 (3.9) for X ≥ 12 at lag 3

Effect on P(u|s) pronounced negative for less educated (ed ≤ 12) and X ≥ 12 workers: -2.9 (2.4) and -3.0 (2.4) respectively

almost contemporaneously, but not significant for (C/W). Duration of unemployment (D) is reduced by the pace of TFP only in the core equation. All results are quite similar in the core and in the extended equation.

On the whole reductions of the incidence of unemployment are consistent with the reductions in turnover and the reduction or no effect on conditional unemployment in the “high tech” sectors. The maximal effects take about 5 years. The training interpretation fits these findings: training to handle new technologies and learning by experience take time.

Time series: The findings by sectors prompt the question whether they are applicable to the aggregate economy. Is the unemployment structure by skill affected

**Table 8.6.** Regressions of unemployment ratios, 1970–1995

	<b>Cap</b>	<b>Ed</b>	<b>RSG</b>	<b>R<sup>2</sup></b>		<b>Cap</b>	<b>Ed</b>	<b>RSG</b>	<b>R<sup>2</sup></b>
<b>TFP</b>	Cap	Ed	RSG	R <sup>2</sup>	TFP <sub>-5</sub>	Cap	Ed	RSG	R <sup>2</sup>
0.23	-0.02	1.12	0.08	0.28	-14.6	-0.017	-0.065	0.04	0.52
n.s.	(1.5)	n.s.	n.s.		(3.2)	(1.8)	n.s.	n.s.	
<b>RDE</b>	Cap	Ed	RSG		RDE <sub>-5</sub>	Cap	Ed	RSG	
2.0	-0.018	4.0	-0.71	0.63	-2.4	0.016	-5.0	1.15	0.67
(4.4)	(2.2)	(3.5)	(3.4)		(5.0)	(1.5)	(3.3)	(4.8)	
<b>C/W</b>	Cap	Ed	RSG		C/W <sub>-5</sub>	Cap	Ed	RSG	
4.4	-0.31	1.38	-1.24	0.49	-9.6	0.031	-2.18	2.73	0.48
(2.9)	(3.0)	(1.3)	(2.6)		(2.8)	(1.5)	(1.3)	(2.8)	
<b>C/E</b>	Cap	Ed	RSG		C/E <sub>-5</sub>	Cap	Ed	RSG	
12.3	-0.033	1.64	-1.4	0.65	-26.6	0.04	-2.92	3.2	0.54
(4.7)	(3.8)	(1.8)	(4.2)		(3.4)	(2.0)	(1.9)	(3.5)	

Note: t-statistics in parenthesis

over time by technology the same way as the wage structure? Unemployment rates of unskilled workers with  $Ed \leq 12$  are 3 to 4 times higher than for the more educated workers ( $Ed > 12$ ). Does this employment ratio widen as the pace of technology grows, as does the wage premium? And does the training response narrow it after a lag? The answers to both questions are positive.

Four alternative measures are used in the regressions shown in Table 8.6: TFP (Total Factor Productivity) and Computers per Worker ( $C/W$ ), as in the cross-section, Research and Development Expenditure per worker (RDE), not available by sector, and computer as a fraction of total equipment ( $C/E$ ). These measures are in regressions synchronous with the dependent variable (the unemployment ratio) as well as with technology lagged 5-years, to infer the results of supply adjustments. The other variables are included to isolate the net effects of technology.

On a synchronous basis (left hand panel), all four technology measures show a widening of unemployment ratios, three of them significantly. When technology effects are observed five years before the unemployment ratio (right hand panel), the effects reverse—the unemployment ratio diminishes. The lag is about half of that observed in the wage premium: Supply responses (in hiring and training) affect the unemployment structure faster than the wage structure.

If technology affects the unskilled/skilled unemployment ratios, does it affect aggregate unemployment levels? The question of “technological unemployment” provokes little interest when unemployment is low, as it has been for close to a decade. But some research into the matter is now prompted by the persistence of low unemployment rates without touching off inflation, while the “high tech” economy was booming in the 90’s.

In recession, unskilled unemployment increases more than skilled, with opposite effect in upswings. So cyclical changes in the structure follow the course of aggregate unemployment. Does the same pattern apply to technological waves? We find in the empirical regression analysis (Table 8.7) that synchronous effects of technology are unclear (not significant), but after five years, three out of four technology parameters are negative and significant.

**Table 8.7.** Factors affecting unemployment rates, 1970–1995

	<b>Age</b>	<b>Imp</b>	<b>Trend</b>	<b>R<sup>2</sup></b>		<b>Age</b>	<b>Imp</b>	<b>Trend</b>	<b>R<sup>2</sup></b>
<b>TFP</b>	0.15	-49.7	0.13	0.35	<b>TFP<sub>-5</sub></b>	n.s.	-70.0	0.20	0.28
	(2.2)	(1.8)	(2.0)				(2.6)	(3.4)	
<b>RDE</b>	0.94	-62.6	0.24	0.37	<b>RDE<sub>-5</sub></b>	-1.6	-20.8	0.25	0.50
	(2.5)	(2.5)	(4.4)		(4.0)	(1.9)	n.s.	(5.0)	
<b>C/W</b>	-5.1	n.s.	n.s.	0.26	<b>C/W<sub>-5</sub></b>	-5.1	n.s.	0.43	0.44
	(3.1)				(3.3)	(3.1)		(5.2)	
<b>C/E</b>	-4.1	-49.5	0.56	0.31	<b>C/E<sub>-5</sub></b>	-4.3	-4.8	0.44	0.44
	(2.5)	(2.5)	(2.5)		(3.2)	(2.5)	n.s.	(5.1)	

Note: t-statistics in parenthesis

Other “standardizing” variables that affect unemployment are: the age distribution of the work force, measured by population ratio of ages 25–44 to 16–24; the volume of imports as a ratio to GDP; and the ratio of service to goods producing employment. Experienced workers are more productive and have less unemployment than younger ones because they are less mobile with greater firm and locational attachment. An increase in imports (measured as ratio to GDP) reduces demand for import competing goods and services, but both increased exports and increased real incomes (associated with cheaper imports) generate increases in employment that, in the longer run, overwhelm the sectoral unemployment effects, if any. Regressions in Table 8.7 show that in the short run the import parameters are negative but largely not significant. The age variable is not significant in the short run but strongly negative and significant in the long run.

In sum, the short run effects of technology, age distribution and imports on unemployment are usually negative but largely not significant. In the longer run effects are negative and largely significant. There is no evidence of technological unemployment in the short run and in the longer run supply responses tend to reduce unemployment. So “technological unemployment” appears to be a myth in the current economy.

We also attempted to ask the parallel question why the very low current unemployment has not as yet triggered inflation. Changes in technology, demography and growth of international trade could be expected to reduce inflation, as well as unemployment. Cost reductions and product innovations are the contributions of technology that ought to raise the capacity of the economy and reduce prices. A more mature labor force is more productive thus raising the economy’s capacity and reducing prices. Increased imports are a direct consequence of lower prices of imported goods.

The empirical analysis (Table 8.8) confirms these hypotheses: Using the same alternative definitions of technology, we find that they have negative effects on the pace of inflation, stronger in the short run, but also significant in the longer run. Age has negative effects that are stronger in the longer run, apparently after some training.

**Table 8.8.** Factors affecting the inflation rates (dp), 1970–1995

<b>TFP</b>	<b>Age</b>	<b>Imp.</b>	<b>Trend</b>	<b>U<sub>-1</sub></b>	<b>R<sup>2</sup></b>	<b>TFP<sub>-5</sub></b>	<b>Age</b>	<b>Imp.</b>	<b>Trend</b>	<b>U<sub>-1</sub></b>	<b>R<sup>2</sup></b>
-4.9 (2.7)	-5.3 (7.8)	-89.4 (3.6)	-0.33 (5.3)	-0.31 (2.3)	0.83	-4.8 n.s.	-5.2 (6.7)	-116.7 (4.6)	-0.43 (7.4)	-0.37 (2.3)	0.79
<b>RDE</b>	<b>Age</b>	<b>Imp.</b>	<b>Trend</b>	<b>U<sub>-1</sub></b>		<b>RDE<sub>-5</sub></b>	<b>Age</b>	<b>Imp.</b>	<b>Trend</b>	<b>U<sub>-1</sub></b>	
-10.7 (8.6)	-3.8 (8.5)	-106.8 (7.8)	0.51 (5.5)	-0.55 (6.6)	0.94	-4.9 (2.0)	-6.4 (6.9)	-92.7 (3.5)	0.5 (7.8)	-0.62 (3.2)	0.81
<b>C/W</b>	<b>Age</b>	<b>Imp.</b>	<b>Trend</b>	<b>U<sub>-1</sub></b>		<b>C/W<sub>-5</sub></b>	<b>Age</b>	<b>Imp.</b>	<b>Trend</b>	<b>U<sub>-1</sub></b>	
-14.6 n.s.	-3.2 (1.8)	-91.6 (2.4)	0.58 (3.1)	-0.38 (2.5)	0.79	17.4 n.s.	-7.5 (3.4)	-143.8 (4.1)	0.31 (2.5)	-0.2 n.s.	0.80
<b>C/E</b>	<b>Age</b>	<b>Imp.</b>	<b>Trend</b>	<b>U<sub>-1</sub></b>		<b>C/E<sub>-5</sub></b>	<b>Age</b>	<b>Imp.</b>	<b>Trend</b>	<b>U<sub>-1</sub></b>	
-142.0 (4.5)	2.8 n.s.	-73.3 (3.3)	1.2 (6.9)	-0.45 (3.8)	0.87	22.8 n.s.	-6.3 (3.3)	-131.2 (3.9)	0.36 (2.9)	-0.47 (1.9)	0.79

Note: t-statistics in parenthesis

Imports reduce price levels both in the short and longer run. The parallel effects of changes in these variables (which became pronounced in the late 80's) were sizable. Our calculations based on the estimated parameters of these variables account for 60%–70% of the declines in unemployment and inflation in the latter half of the decade of the nineties. These changes reduced the “natural rate” of unemployment, or masked its existence, or prove its unreality.

#### 8.6. TECHNOLOGICAL CYCLES AND TRENDS IN HUMAN CAPITAL<sup>11</sup>

The twentieth century U.S. economy experienced two waves of skill-biased technological innovations. The first surge between 1909 and 1929 was apparently associated with continuous process and batch methods, in manufacturing, and the adoption of electric motors (Goldin and Katz, 1999). Demand for relatively skilled blue-collar workers widened the skill structure as evidenced by increased returns to high school education. The rapid growth of high school education, partly unrelated to technology and partly a supply response to the increased demand, eventually narrowed the skill structure and reduced inequality. In both earlier and current periods we observe cycles in the wage structure. The supply responses reversed the first cycle by 1950, and in the current period we reached the peak (plateau) of the expansion phase in the 90's. The relevant skills now in demand are visible in increased returns to postsecondary education. When the cycles are completed we are back to trendless rates of return.

Tinbergen's proposition to explain the absent trend in rates of return to human capital calls for equal speeds in the growth of demand and in the supply responses. This misses the mechanism of long cycles in the wage structure and inequality that induce acceleration and deceleration in human capital formation. These cycles are generated by the lag between human capital formation (e.g. school enrollment and job training) and the human capital stock, the supply of human capital. The supply becomes effective in narrowing the wage structure, either because demand decelerates or supply accelerates or both. Our estimates (in section 8.4) show a decade long interval between onset of accelerated demand and effective supply response. But our



procedure postulates a cessation of growth of demand during the lag, while supply accumulates. Relaxing this assumption clearly prolongs the cycle. Indeed the relative speeds of demand and of investments in supply should determine both the amplitude and duration of each of the phases of the technological cycle.

Though technological cycles are plausible consequences of the interactions between new technologies, wage dynamics, and human capital formation one and half cycles in a century is a small sample. Is it historically unique? And why are the new technologies skill-biased? Endogenous growth theories would argue that it is the growing levels of skill (education and job learning) that induce innovations rather than the converse. With a large proportion of college graduates in the work force, current new, sophisticated technologies can be handled by many workers. In contrast, a century ago when most of the labor force consisted of uneducated, unskilled workers and immigrants who could barely speak the language, the most efficient adaptation was the technology of the assembly line. But the endogeneity of technology raises the question where the secular growth of human capital comes from. The question why human capital continues to grow over the (very) long run is one I explore more fully now.

Human capital is implicated in the process of economic growth not only as a cause but also as a consequence. Economic growth and development affects the supply of human capital through the growth of family income, urbanization, demographic change, and the rising cost of time. But the supply side alone cannot explain the continuous growth of human capital as it implies a self-limiting decline in rates of return below those in alternative investments. Such declines are offset by growing demands for human capital in the labor market, due to capital accumulation and technological change, as analyzed before. On the supply side growth of human capital is generated indirectly in consequence of economic growth, while on the demand side it is produced as a response to innovations that contribute to economic growth. Without technical innovations the level of human capital would stabilize when rates of return reach equilibrium levels, that is levels equivalent to rates on alternative investments.

I proceed to a discussion of supply factors that produce growth of human capital:

(1) Income growth:

Education is directly related to income because aside from earnings it generates a stream of nonmarket utilities involving learning and culture. As such, education may be viewed as a consumption good that, therefore, is directly related to income. The positive income effects apply also to the acquisition of education as an investment good, to the extent that imperfect capital markets necessitate a degree of self-financing. The positive effect of parental income on school enrollment is documented in many microeconomic studies (e.g. Freeman, 1986). Our Table 8.2 (in section 8.4) shows this effect using the “parental education” variable which represents both “permanent” income as well as educational preferences in the family. This is true net of the positive effect of the rates of return to education, which is holding market demand for education constant. Inter-country comparisons (Table 8.9) show similar results. Here income effects are reduced when the other supply variables—

**Table 8.9.** Education and factors affecting it

On Variable	Years of School		Enrollment Rate	Percent Urban	Infant Mortality	Life Expectancy	Women's Labor Force Rate <sup>b</sup>
	Male	Female					
a. Effects of Income: Simple Regression Coefficients of (log) Income <sup>a</sup> (OLS).							
Coefficient	(1)	(2)	(3)	(4)	(5)	(6)	(7)
T-ratio	1.83 (18.9)	2.03 (19.6)	19.1 (29.0)	15.1 (29.0)	-32.4 (18.2)	6.9 (35.5)	5.8 (29.5)
R <sup>2</sup>	.71	.71	.77	.68	.46	.76	.69
b. Factors Affecting Education <sup>c</sup> : Multiple Regression (OLS)							
Dependent Variable	Ln Y	TFR <sup>d</sup>	L EXP <sup>e</sup>	UWLF <sup>f</sup>	MUS <sup>g</sup>	R <sup>2</sup>	
Male education	53 (2.3)	-33 (2.6)	.065 (2.5)	.0005 (2.1)	.21 (0.6)	.77	
Female education	52 (2.2)	-28 (2.2)	.092 (3.6)	.0006 (2.2)	-0.90 (2.6)	.80	
Secondary school enrollment rate	6.65 (4.8)	-5.16 (6.0)	.066 (3.5)	.0034 (2.3)	3.91 (1.7)	.85	

Sources: U.N. Human Development Reports (1993-95)  
 Note: Sample = 83 countries with comparable data for years 1970 to 1990 in five-year intervals  
 a. Log of GNP per capita = ln Y; intercepts not shown  
 b. Ratio of women's urban labor force to population  
 c. Ln Y is lagged 10 years in rows (1) and (2); intercepts not shown  
 d. Total fertility rate  
 e. Life expectancy at birth  
 f. Women's urban labor force rate  
 g. Dummy for Muslim countries

urbanization, demographic change, and women's labor force participation are included in the multiple regression. The income coefficient is reduced because the additional variables are, in part, generated by income (wage) growth. Their effect on education can therefore be viewed as an indirect effect of economic growth.

(2) Urbanization:

Given low price and income elasticities of the demand for food, the growth of productivity results in a reduced demand for farm labor and lower wages in agriculture than in industry. Cities grow as a result of labor migration from farms in response to the urban-rural wage differential. With costs of raising children higher in the city and greater profitability of education, urban fertility is lower than on the farm, and urban families devote more resources per child to their education. With increasing urbanization these incentives spread through the economy. At the same time expected out-migration reduces fertility on the farm and increases investments in education of future migrants as its payoff is greater in the migrants' destinations.

(3) Demographic change:

Going back two centuries in advanced countries and less than a century in less developed countries, the demographic transition was a long-term change from populations with high birth and death rates to much larger populations with low birth and death rates. The starting point of the demographic transition is the decline in mortality that set in with the growth of income generated by the industrial revolution. After a lag, fertility began to decline in response to the decline in mortality. This is an outcome of choice rather than biology: if the family contemplates an optimal rather than maximal number of surviving children, the decline in mortality forces a decline in fertility, since the same number of survivors can be produced with fewer births. Initially, fertility declines less than mortality, resulting in increased rates of population growth (so-called "population explosion"). In the later phase of the demographic transition fertility declines more sharply than mortality. This happens as cost of raising children continues to grow with urbanization and with growth in real wages, and therefore a rising opportunity cost of parental time. At the same time the reduction in mortality produces increased incentives to invest in human capital: Increases in longevity and the improved health underlying them imply a greater profitability of investment in the human capital of children as the effective payoff period lengthens. With limited family budgets, faster growing investments in health and education of children reduce fertility.

In effect, the family substitutes "quality" for quantity of children, as the number of children per family declines and income per child grows.

(4) The Growing Cost of Time:

Growth of the female labor force is a feature of twentieth century societies experiencing economic growth. The basic analysis of this phenomenon recognizes the productive non-market activities of consumers that are combined with purchased market goods and services to create final objects of utility. These activities use time, and growth of real wages raises the opportunity cost of nonmarket time. Consequently, time spent in household production is reduced in favor of substitute market inputs bought with increased market earnings. The transfer from household

production to market activities, especially curtailing time-intensive household activities, such as raising children shows up both in growing labor force participation of women and in the decline of fertility. Once again, income per child increases, and so do expenditures per child, much of them as investments in their health and education.

The growth of human capital as an outcome is not restricted to children. It also extends to women as they contemplate their role in the market and in the family. Two considerations lead to incentives for women's expanded investments in themselves: First, as time spent in the workforce increases with improved health and longevity and as time spent in child care decreases, the payoff to human capital investments at school and on the job grows since the payoff period is lengthened. Second, the growing probability of marital separation, itself perhaps not unrelated to the other changes in family economic behavior, leads to a precautionary growth of market work activities to ensure economic security in such contingencies (William Johnson and Jonathan Skinner 1986). Women's increased investments in education and training and delayed marriage and fertility are vital part of this response to risk and more generally to the growing expectation of a long working life.

#### 8.7. SUMMARY AND CONCLUSIONS

Research on the impact of new and spreading technologies on the labor market reveals an interaction between technical change, human capital, changes in the wage structure, and in wage inequality. Human capital and wage dynamics are produced by technical change as follows: growth of new technologies generates increases in demand for human capital, their complementary factor. These skill-biased increases in demand for labor raise the rate of return to human capital, which shows up as an increasing wage gap between skilled (more educated) and unskilled (less educated) labor. Investments in human capital increase in response to increasing rates of return. The increasing supply of human capital cumulates overtime in the form of training and school enrollments, eventually reducing the "wage gap" to equilibrium levels, that is, to rates of return comparable to those on alternative investments. The technological cycle is thus brought to completion, until a new wave materializes.

The consequences of increasing demand for human capital in the expansion phase of the technological cycle, is the widening of the "wage gap" that is increases in rates of return to human capital. The effects on the wage structure are distinguishable from effects on overall wage inequality, of which it is a part. Rates of return or "wage premia" measure inter-group (skill) wage differentials. Total inequality also contains "residual" differentials, that is, wage differentials for workers at the same measured level of skill. Skill wage structure and residual inequality need not move in the same direction. Indeed, the two components of inequality moved in opposite directions in the 1970's when rates of return to human capital declined, while intra-group and total inequality increased.

A human capital decomposition resolves the apparent puzzle: The distribution of relative (log) wages is determined by sets of intersections of demand and supply curves of human capital of individuals (Becker, 1967). An increase in demand for

human capital is represented by a shift of the set of demand curves ( $D_i$ ) to the right, increasing the average rate of return ( $\bar{r}_i$ ) which widens the inter-group inequality. A rightward shift in the supply curves ( $S_i$ ) reduces  $\bar{r}$  thereby reducing inter-group inequality. Skill bias in the demand for human capital shows up in a widened dispersion among demand curves, consequently in the variance of  $r_i$  among individuals. The latter is a major component of the residual or intra-group variance of (log) wages. Movements in  $\sigma^2(r)$  are independent of movements in  $\bar{r}$ , and changes in the spread of demand curves are independent of changes in the spread of supply curves.

The history of the 1970's is therefore interpretable as a dominant increase in supply, hence a decline in the inter-group variance due to the decline in the average rate of return. However, this change was accompanied by a widening in the set of demand curves due to a growing skill-bias in the demand for human capital that resulted in an increased variance of rates of return among individuals, within education levels. With the opposing movement of rates of return and residual wage inequality, the latter, as the larger variance component, dominated wage inequality. This produced the apparently puzzling result of a narrowed (inter-group) wage structure, yet widened total inequality in the 70's. After 1980 both  $\bar{r}$  and  $\sigma^2(r)$  increased. This means that the widening across demand curves continued while the set of demand curves shifted to the right.

The analysis of components of inequality reveals also that the spread among demand curves  $\sigma^2(D_i)$  was smaller than the spread among supply curves  $\sigma^2(S_i)$  in the 70's. The ranking reversed after 1980 as  $\sigma^2(D_i)$  widened, while  $\sigma^2(S_i)$  shrank. According to Becker (1967) the narrowing of supply curves represents a growing *equality* of opportunity. This was masked by the *growing inequality* in wages.

The widening of the skill wage structure, or the "wage gap" is often viewed as a dangerously widening social divide. This is an incomplete perspective: As the growing "wage gap" represents a growing payoff to investment in human capital, it is an incentive for building up the stock of human capital in the economy. Thus, nearly tripling the "wage premium" over two decades prior to the 90's led to doubling of the proportion of workers with post-secondary education and to a reduction of low wage high-school dropouts from one third of the work force in 1975 to below 10% in 1997.

Looking at timing of this supply response, it appears to be perverse: Thus educational attainment rose to a peak in the late 70's when rates of return reached a historic low. And there was no increase in attainment in the 1980's when the need for a more highly skilled labor force accelerated, as suggested by the rising wage premium. This misperception of the supply response is corrected when investment rather than stocks of human capital are seen as the responding supply. Enrollments rather than attainment respond to changing rates of return, as does job training. The stock of human capital (attainment) is built up over time by enrollments. Hence there is a rather lengthy lag between enrollments and attainment of the same cohort. This built-in lag can generate long cycles of "wage premia," wage inequality, and human capital formation. The two pronounced surges in technology in the 20<sup>th</sup> century produced such long cycles, the second of which is not yet completed.

It should be noted that unemployment differentials by skill move similarly to the wage gap as a result of changes in the demand and supply of human capital. The lag in the supply response, mainly in the form of training, is shorter: Empirical estimates show hiring and layoff responses to be twice as fast as wage responses.

It appears that while technology imposes cycles on relative unemployment as it does on relative wages it does not increase levels of aggregate unemployment in the short run and tends to reduce it in the longer run. Apparently, technological unemployment, though it affects some workers, does not appear in the aggregate. Moreover, the increasing pace of technology contributes to a decline in inflation rates. The resulting parallel declines in unemployment and inflation put a question mark on the level or reality of “the natural unemployment rate”.

Cycles in human capital formation attributable to the appearance and spread of new technologies are superimposed on an upward trend that appears to be continuous. Why does human capital grow, apparently without limits? The short answer is that growth of the demand for, and of the supply of, human capital results from economic growth. On the demand side, as described here, are the growth of capital and technology, which are direct causes of economic growth. On the supply side are consequences of economic growth such as growth of family income, urbanization, demographic change, and the rising cost of time. Education viewed as a consumption good is positively related to parental income. Parental preferences and imperfect capital markets also contribute to the income effect. Urbanization reduces the demand for children, but makes human capital investments in them more profitable than on the farm. The demographic transition is spurred by declining infant mortality, which, in turn, reduces fertility, as fewer births are needed for achieving a given (surviving) family size. At a later stage of the demographic transition, when economic growth becomes pronounced, fertility declines faster than mortality and number of children (hence population growth) declines. This is because costs of raising children increase with increases in the cost of time, that is, in real wages. An important example of the consequences of the increasing cost of raising children is the wage foregone in the time devoted to children. The optimizing results are both declines in fertility, increases in labor force participation and in human capital investments per child. All are mutually reinforcing.

In effect, all the supply factors generate an apparent trading of numbers of children for their “quality” (their “human capital”). However in the absence of demand pull, supply growth due to these factors would depress the rate of return to human capital below those on alternative investments, at which point the level of human capital would stop growing. The growth or spurts of growth of demand due to technology by raising the rate of return on human capital investments propel a continuation of growth in human capital.

Economic developments of the past 3 decades posed new questions to economists: What are the causes of fluctuations in rates of return to human capital? What is the relation between the changing skill-wage structure and changing overall wage inequality? Does the widening of the wage structure produce an equilibrating supply response? What are the causes, dimensions and implications of the “technological

cycle” for wages, unemployment, and its “natural rate”? Why is the long-term trend of human capital formation relentlessly upward?

My research of the past decade, together with that of other economists, attempted to provide answers to these questions, as described above. In the course of the analysis several misconceptions are clarified: (1) The view of an increasing “wage gap” as a worsening “social divide” misses the incentive effects of the increased rates of return on furthering investments in human capital. These are empirically documented. (2) Growing overall wage inequality can conceal a declining inequality of opportunity as it did in recent decades. (3) Technological unemployment as an aggregate phenomenon appears to be a myth. (4) The concurrent supply response to increasing demand for human capital applies to investments, not to the stock. The accumulation of investments (such as enrollments) over time produces a lag in the response of the human capital stock. This lag is a basic cause of the “technological cycle”.

Finally, it is worth noting that a positive skill bias is not inherent in technological changes. These may sometimes carry a negative effect on the demand for human capital. The implications of “deskilling” (the assembly line is an example) would be the opposite of what we found for the recent decades (1970–2000). However, the long-term growth of human capital suggests a positive skill bias in the long run.

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#### NOTES

1. See Frank Levy and Richard Murnane (1992).
2. See Mincer (1991, 1993), John Bound and George Johnson (1992), Lawrence Katz and Kevin Murphy (1992), Anne Krueger (1993), Chinhui Juhn, K. Murphy and Brooks Pierce (1993). Subsequent studies corroborate most of the findings and conclusions of the works cited.
3. Section 8.2 is based mainly on Mincer (1991, 1993).
4. See Barry Chiswick and Mincer (1972).
5. Section 8.3 is based mainly on Mincer (1996a, 1997), which contain a complete exposition.
6. Focus on the “overtaking set” simplifies the exposition. Extension to the complete working ages is provided in Mincer (1996a, 1997). Conclusions drawn from the overtaking set are preserved.
7. An empirical range of 6 to 10 years of work experience yields a sample that accommodates differences in  $r_i$ .
8. For qualifications, see Appendix A in Mincer (1996a, 1997).
9. Section 8.4 is based mainly on Mincer (1998).
10. Section 8.5 is based mainly on Stephan Danninger and Mincer (2000).
11. Section 8.6 is based mainly on Mincer (1996b). The concepts of technological cycles date back to Joseph Schumpeter (1934, 1939) who saw them as underpinning the usual business cycle.

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**PART IV. JACOB MINCER AND HUMAN CAPITAL: NEW PERSPECTIVES**

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## 9. PROVING MINCER RIGHT: MINCER'S OVERTAKING POINT AND THE LIFECYCLE EARNINGS DISTRIBUTION\*

BY SOLOMON W. POLACHEK

### ABSTRACT

*In 1958, Jacob Mincer pioneered an important approach to understanding earnings distribution. In the years since Mincer's seminal work, he as well as his students and colleagues extended the original human capital model, reaching important conclusions about a whole array of observations pertaining to human well-being. This line of research explained why education enhances earnings; why earnings rise at a diminishing rate throughout one's life; why earnings growth is smaller for those anticipating intermittent labor force participation; why men earn more than women; why whites earn more than blacks; why occupational distributions differ by gender; why geographic and job mobility predominate among the young; why unemployment is lower among the skilled; and why numerous other labor market phenomena occur. This paper surveys the answers to these and other questions based on research emanating from Mincer's original discovery. In addition, this paper provides new empirical evidence regarding Mincer's concept of the "overtaking age" – a topic not currently well explored in the literature. In this latter vein, the paper shows that Mincer's original finding of a U-shaped (log) variance of earnings over the life cycle is upheld in recent data, both for the U.S. as well as at least seven other countries.*

\*This chapter is a slightly shortened version of Polachek (2003). It represents the substantive portions of the paper I presented at the Columbia University Conference Honoring Jacob Mincer's 80<sup>th</sup> Birthday. This paper acknowledges the intellectual debt I owe Jacob Mincer for the superb training I received from him at Columbia University, and for the continued interactions and collaborations since. I also wish to thank Jeff Xiang for extremely valuable research assistance, as well as my entire Spring 2002 graduate labor economics class for sharing their insights on Mincer's seminal contributions to labor economics. Finally, I thank Barry Chiswick, Shoshana Grossbard and an anonymous referee for valuable comments, as well as the Industrial Relations Section at Princeton University for providing a conducive environment to revise this paper during my sabbatical.

### 9.1. THE TOPIC: MINCING THE EARNINGS DISTRIBUTION – A HUMAN CAPITAL APPROACH

Mincer was not the first scholar to examine the distribution of earnings. But he *was* the first to use the analytical techniques of capital theory in an extremely innovative way. His discoveries clearly contributed more to understanding economic well-being than the work of any other individual. By developing a very parsimonious model employing only schooling, age, and annual weeks worked as variables, he was able to account for about 60 percent of the variation in U.S. annual earnings for adult white men. His resulting functions have been applied in over 100 countries with the same resounding success achieved with US data. Invariably, schooling rates of return are in the 5 to 15% range, exactly the same range as high-grade commercial investments. Similarly all cross-sectional earnings profiles proved concave, just as he predicted.

To understand worker earnings, as Mincer did, gets at the very core of economics, which entails understanding human well-being. Indeed comprehending the determinants of earnings helps policy makers develop tactics to promote wealth, to help ease poverty and eventually to put countries on a path to increased growth and prosperity. Mincer's work shows that neither luck nor decree lessen poverty, but instead concerted individual investments in human capital raise earnings and ease hardship. Even low-ability workers can benefit from training. Mincer's insights led to viable policies increasing overall wealth. As many have shown (e.g. Robert Barro and Xavier Sala-i-Martin, 1999), Mincer's insights have strong implications for economic growth.

Early economists looked at the functional distribution of income i.e., labor's share. But how labor's share is divided is also crucially important. Before 1958 (when Mincer published his first article on human capital based on his 1957 Columbia University dissertation), the reigning earnings distribution theories relied mostly on stochastic chance to determine who succeeded financially, and who did not. As such, theory offered no economic insights into the distribution process.<sup>1</sup> As Victor Fuchs states, "... The subject [of Mincer's classic *Schooling, Experience, and Earnings*] is earnings inequality, but the reader will look in vein for references to unions, monopsonists, minimum wage laws, discrimination, luck and numerous other institutional factors that are frequently introduced in such studies" (Fuchs, in J. Mincer (1974): xiii). Adopting notions of Adam Smith's theory of compensating differentials coupled with Friedman's notions of "tastes for risk and hence to choices among alternative [work options] differing in the probability distribution of the income they promise" [Mincer, 1974: 6], Mincer was able to come up with an entirely new theory. His innovation was to realize that these choices produced income streams easily evaluated using capital theory. As such, treating schooling and occupation as investment opportunities, Mincer ingeniously modeled the outcome of individual investment choices.

Although Mincer came up with these innovations in the late 1950's, human capital's roots go back to Sir William Petty (1691) who, according to B. F. Kiker, considered labor to be "the father of wealth" (Kiker, 1971, p. 61). Petty capitalized the wage bill (which he got by deducting property income from national income) to

obtain an estimate of human wealth (Charles R. Hull, 1899, I, 108). Slightly later, the Spanish economist Gaspar Melchor de Jovellanos (1744–1811), another very early human capital pioneer (Donald Street, 1988), dealt with the capitalized value of labor and applied his human capital ideas to redirect financing so that Spain could use education to solve its economic problems. Other early economists who considered human capital include Adam Smith, Jean Baptiste Say, Nassau William Senior, Friedrich List, Johann Heinrich von Thünen, Ernst Engell, Léon Walras, Irving Fisher (Kiker, p. 51) and Karl Marx (J. R. Walsh, 1935). Indeed, according to Kiker, “Human capital was somewhat prominent in economic thinking until Marshall discarded the notion as ‘unrealistic’ (ibid., p. 51) ... since human beings are not marketable” (ibid., p. 60).<sup>2</sup>

## 9.2. THE MINCER EARNINGS FUNCTION

Mincer, in his quest to devise econometric techniques to estimate these returns, is the first to model human capital investment using capital theory's mathematical tools. By realizing that opportunity costs constitute the bulk of training costs, and by making use of the fact that the internal rate of return emerges when individuals invest up to the point where investment costs just equal the present value of schooling gains, he obtained a simple and tractable econometric specification leading to the now famous log-linear earnings function. The so-called Mincer schooling model was published in 1958 and the more general model encompassing on-the-job training in 1970.<sup>3</sup>

Not only did this formulation provide a measure of private returns to schooling, but also it generalized to get at post-school on-the-job training, as well Mincer's measures of on-the-job training.<sup>4</sup> On-the-job training accounts for between 11 and 15% of total worker compensation (ibid. p. 279).

Mincer's empirical work showed that a worker's wages rise over the life cycle at a decreasing rate until depreciation becomes more important than skill acquisition, yielding a concave earnings profile for most individuals. Not only does human capital theory explain this concavity, but human capital theory has strong implications concerning the rate at which earnings rise at each phase of the life cycle. Human capital theory also explains gender, race, and ethnic differences in earnings, geographic and job mobility, occupational choice as well as labor turnover, unemployment and other labor market issues. But these applications came later in the development of human capital theory.

Before going on, let me note that other theories of earnings are now becoming popular. The most recent approaches involve incentive based compensation schemes. In these models, firms provide an earnings contract to maximize effort and hence productivity. Some argue that these contract models complement human capital in explaining wages and other labor market phenomena; others argue that contract models substitute for the human capital model. In Polachek (1995), I laid out a unified framework nesting both type of models in order to determine the relative merits of each. In that article, I also surveyed tests of Mincer's human capital model along with extensions of the model. Now, in the next section of this paper, I update

part of that survey. Then, in the section after, I turn to new interesting unexplored international evidence testing implications of Mincer's "overtaking age" concept.

### 9.3. PROVING MINCER RIGHT: TESTS OF THE HUMAN CAPITAL MODEL

#### 9.3.1. Education

By now, all take for granted the positive correlation between earnings and schooling. Indeed there are so many empirical studies on the topic that it would be too difficult to do justice surveying even a subset. However, in a recent special edition of *Labor Economics* devoted to the topic, Orley Ashenfelter *et al.* (1999) note that "these studies provide us strong evidence that schooling is a powerful investment in a wide variety of settings" (Ashenfelter *et al.*: viii).<sup>5</sup> Barry Chiswick, Yew Lee and Paul Miller (2002) confirm this using data from the 1996 Australian Survey of Aspects of Literacy by in essence showing that "education is a value-added process in which skills, including literacy and numeracy, are improved...." Further, though there are different interpretations, data indicate that school directly enhances real output. For example, Zvi Griliches (1963, 1964) used aggregate state (and regional) data to find far higher farm production in states with higher education levels. More recently, utilizing more appropriate micro-level information on 296 household farms in West Bengal, India, Subal Kumbhakar (1996:188) showed "that education increases [actual] productivity" and that this enhanced productivity increased farmers' wages. Generalizing these results to economic growth, Barro and Sala-i-Martin (1999) find that the higher a population's education, the higher its GDP and GDP growth per capita. Also, educated immigrants assimilate far more quickly into the U.S. economy (George Borjas, 1993, 1994). Thus education has direct measurable effects on productivity and labor market success.<sup>6</sup>

#### 9.3.2. Race, Education and Black-White Earnings Differences

Prior to 'Brown vs. the Board of Education,' blacks in the U.S. were relegated to separate but "equal" schools. Finis Welch (1974) argued that at least a portion of the black-white earnings gap is attributable to black school quality deficiencies. Using data from several age groups, he shows dramatic increases in educational rates of return to "newer" vintage black cohorts. Welch attributes these greater schooling returns to increases in black school quality relative to whites. He proceeds to make a case that school quality is an important aspect of the black-white earnings gap. Despite its persuasiveness, the Welch study is limited because it contained no direct measures of per capita inputs for black compared to white schools. By going back to state data, David Card and Alan Krueger (1992) rectified this deficiency by comparing direct measures of school quality. These include: pupil-teacher ratios, annual teacher pay, and length of school term, all of which are linked to U.S. Census data. Changes in school quality explain at least 50–80% of the relative increase in black educational rates of return and at least 15–25% of the narrowing of the black white earnings gap between 1960 and 1980. In addition, David Card and Thomas Lemieux (1996) use changes in rates of return to explain black-white differences over the

1980s. While some might offer explanations other than human capital, there is a striking consistency with human capital predictions: education positively enhances labor market success, and better schools do the same.<sup>7</sup>

### 9.3.3. Earnings Function Concavity

Turning back to the earnings function and post-school investment, there is one finding that is virtually universal. This widespread result is “earnings function concavity”.<sup>8</sup> For those continuously attached to the labor market, earnings rise at a decreasing rate throughout one’s life until depreciation exceeds human capital accumulation.<sup>9</sup> Early studies (Mincer, 1974) tested this proposition using OLS regression with cross-sectional data. But the results hold when one adjusts for selectivity biases (Joop Hartog, et al., 1989; B. F. Kiker and M. Mendes de Oliveira, 1992; or Marjorie Baldwin, Lester Zeager and Paul Flacco, 1994) and individual specific heterogeneity (Mincer and Polachek, 1978; Georg Licht and Viktor Steiner, 1991; Moon-Kak Kim and Solomon Polachek, 1994; Audrey Light and Manuelita Ureta, 1995).

### 9.3.4. Earnings of Women

Interestingly, with respect to concavity, the human capital model, Polachek (1975a) predicts that female earnings profiles are lower and flatter. Furthermore age-earnings profile differences vary by marital status. Married women have 55% lower earnings profiles than married men. Additionally, married women’s profiles are best fit by a cubic equation rising initially at a slow rate, then falling until the mid-thirty age group, finally rising at about the same rate as males (Mincer and Polachek, 1974, 1978; Mincer and Ofek 1982). In contrast to these stark differences for the married, single men and women have roughly comparable profiles. Were discrimination the prime explanation for gender wage differences, one would need an alternative explanation why the discrimination model applies to married but not to single men and women. Thus discrimination cannot explain these marital status patterns, but human capital theory does.

At least in the past, the average woman exhibited intermittent labor force behavior, dropping out on average over ten years to bear and raise children. Such labor market patterns have implications for human capital investment. Discontinuous workers invest less, and their investments need not decline monotonically (Polachek, 1975a; Yoram Weiss and Reuben Gronau, 1981; and Claudia Goldin and Polachek, 1987). As a result the simple quadratic earnings function should be “segmented” into various work and non-work time periods to capture the appropriate investment patterns. The “segmented-earnings-function” developed in Mincer and Polachek (1974) established that earnings power depreciates  $\frac{1}{2}$ – $4\frac{1}{2}$  percent per annum during periods spent time out of the labor force (home time). Mincer and Polachek denote this to be a form of “atrophy” since it reflects earnings power deterioration when not using one’s skills.

Because the estimation only makes use of past labor market experience, even the segmented function doesn’t fully account for future work expectations (Polachek, 1975a and Goldin and Polachek 1987). Failure to account for expectations leads to potential

omitted variable biases in estimating male–female discrimination (Polachek, 1975b). This bias is evidenced by renewed human capital investment resulting in a rapid restoration of earnings power when intermittent workers permanently reenter the labor market upon completing home time (Mincer and Polachek, 1974, Mincer and Ofek, 1982).

### 9.3.5. Heterogeneous Human Capital and Matching

Applying the above segmented–earnings–function to specific occupations enables one to compute occupation–specific depreciation rates. Such a framework implies that occupations differ from each other in skill content. Some skills deteriorate more quickly when not used, while others become obsolete as technology changes. As such, human capital is heterogeneous. In this structure, individuals select a type of human capital (occupation) to best match their attributes.<sup>10</sup>

This framework enables one to apply the human capital model to predict gender differences in occupational choice (Polachek, 1979, 1981). Workers expecting to drop out the longest minimize atrophy costs by choosing occupations with the lowest depreciation. Women maximize by choosing occupations with lower atrophy rates, since on average their labor force participation is more intermittent than men’s. This approach to occupational segregation has not been without controversy, but the latest evidence overwhelmingly supports the conclusions (John Robst and Jennifer VanGuilder, 2000).

Although initially applied to occupations, the same framework holds in other domains. For example, Morton Paglin and Anthony Rufolo (1990) show how one’s comparative advantage in quantitative versus verbal ability affects college major. Polachek and Francis Horvath (1978) show how location and job attributes affect one’s life cycle geographic and job mobility. Boyan Jovanovic and Mincer (1981) show how the quality of one’s job match explains declining turnover with tenure on-the-job. Alison Booth and Jeff Frank (1999) show how performance related pay attracts high quality workers. Becker (1974) even carries this type matching one step further by considering assortive mating, thereby getting more generally at family investments in human capital.<sup>11</sup>

### 9.3.6. Incomplete Employee and Employer Information

In a sense, the whole matching process is a form of search. Labor force participants search for the best job matches and employers search for employees with the best skills. Search and matching models developed independently of human capital (George Stigler, 1961), but in reality information is a form of human capital in which employees and employers both invest. The more information each party obtains, the better the match and the higher worker wages and productivity.

Search strategies have two implications: First, there is incomplete information because search is costly. Efficient search entails stopping rules that lead searchers to compromise by sufficing instead of ending up in the *best* job possible. (The same can be said for employers searching for the best possible employee.) Second, incomplete information likely results in eventual job turnover because imperfect information on both sides can lead to bad matches, and both sides acquire information with time on the job.



One can apply frontier estimation (Dennis Aigner, C. A. K. Lovell and Peter Schmidt, 1977) to Mincer earnings functions to separate observed wage dispersion into purely random variation (noise in the data), variation due to incomplete employee information, and variation due to incomplete employer information (Polachek and Bong Yoon, 1987). To get at these facets, simply estimate Mincer's earnings function with an error term containing three components  $\varepsilon = u + v + w$ , such that  $-\infty < u < \infty$ ,  $-\infty < v < 0$ , and  $0 < w < \infty$ , as indicated below:

$$\ln Y = a_0 + a_1 S + a_2 t + a_3 t^2 + u + v + w.$$

The error component  $u$  represents the typical two-sided error term representing pure noise. The negative error term  $v$  represents a worker's incomplete information since it represents the difference between the wage a worker receives and the wage that could have been attained given knowledge of a higher paying firm. The positive error term  $w$  represents a firm's incomplete information since it represents the difference between the wage a firm pays and the wage it could have paid had it known of workers willing to work at lower wages. By introducing independent direct measures of workers' knowledge of the *World of Work*, Polachek and Robst (1998) verify that this generalization of Mincer's earnings function can be used to actually measure incomplete market information, thus illustrating yet another application of the Mincer earnings function.

#### 9.4. MINCER'S OVERTAKING AGE REVISITED

Perhaps one of the more unique, interesting, but rarely explored concepts to emerge from Mincer's earnings function formulation is the "overtaking point." The overtaking point is the point in one's lifecycle when observed earnings just equals one's potential earnings at graduation, were there no post-school investment. As illustrated in Figure 9.1 (Mincer, 1974:17), the concave curve  $Y_0 Y_j Y_p$  plotted over the lifecycle reflects observed earnings, which are potential earnings ( $E_j$  depicted by curve  $Y_S E_j Y_p$ ) minus (net) human capital investments  $C_j$ .<sup>12</sup> At the overtaking point  $\hat{j}$ , observed earnings  $Y_j$  equal potential earnings upon graduation, i.e.,  $Y_j = E_0 = Y_S$ . As is the case for many profound discoveries, the overtaking point should have been obvious. Early in one's career, the typical person takes a job below  $Y_S$ , say  $Y_0$ , to finance post-school investment. Eventually earnings grow higher than  $Y_0$ , surpassing  $Y_S$  as one reaps returns from investments  $C_j$ . Figuring out the overtaking point merely implies solving for the age at which this occurs.

##### 9.4.1. Mincer's Derivation of the Age at Overtaking

To derive the overtaking point, Mincer rigorously specifies the experience level at which observed earnings just equals one's earnings potential at graduation. This is point  $\hat{j}$  when  $Y_S = \hat{j}$  (again refer to Figure 9.1, taken from Mincer, 1974, Figure 1.2, page 17). Recall that upon graduation, one invests a portion of potential earnings  $Y_S$  in on-the-job training. This investment lowers observed earnings to  $Y_0 = Y_S - C_0$ .

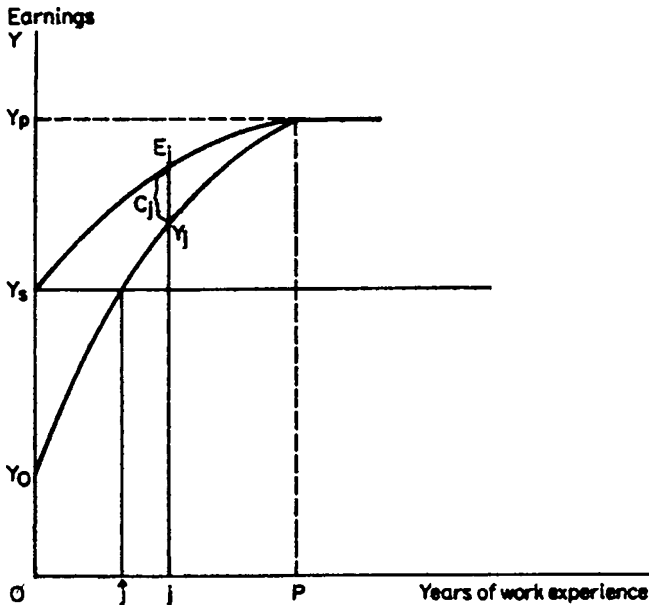


Figure 9.1. Earnings profiles.  
 Source: Jacob Mincer (1974)

Observed earnings then rise as one begins to accumulate the returns from investments  $C_t$ . Thus according to Mincer,

$$Y_{\hat{j}} = Y_s + r \sum_{t=0}^{\hat{j}-1} C_t - C_{\hat{j}} = Y_s \tag{1}$$

occurs when  $r \sum_{t=0}^{\hat{j}-1} C_t = C_{\hat{j}}$ . If human capital investment ( $C_t$ ) occurring from  $t = 0$  through  $t = \hat{j}$  is constant, then  $r\hat{j}C_{\hat{j}} = C_{\hat{j}}$  implying  $\hat{j} = \frac{1}{r}$ . If  $C_t$  declines between time 0 and  $\hat{j}$ , then the overtaking number of years can be expressed as  $\hat{j} \leq \frac{1}{r}$ .

The overtaking point is important because it enables one to observe what one would have earned upon graduation at each level of schooling. This knowledge facilitates computing schooling rates of return. Simply compare  $Y_{\hat{j}}$  at each schooling level  $S_{\hat{j}}$ . Percentage earnings differences reflect the impact of schooling and define rates of return (assuming all schooling costs are opportunity costs). Indeed at  $\hat{j}$  the Mincer “Schooling Model” should work best. Empirical tests (Charles Brown, 1980) somewhat (but do not completely) corroborate this.

The overtaking point is also important for another reason. Mincer uses it to get at some interesting implications regarding earnings distribution.

#### 9.4.2. Implication Regarding Earnings Distribution

Define  $\sigma^2(Y_j)$  to be the variance of earnings, and define  $\sigma^2(\ln Y_j)$  to be the *relative* earnings variance. According to Mincer,  $\sigma^2(Y_j)$  and  $\sigma^2(\ln Y_j)$  must vary over the life cycle. The pattern of variation depends on the dispersion in post-school investments and the correlation between post-school investment and earning capacity (Mincer, 1974: 98–103). “If ... the correlation between (dollar) schooling and post-school investment is positive ... dollar variances must rise from overtaking to peak earnings. In addition, dollar variances will rise throughout if  $\sigma^2(Y_0) < \sigma^2(Y_{\hat{j}}) \dots$ ” (Mincer, 1974: 98). In contrast,  $\sigma^2(\ln Y_i)$  is more likely to be U-shaped (Mincer, 1974:103).

To see this more rigorously, Mincer defines earnings ( $Y_{si}$ ,  $Y_{\hat{j}i}$ , and  $Y_{pi}$ ), and the log of earnings ( $\ln Y_{si}$ ,  $\ln Y_{\hat{j}i}$ , and  $\ln Y_{pi}$ ) as well as earning variance at three points in the lifecycle: (1) at graduation, point S; (2) at the overtaking point  $\hat{j}$ ; and (3) at point p, when the earnings profile peaks. Accordingly, as depicted in equation (2) below, earnings upon graduation ( $Y_{si}$ ) for any individual  $i$  equal earnings potential ( $E_{si}$ ) minus investments made in the first year out in the labor force ( $C_{oi}$ ). Earnings at the overtaking point  $Y_{\hat{j}i}$ , depicted in (3), are simply ( $E_{si}$ ). Finally, earnings at the profile peak ( $Y_{pi}$ ), depicted in (4), are initial earnings potential upon graduation ( $E_{si}$ ) plus the returns to all past post-school investments ( $rC_T$ ). Equations (5) – (7) give comparable definitions for relative earnings ( $\ln Y$ ) where  $k$  is time-equivalent investment ( $k = C/E$ ) and  $K$  is time-equivalent human capital stock ( $K_i = \sum_{j=0}^{t-1} k_j$ ):

$$Y_{si} = E_{si} - C_{oi} \Rightarrow \sigma^2(E_s) + \sigma^2(C_o) - 2\rho(C_o, E_s)\sigma(E_s)\sigma(C_o) \quad (2)$$

$$Y_{\hat{j}i} = E_{si} \Rightarrow \sigma^2(Y_{\hat{j}}) = \sigma^2(E_s) \quad (3)$$

$$Y_{pi} = E_{si} + rC_T \Rightarrow \sigma^2(Y_p) = \sigma^2(E_s) + r^2\sigma^2(C_T) + 2r\rho(C_T, E_s)\sigma(E_s)\sigma(C_T) \quad (4)$$

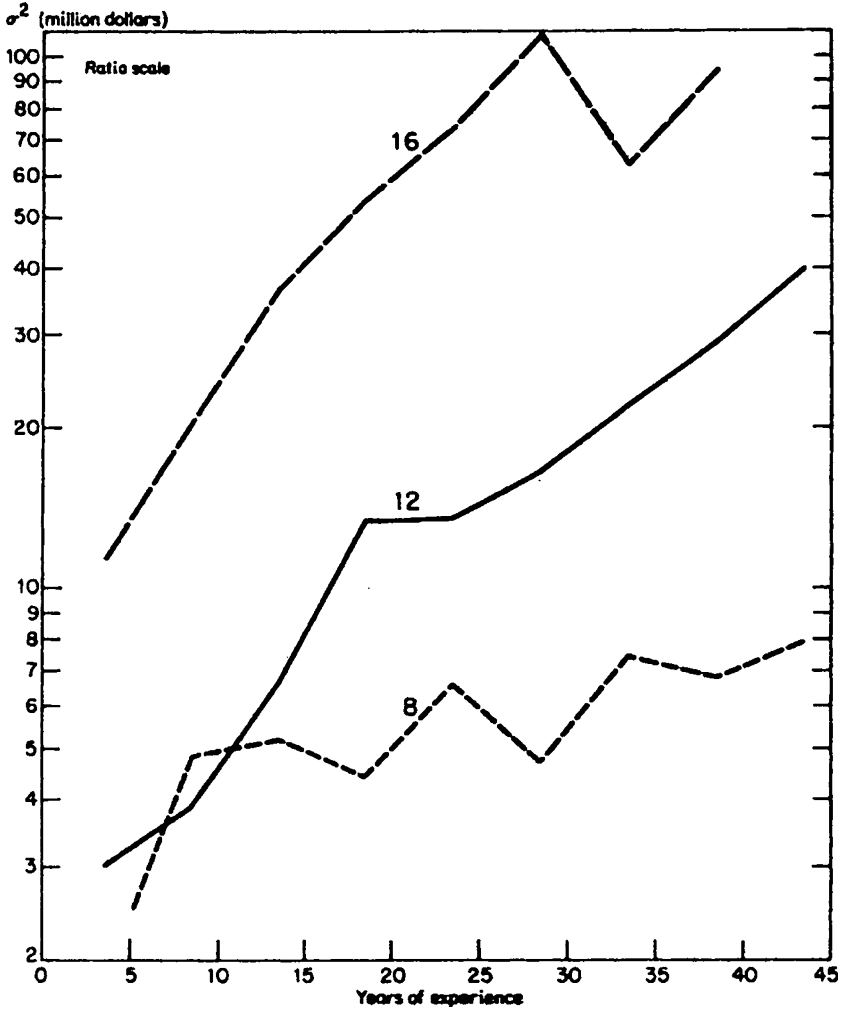
and

$$\ln Y_{si} = \ln E_{si} + \ln(1 - k_{oi}) \Rightarrow \sigma^2(\ln Y_s) = \sigma^2(\ln E_s) + \sigma^2(\ln(1 - k_o)) + 2\rho(\ln E_s, \ln(1 - k_o))(\sigma(\ln E_s), \sigma(\ln(1 - k_o))) \quad (5)$$

$$\ln Y_{\hat{j}i} = \ln E_{si} \Rightarrow \sigma^2(\ln Y_{\hat{j}}) = \sigma^2(\ln E_s) \quad (6)$$

$$\ln Y_{pi} = \ln E_{si} + rK_{Ti} \Rightarrow \sigma^2(\ln Y_p) = \sigma^2(\ln E_s) + r^2\sigma^2(K_T) + 2r\rho(\ln E_s, K_T)\sigma(\ln E_s)\sigma(K_T). \quad (7)$$

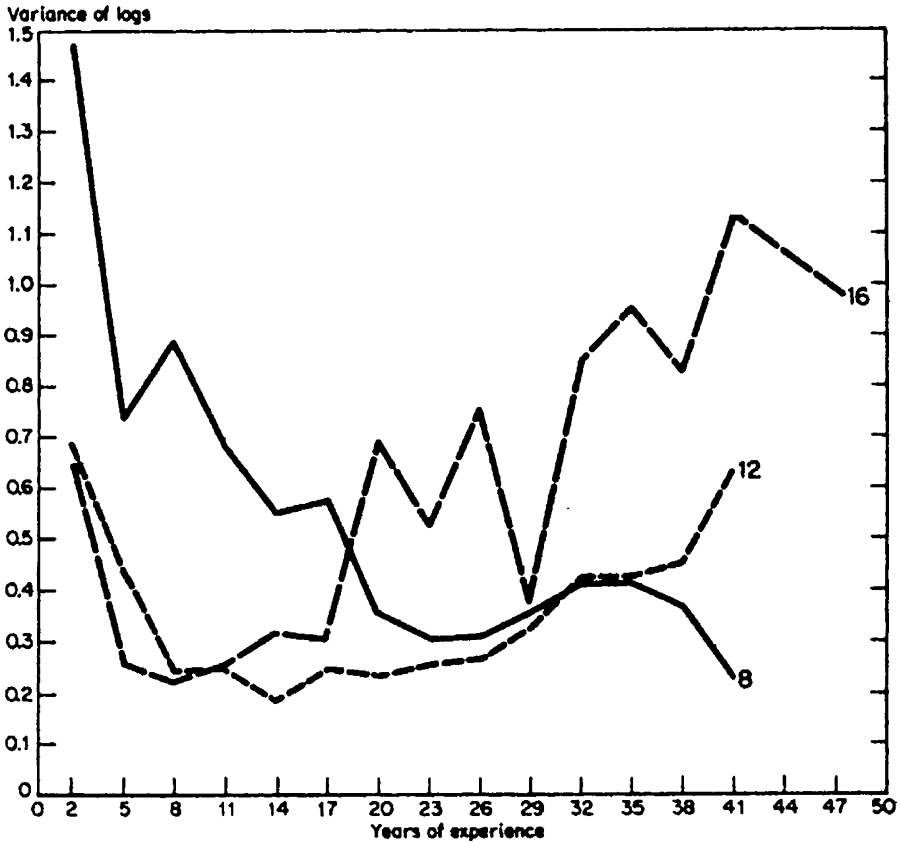
Variances of earnings (and relative earnings) across all  $i$  individuals at each of these three points are also given in equations (2) – (7). Note, as just indicated above, the variances (or standard deviations) depend on the correlation between school and post-school investments. For dollar earnings, these are generally positively correlated, leading to the possibility that the earnings distribution widens throughout life (or more specifically from graduation, to the overtaking point, and finally to the point where the



**Figure 9.2.** Experience profiles of variances of annual earnings of white, nonfarm men, 1959. Note: Figures on curves indicate years of schooling completed. Source: 1/1,000 sample of U.S. Census, 1960. Source: Jacob Mincer (1974)

earnings profile peaks). But changes in logarithmic earnings variances over the working life depend on the correlation between  $\ln E_S$  and  $\ln(1 - k_0)$ . As Mincer states, “If the correlations are weak,  $\rho_1 = \rho_2 = 0$  and the profile of log variances is U-shaped, with the bottom at [the] overtaking [age]” (Mincer, 1974: 103). Mincer illustrates the validity of these conjectures in two Figures, reproduced below as Figures 9.2 and 9.3.

Given the uniqueness of these results, I think it is worthwhile to examine whether these patterns generalize to the U.S. economy today, so many decades after Mincer’s

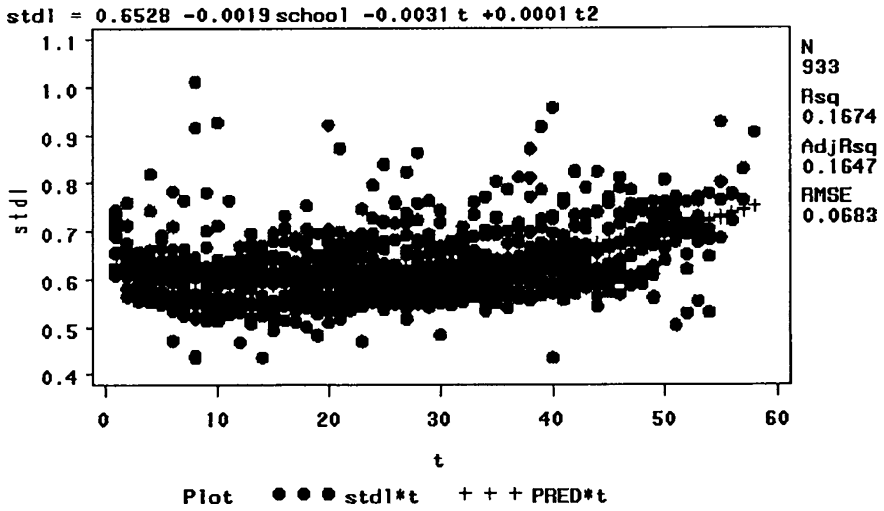


**Figure 9.3.** Experience profiles of log variances of annual earnings of white, nonfarm men, 1959. Note: Figures on curves indicate years of schooling completed. Source: 1/1,000 sample of U.S. Census, 1960. Source: Jacob Mincer (1974)

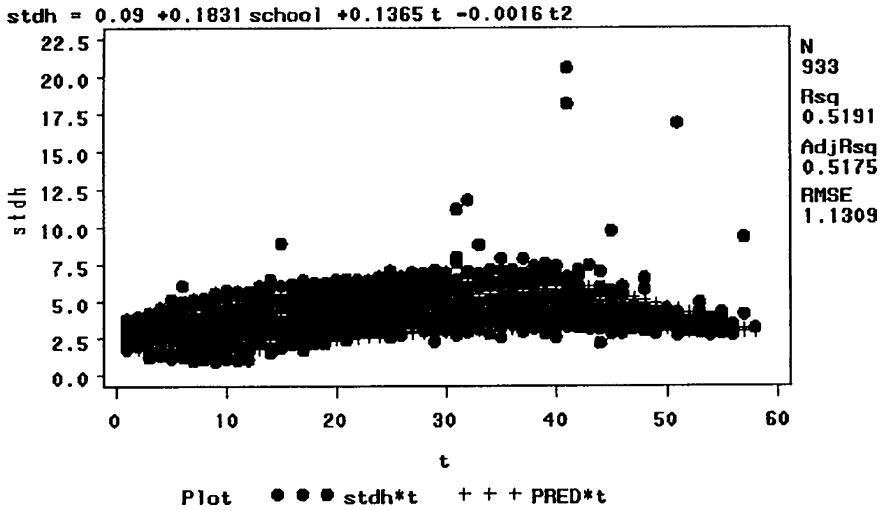
original contribution in this area. Investigating these earning distributions is the point of the remainder of this paper. But, in addition to exploring the United States, I utilize the Luxembourg Income data to also analyze a set of seven of that data's twenty-six countries, thereby testing whether the results generalize internationally.<sup>13</sup>

#### 9.4.3. Earnings Distribution in the United States, 1980 and 1990

I use the 1980 and 1990 Census to examine U.S. earnings variations over the life cycle.<sup>14</sup> To avoid confounding earnings distribution with gender and race and to conform to Mincer (1974), I concentrate on white males.<sup>15</sup> And to circumvent labor supply issues, I examine hourly earnings (computed as annual earnings divided by a



**Figure 9.4.** Standard deviation Ln hourly earnings (stdl) over the life cycle (t), white males, USA, 1980.  
*Abbreviations:* Rsq: R-square  
AdjRsq: Adjusted R-Square  
RMSE: Root Mean Square Error



**Figure 9.5.** Standard deviation of hourly earnings (stdh) over the life cycle (t), white males, USA, 1980.

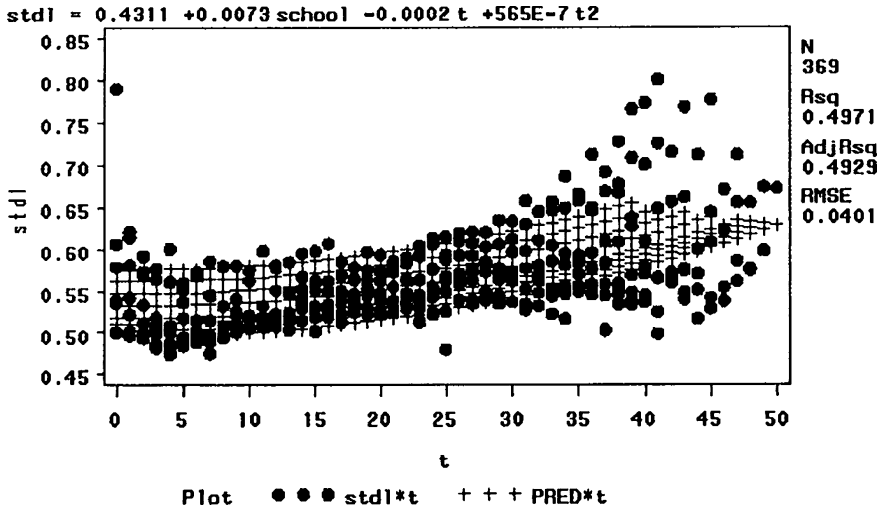


Figure 9.6. Standard deviation Ln hourly earnings over the life cycle, white males, USA, 1990.

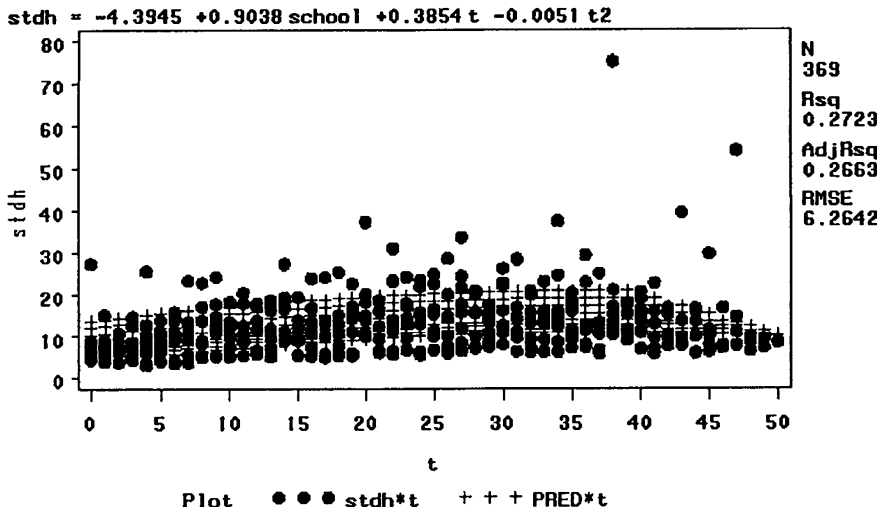


Figure 9.7. Standard deviation of hourly earnings over the life cycle, white males, USA, 1990.

measure of hours worked per year). The final graphs are given in Figures 9.4–9.7.<sup>16</sup> Two figures are presented for each decade: one for the standard deviation in relative hourly earnings  $\sigma(\ln Y)$  and another for the standard deviation of dollar hourly earnings  $\sigma(Y)$  over the life cycle.

Several interesting observations are apparent. First, the standard deviation of the *logarithmic* wage profile is U-shaped. However, the lifecycle pattern of the standard deviation in *dollar* wage is not. Second, the trough in 1980 is at about 19 years of experience, while the trough in 1990 is at about 12½ years of experience. Both observations are consistent with Mincer's expectation. That the log variance profile is more U-shaped is consistent with a lower correlation between time-equivalent investment and initial earnings. Also, observing an earlier 1990 than 1980 over-taking point  $\hat{j}$  is consistent with rising human capital rates of return. (See Polachek (2003) for a table containing U.S. earnings profile parameters including the rate of return to schooling for 1980 and 1990.) Third, and perhaps inconsistent, is the exact age when overtaking takes place. According to Mincer, the 1980 experience level at overtaking should be less than 13.9 years [ $\hat{j} < (1/.061) = 16.4$ ], and the 1990 experience level should be less than 10.5 [ $\hat{j} < (1/.095) = 10.5$ ]. Both are lower than the 19 and 12½-year troughs just observed in Figures 9.4 and 9.6. While bothersome, a number of factors can explain this incongruity. Most likely, the finding results from difference in rates of return between schooling and on-the-job training. On the one hand, schooling is subsidized which normally would imply higher investment levels and possibly lower rates of return. On the other hand, subsidization lowers costs and raises returns. Thus it is conceivable that schooling rates of return exceed on-the-job training rates of return, thereby leading to downward biased estimates of the overtaking age. Obviously other issues are also involved. For example, using cross-sectional rates of return estimates for a lifecycle phenomenon might bias rates of return, but the whole econometric issue that evolved on how to appropriately estimate Mincer's earnings functions is not the focus of this paper.

#### 9.4.4. International Data

The Luxembourg Income Study (LIS) is a collection of household data compiled from ongoing statistical surveys in 26 countries.<sup>17</sup> The database provides statistics on demographic, income and expenditure variables on three levels: households, persons and children. I concentrate on extracting education, age, and earnings data for white males from the person files of the countries, at least half of which contain information on hourly earnings.<sup>18</sup> Of those, I concentrated on nine countries chosen randomly.

For each of these countries, I first ran an earnings profile for the entire sample (see Table 1 in Polachek, 2003). Then I stratified by education and age to compute age-specific earnings variations. As such, I computed  $\sigma(Y_{S,A})$  where  $S$  equals schooling level and  $A$  equals age. To get at non-linearities, I plotted an age-specific earnings variation profile (both in log and dollar formats). For each profile I fitted a sixth degree polynomial in age. (These are available on request.) To preserve space, I re-calibrated each profile with potential experience level (rather than age) and



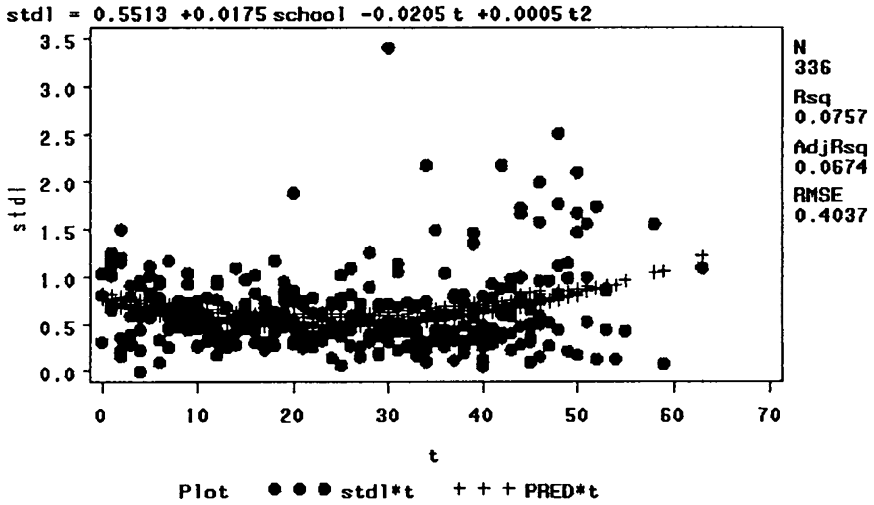


Figure 9.8. Standard deviation of Ln gross annual earnings (stdl) over the life cycle, white males, Australia, 1981.

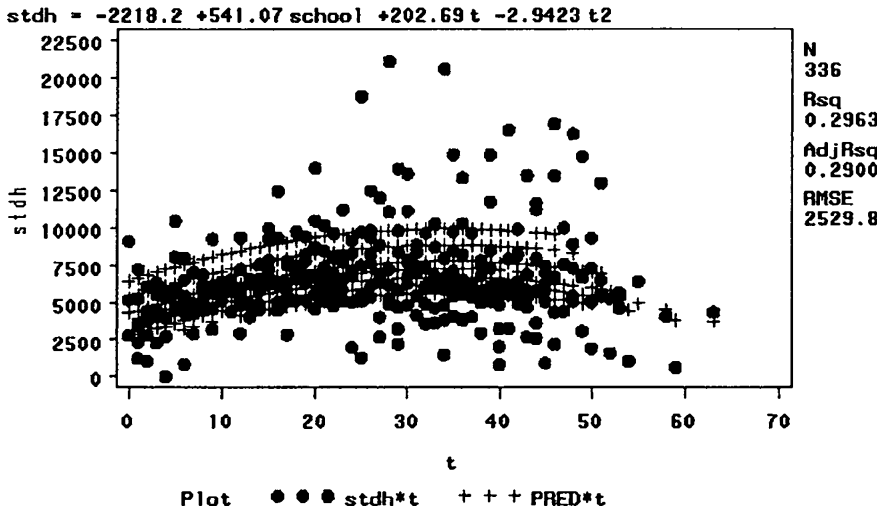


Figure 9.9. Standard deviation of gross annual earnings (stdh) over the life cycle, white males, Australia, 1981.

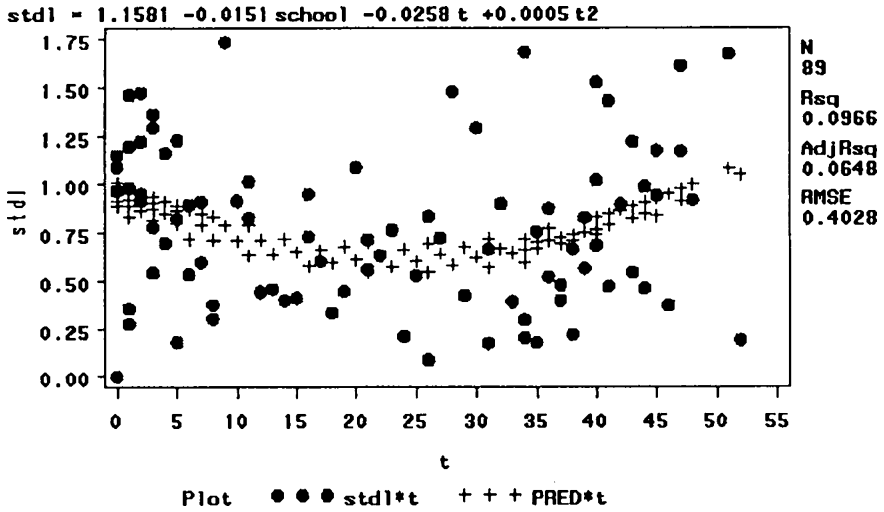


Figure 9.10. Standard deviation of Ln gross annual earnings over the life cycle, white males, Australia, 1994.

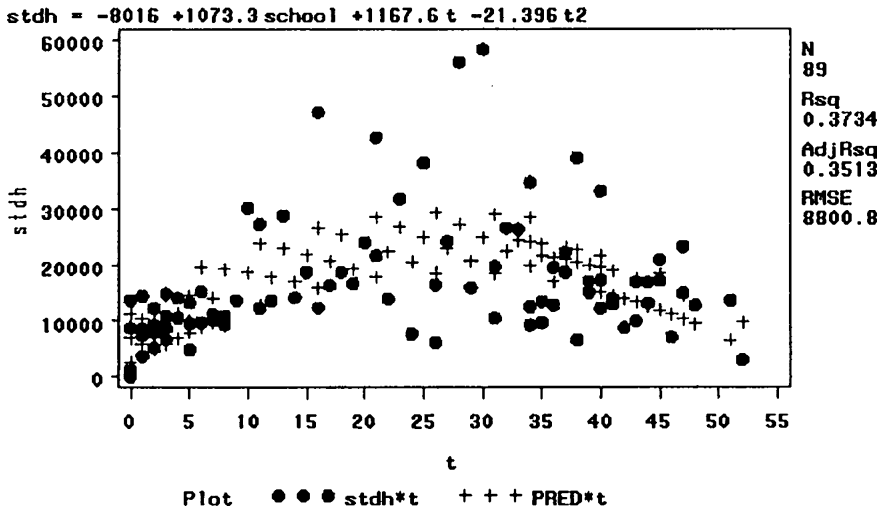


Figure 9.11. Standard deviation of gross annual earnings over the life cycle, white males, Australia, 1994.

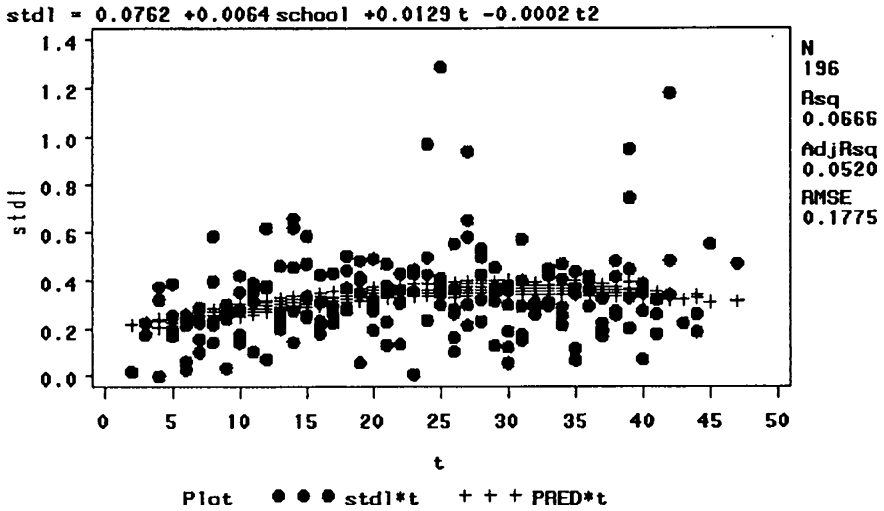


Figure 9.12. Standard deviation of Ln hourly earnings over the life cycle, white males, Belgium, 1997.

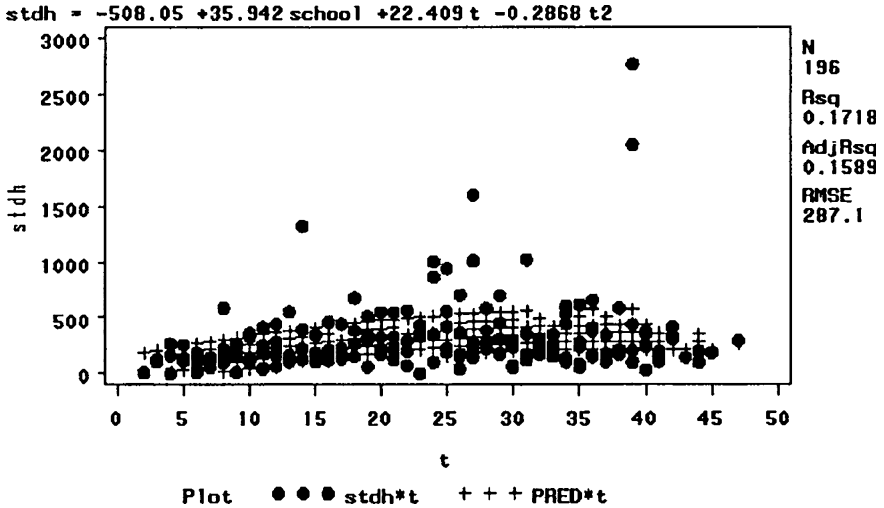


Figure 9.13. Standard deviation of hourly earnings over the life cycle, white males, Belgium, 1997.

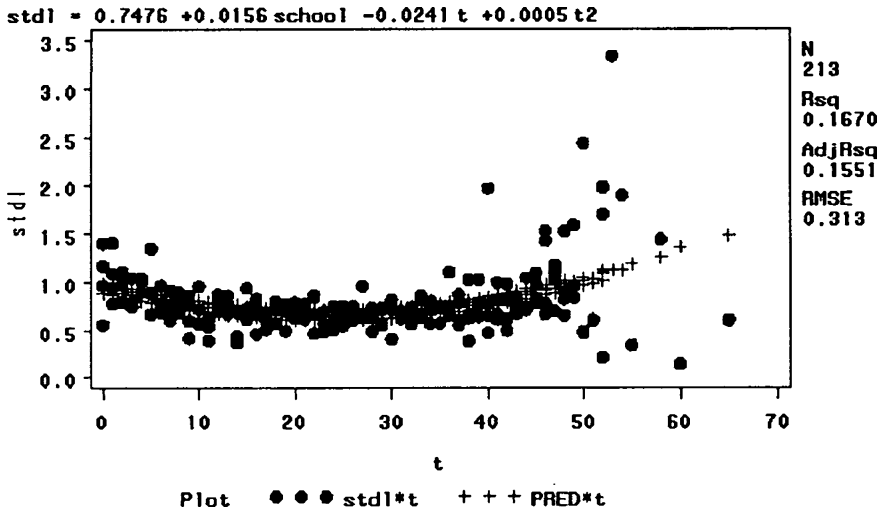


Figure 9.14. Standard deviation of Ln hourly earnings over the life cycle, white males, Canada, 1997.

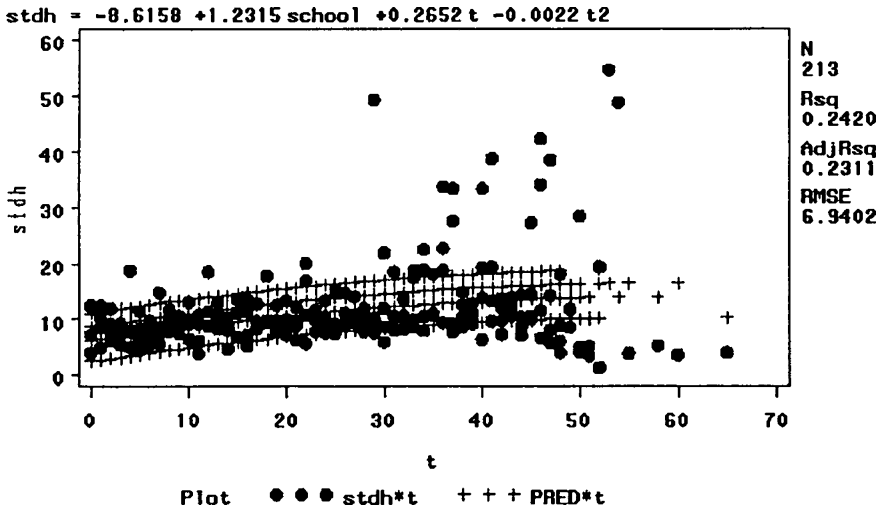


Figure 9.15. Standard deviation of hourly earnings over the life cycle, white males, Canada 1997.

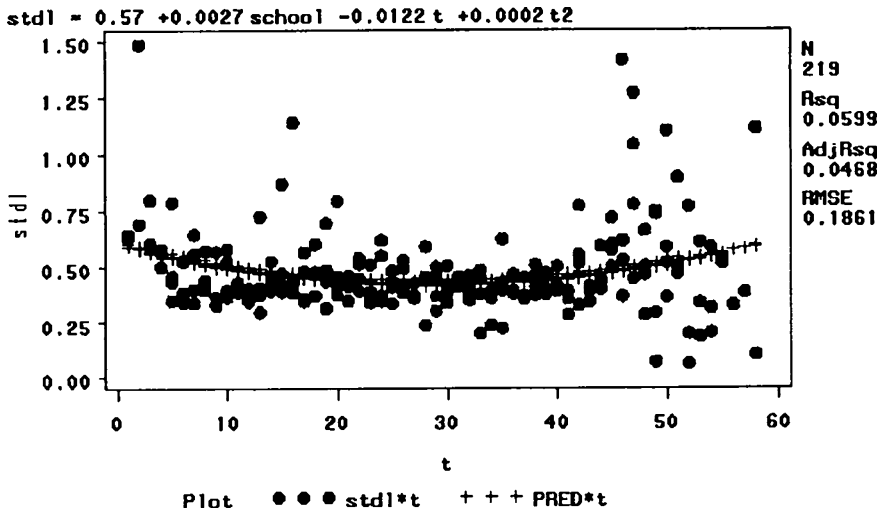


Figure 9.16. Standard deviation of Ln hourly earnings over the life cycle, white males, Czech Republic, 1996.

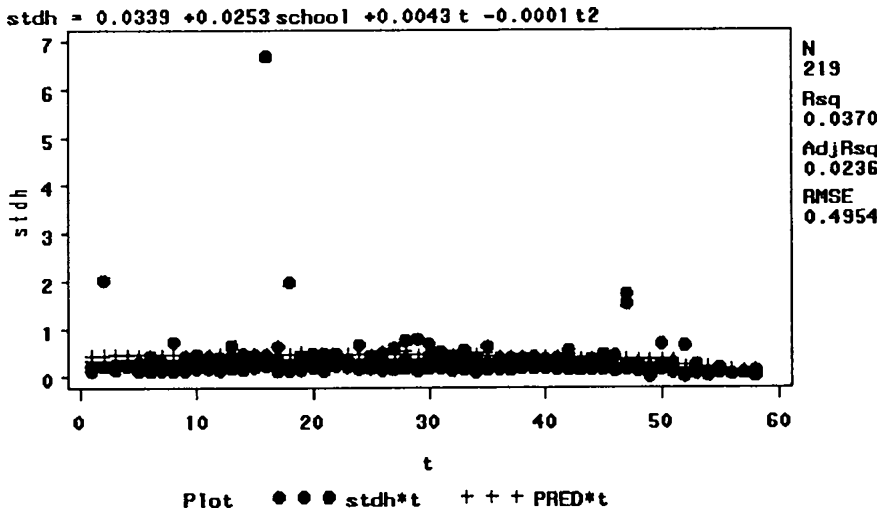


Figure 9.17. Standard deviation of hourly earnings over the life cycle, white males, Czech Republic, 1996.

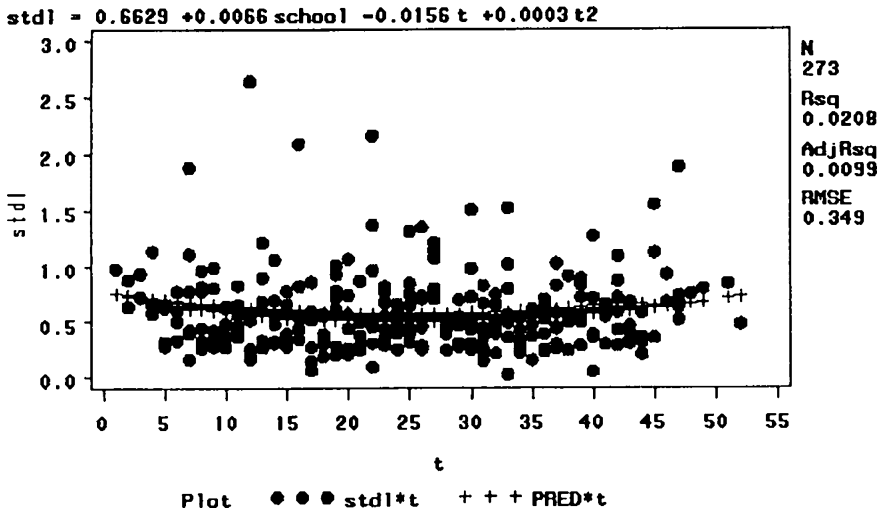


Figure 9.18. Standard deviation of Ln hourly earnings over the life cycle, white males, France, 1994.

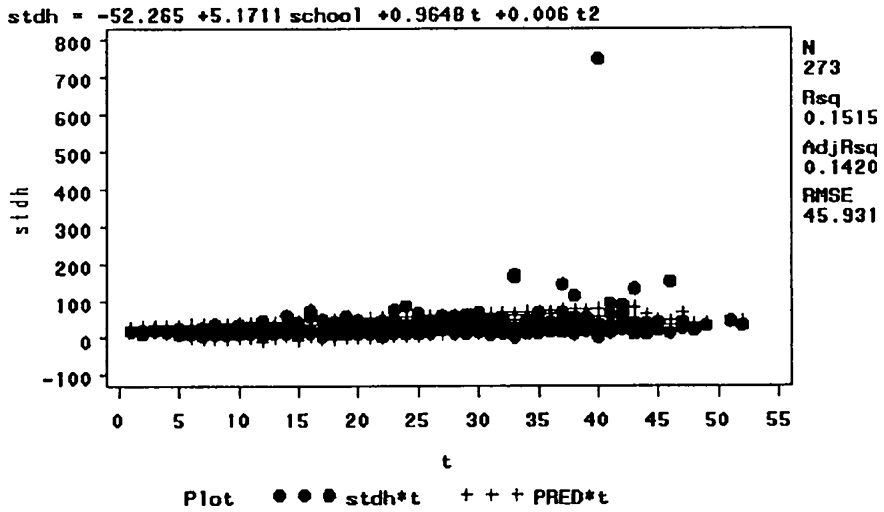


Figure 9.19. Standard deviation of hourly earnings over the life cycle, white males, France, 1994.

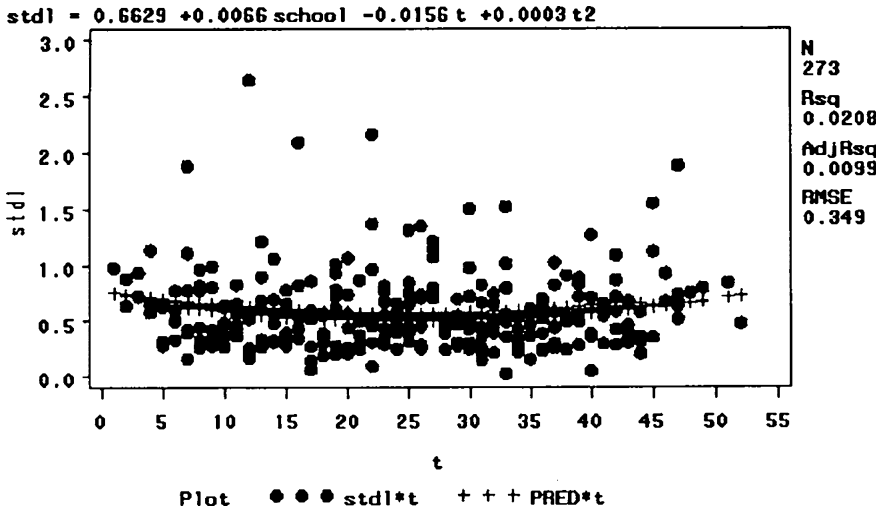


Figure 9.20. Standard deviation of Ln hourly earnings over the life cycle, white males, Mexico, 1988.

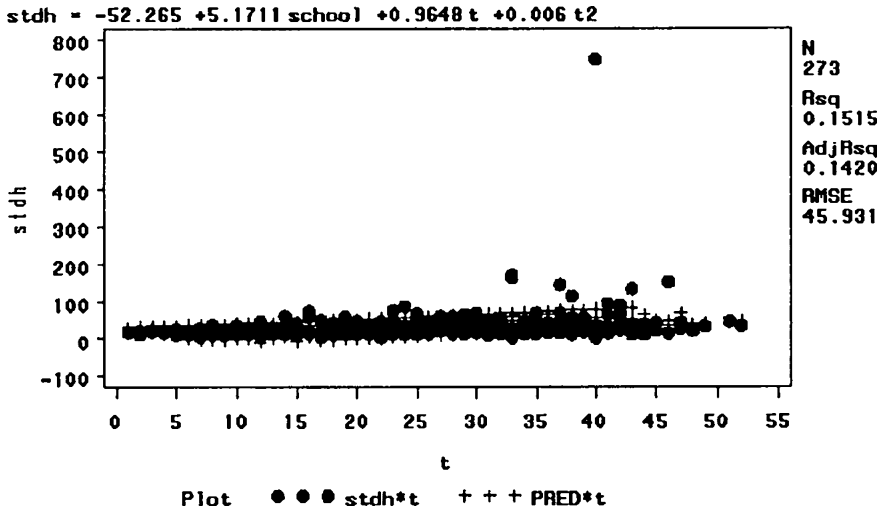


Figure 9.21. Standard deviation of hourly earnings over the life cycle, white males, Mexico, 1988.

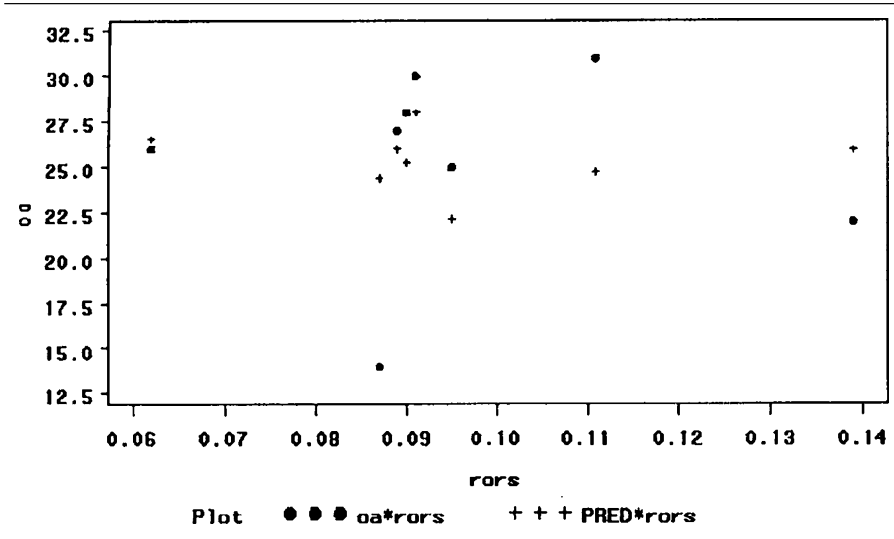


Figure 9.22. Overtaking age (oa) vs. educational rate of return (rors).

graphed them on one diagram. I followed the same procedure for each country. Finally, I fit a quadratic equation for the final re-calibrated age-specific  $\sigma(Y_{S,A})$  points. The predicted values from these equations along with the original data points are contained in Figures 9.8–9.21.<sup>19</sup> For each country, there are two figures. One figure is for the standard deviation of *relative earnings* (Figures 9.8, 9.10, 9.12, 9.14, 9.16, 9.18, and 9.20 with vertical axes denoted as *stdl*, standing for the standard deviation of the logarithm of earnings). The other is for the variance in earnings (Figures 9.9, 9.11, 9.13, 9.15, 9.17, 9.19, and 9.21 with vertical axes denoted as *stdh*).

A number of patterns emerge. First, *relative earnings* standard deviation profiles tend to be U-shaped. *Dollar* standard deviation profiles are not. Second, the troughs of the U-shaped profiles tend to hover around twenty-five years of experience. (Twenty-three when including Sweden, the one country with a rising log-variance experience profile). Figure 9.22, which graphs each country's rate of return against trough experience levels (measured as overtaking age), implies a negative correlation between these troughs (i.e., the experience levels at these troughs) and rates of return.<sup>20</sup> This result implies that countries with high rates of return tend to have lower overtaking points, just as Mincer predicted. Third, as Mincer finds, *dollar* variance profiles rise as schooling increases. However, while *relative* variance profiles tend to rise with schooling, this is not the case for every country.

As with the U.S., the experience levels associated with each trough are somewhat larger than expected, given estimated rates of return. Of course, one reason may be that schooling returns overstate post-school investment returns. Another may be that underlying earnings function parameters vary across members of the population. This



heterogeneity adds to earnings dispersion, making the overtaking point less discernable. Still another reason may be that rates of return depend on investment level, which could alter the shape of the earnings-dispersion-experience profile. Clearly, these possibilities need to be explored in future work.

## 9.5. CONCLUSIONS

An individual's labor market success is probably the most important indicator of individual welfare.<sup>21</sup> As such, how earnings are distributed across the population is of paramount importance. In his 1957 Ph.D. dissertation, followed by his 1958 *Journal of Political Economy* article, Jacob Mincer pioneered an important approach to understand earnings distribution. In the years since this seminal work, he, his colleagues, and his students have extended the original model, reaching important conclusions about a whole array of observations pertaining to worker well-being. The line of research proved powerful and robust because it explained many important earnings-related phenomena. For example, it explained why education enhances earnings so that an extra year of school provides approximately 5 to 15% higher earnings; why earnings rise through one's life cycle at a diminishing rate; how earnings power atrophies with intermittent labor force participation; why earnings growth is smaller for those anticipating intermittent labor force participation; why men earn more than women, why married women earn less than single women, and why whites earn more than blacks; why occupational distributions differ by gender; why geographic and job mobility predominates for the young more than the old; why on-the-job tenure reduces turnover; why unemployment is lower among the skilled.

However, in the years since Mincer's groundbreaking work, a number of alternative theories were developed to explain *subsets* of the patterns mentioned above. For example, screening models look at why education raises earnings. Occupational segregation models attempt to get at why the male occupational distribution differs from the female occupational distribution. Efficiency wage models hypothesize why an economy sustains unemployment, but not necessarily how unemployment is distributed across the population.<sup>22</sup> And, effort enhancing contract models emerged to offer an alternative explanation to upwardly sloped earnings profiles, though it's not obvious they account for the specific concave shape.

Only one theory – the human capital theory – seems to explain *each* phenomenon. The human capital theory is well grounded in standard neoclassical economic theory and subject to much econometric testing across time (over 40 years) and across space (over 100 countries). This paper surveys human capital theory related to Mincer's earnings function. In addition it provides new empirical work regarding the overtaking age. Its main substantive contribution is to reexamine one implication of this concept as it relates to the earnings distribution, particularly Mincer's prediction of a U-shaped lifecycle log-variance of earnings profile. No alternative model gives this prediction. In this vein, the paper not only replicates Mincer's original findings using U.S. Census 1980 and 1990 data, but also using nine other countries. As Mincer predicted, I find U-shaped earnings variance profiles for relative earnings, but not for nominal earnings.

## NOTES

1. Perhaps most well known was Robert Gibrat's theory modified by Michal Kalecki and R. S. G. Rutherford. These theories point out that a log-normal income distribution results when individuals are bombarded annually with random percent income augmentations, perhaps as a result of 'luck' or 'chance.' The distribution's overall variance is preserved over time/stays constant either "if there is "a negative correlation between the size of the random shock and the level of income (Kalecki)" [Mincer p. 5] or if the random shock is applied "without restriction separately to age cohorts throughout their life histories"[Mincer p.5].
2. Of particular concern in much early work was applying the human capital concept to measure national wealth and the changes in national wealth caused by war (e.g., Yves Guyot, 1914 and Harold Boag, 1916). Not considered in these works were life cycle aspects, though in 1924, Stanislav Strumlin calculated (without appropriate discounting) returns to education and on-the-job training for a group of Russian metal trade workers, and in 1935 Walsh produced tables essentially containing age-earnings profiles for law, engineering and medicine. Later in 1945, Milton Friedman and Simon Kuznets examined the income structure in medicine, dentistry, law, accounting, and engineering during 1929–36.
3. Also see Becker (1964) and Becker and Chiswick (1966).
4. See Mincer (1962), which is updated in Mincer (1993).
5. Other recent work on this includes Heckman *et al.* (1996) and Card (1998).
6. In addition, education positively affects non-labor market activities. For example, Robert Michael (1973) shows that education improves one's efficiency in consuming every day commodities. Dora Polachek and Solomon Polachek (1989) illustrate "reverse intergenerational transfers" by showing that even one's children's education positively affects the way one consumes.
7. One should note contrasting views on school quality. For example Eric Hanushek (1996) states that specific educational programs are not consistently related to student performance. On the other hand, he John Kain and Steven Rivkin (2002) find that special education boosts mathematics achievement for learning disabled students. However, how these educational achievements translate into market success requires further study, according to Eric Hanushek, James Heckman and Derek Neal (2002).
8. This result is obtained from the negative  $a_3$  coefficient found when estimating the well-known quadratic Mincer earnings function:  $\ln Y = a_0 + a_1 S + a_2 t + a_3 t^2 + u$ . The variable  $\ln Y$  = the logarithm of earnings,  $S$  = years of schooling,  $t$  = labor market experience,  $t^2$  = experience squared, and  $u$  = the typical randomly distributed normal error term.
9. Some exceptions are in panel data, but one can question how to adjust for price changes. Another exception is in executive pay late in some individuals' career paths.
10. See David Autor (2001) for implications regarding new labor market institutions that might evolve from this matching process.
11. See Raquel Fernandez and Richard Rogerson (2001) for a recent generalization and Robert Nakosteen and Michael Zimmer (2001) for an empirical analysis of marital selection. An early matching application I first heard described in a conversation with James Heckman while he was at Columbia University views women who choosing the occupation "wife" as being matched with men who demand various levels of "wife services." This was implemented by Amyra Grossbard-Shechtman (1984).
12. Net investment equals *gross* human capital investments minus *depreciation*. See Solomon Polachek and W. Stanley Siebert (1993) Chapter 2 for an exposition and diagrams contrasting gross and net investment.
13. Two additional countries are considered in Polachek (2003).
14. For consistency as well as because of data limitations (particularly with the international data which will be used shortly), I follow Mincer's approach of using a "cross-sectional" cohort. This means I compare earnings data for variously aged individuals in a given year. Interpreting these age comparisons to reflect purely lifecycle (age) effects requires one to assume that both cohort effects and time-period effects are negligible. Thus one must assume that observations on each successive age group represents the effect of a given cohort of individuals getting older and not the effect of being born in the following year (cohort effect) or the effect of having earnings measured in a successive year (time-period effect). Researchers have long recognized that true cohort and cross-sectional profiles differ. Further it would be a mistake to simply add general growth rates of real earnings to growth rates of earnings associated with age, because at least recently, age-earnings profiles grew differently for individuals with higher levels of education than those with lower levels of education. For example, see

- Paul Beaudry and David Green (2000) who illustrate this with the Canadian Surveys of Consumer Finance and the Canadian Census. Also see James Heckman and Richard Robb (1985).
15. Using women would be interesting but the results would not be comparable because on average their lifetime labor force participation is so different than males that their human capital investment function is non-monotonic resulting in lower and flatter non-concave earnings functions (Polachek, 1975a). Most likely these earnings profile differences also affect women's earnings *distributions*.
  16. The regression results underlying the figures are available upon request.
  17. An appendix containing a list of the countries contained in the LIS data is available from the author upon request. Also available is an appendix with the particular country surveys comprising the data.
  18. The following countries were analyzed: Australia, Belgium, Canada, Czech Republic, France, Mexico, Republic of China (Taiwan), Spain and Sweden. Annual earnings were substituted for those countries with no reported hourly wages.
  19. Due to space limitations this chapter only presents results for six countries. Graphs for Taiwan, Spain, and Sweden are presented in Polachek (2003). However, to get a sense of intertemporal consistency, I present evidence for Australia comprising two separate years (1981 and 1994).
  20. The simple correlation between the overtaking age and the rate of return is  $-.092$ . The simple correlation between the experience coefficient (a composite between the rate of return and the level of human capital investment) is  $-.25$ .
  21. This section extends the conclusions reached in Polachek (1995).
  22. Carmel Chiswick (1986) argues that efficiency wage models actually *assume* rather than explain unemployment because they require "surplus labor ... to justify the zero price paid to labor quantity units." I thank one of the journal referees for pointing out this reference.

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## 10. JACOB MINCER, EXPERIENCE AND THE DISTRIBUTION OF EARNINGS\*

BY BARRY R. CHISWICK

### ABSTRACT

*This paper reviews Jacob Mincer's contributions to the analyses of earnings and the distribution of earnings through his pioneering focus on labor market experience or on-the-job training. It begins with a brief discussion of the theoretical literature on the distribution of earnings in the pre-Mincer period, and then discusses his analysis of human capital and earnings developed in his 1957 doctoral dissertation and 1958 *Journal of Political Economy* (JPE) article. Further analyses of on-the-job training, and in particular estimates of the rate of return from on-the-job training, are presented in his 1962 JPE paper. The synergy between Mincer and Becker during the 1960s is discussed, as is the development of the schooling-earnings function by Becker and Chiswick (1966). Mincer (1974) extended this relationship by incorporating experience to form the "human capital earnings function" in his *Schooling, Experience and Earnings* (1974). Subsequent modifications, extensions, tests of robustness and the wide applicability of the human capital earnings functions are presented.*

\*This is to acknowledge my intellectual debt to Jacob Mincer as a student in his courses in Statistics and Labor Economics at Columbia University, as a reader of his research and as a beneficiary of his comments on my research. He is a master teacher as well as a pioneering scholar who stimulated my own research, as well as that of many others. I appreciate the comments on an earlier draft of this paper from Carmel U. Chiswick, Shoshana Grossbard, Evelyn Lehrer, Paul W. Miller, Harry Patrinos and Richard Peck. I am, however, solely responsible for any errors of omission or commission

**“Experience on the job is often the most essential part of the learning process.”** Jacob Mincer, *Journal of Political Economy*, 1958, p. 287.

### 10.1. INTRODUCTION

The purpose of this paper is to review Jacob Mincer’s contribution to the analysis of earnings and the distribution of earnings through his pioneering focus on labor market experience or on-the-job training. This includes the development of the “human capital earnings function.” This review puts Mincer’s contributions in the broader context. It explores antecedents to Mincer’s research, as well as the interaction of his contributions with those of others.

In addition to recognizing and celebrating Mincer’s own crucial contributions, the paper implicitly emphasizes both the linear and the interactive progression of research. Each step in this area was built on the previous step, and each step served as a stepping-stone for the next step. This is an ongoing process, and we are not near the end.

This paper begins (section 10.2) with a brief discussion of the literature on human capital and earnings distribution in the pre-Mincer period, starting with Adam Smith. Section 10.3 discusses Mincer’s early work in his Ph.D. dissertation and 1958 *Journal of Political Economy* article where, for the first time, there is an explicit modeling of the relationship between earnings and both schooling and labor market experience. The synergy between the work of Mincer and Gary S. Becker is the topic of section 10.4, while section 10.5 discusses the development of the schooling-earnings function. Section 10.6 focuses on Mincer’s book, *Schooling, Experience and Earnings*, and in particular on the development of the expanded earnings function to include on-the-job training, which has become known as the human capital earnings function. This paper closes (section 10.7) with a discussion of the lasting impact of Mincer’s contribution in this area.

### 10.2. THE EARLY PERIOD

In his *Wealth of Nations*, Adam Smith lists five “principal circumstances, which, so far as I have been able to observe, make up for a small pecuniary gain in some employments, and counter-balance a great one in others...” (Smith 1937, Book 1, Chapter X, pp. 100–103). The second of these “circumstances” is the “easiness and cheapness, or the difficulty and expense of learning them.” In his discussion of this “circumstance” Smith first considers two categories of workers, “common labour” and “skilled labour,” where the latter includes “mechanics, artificers and manufacturers.” He then relates that the skilled workers are required to go through an apprenticeship program, in contrast to common labor, which is “free and open to every body.” Moreover, “the whole labour of the apprentice belongs to his master...Some money too is commonly given to the master for teaching him his trade...They who cannot give money give time....” A third category of labor is those “in the ingenious arts and in the liberal professions,” and, as is the situation today, their education is “still more tedious and expensive.”



In this discussion, Smith relates earnings to investment in education or training, at least some of which (apprenticeships) is undertaken in the workplace. Some of the time of the master and the apprentice, and perhaps other resources as well, are devoted to this training activity. Thus, Smith highlights what we would now call investment in on-the-job training.

Over the next century and a half there was little work by economists on the issue of investment in skills or human capital.<sup>1</sup> This is not to say there was no interest in labor earnings. In the United States there were numerous state labor surveys and studies that estimated wages by occupation and interest in immigration resulted in the 41 volume Dillingham Immigration Commission Report (1911) that, among other analyses, collected and analyzed data on the occupational attainment and earnings (wages) of immigrant and native born workers by country of birth and race/ethnicity, as well as a host of other characteristics. Analyses using the census were limited by the data collected. Although the U.S. Census of Population has asked for the respondent's occupation in every census since 1850, there was no question on earnings or income until the 1940 Census, and this was limited to the earnings of wage and salary workers. Income was asked in 1950, and only since 1960 has the census asked both earnings and income.

When interest in human capital resumed the focus was on the contribution of education to economic growth, investment in education in less developed countries and earnings differences across professional occupations (Milton Friedman and Simon Kuznets 1945, Theodore W. Schultz 1961, and the references therein). During this period, one of the important studies was the Milton Friedman and Simon Kuznets *Income from Independent Professional Practice*, published after a long delay in 1945 by the National Bureau of Economic Research. Net present values of earnings streams for five professional occupations were computed using a four percent discount rate.

Another strand in the economics literature was an interest in the inequality and shape of the distribution of income or earnings. What was the cause of income inequality and why did the distribution of income have a positive skewness? If ability was normally distributed, as it was assumed, then why was the distribution of income not also normally distributed but rather positively skewed? The literature in this area considered the consequences of combining separate distributions of ability or considered the effects of purely random or stochastic events ("chance") as a determinant of the distribution of income. To reconcile some of these models with the apparent stability over time of the distribution of income required adding complexity that would assure stability. These models had mathematical underpinnings, but were essentially devoid of economic behavior. In 1953 Milton Friedman (p. 277) wrote: "The absence of a satisfactory theory of the personal distribution of income and of a theoretical bridge connecting the functional distribution of income with the personal distribution is a major gap in modern economic theory."

### 10.3. MINCER'S EARLY WORK ON EXPERIENCE

In his path breaking doctoral dissertation and in the seminal article, "Investment in Human Capital and Personal Income Distribution", based on his dissertation, Mincer

(1957, 1958) pioneered the explicit study of the effect of labor market experience or on-the-job training on the determination and distribution of earnings. His model provided an analysis of the manner in which on-the-job training influences differences in earnings across individuals and how this determines the inequality and skewness of earnings. It is a model based on rational economic behavior by individuals in the labor market. As a result, this work served as the base for several strands of research in labor economics.

In Figure 10.1 in his 1958 *Journal of Political Economy* article Mincer draws what we would now call an experience-earnings profile, with the assumption of a linear relation between earnings and age. It is only in later work that he identifies and emphasizes the important distinction between age and labor market experience, and the concave shape of the experience-earnings profile. Indeed, he wrote that “formal training” is more difficult to measure than informal on-the-job training (Mincer 1958, p. 291). In the empirical section he demonstrates the concave age-earnings profile through the graphing of income profiles by level of schooling for adult males for 1949.

With this analysis Mincer (1957, 1958) shows that within an occupation earnings inequality increases with the steepness of the age-earnings profile, and that this profile is steeper for occupations requiring more skill, whether acquired in school or on the job. He also shows theoretically and empirically that inequality increases with age, schooling level and occupational rank (income). He writes that “the greater the average amount of training in the group, the greater the inequality in its income distribution”, whether the group is defined by industry, race, gender, marital status or city size (Mincer 1958, p. 300). An implication of the model that was to be essential in the subsequent development of the human capital earnings function is that: “absolute differences in the length of training result in percentage differences in annual earnings” (Mincer 1958, p. 301). This implication also generates the positive skewness in earnings.

While there have been numerous studies over the years of rates of return from formal education or from specific formal job training programs, the literature in economics is virtually devoid of studies of the magnitude of and rates of return from investments in on-the-job training, especially experience or merely learning by doing.<sup>2</sup> This may be due, at least in part, to the difficulty of measuring the cost of the investment in on-the-job training.

In October 1962, the *Journal of Political Economy* published a supplement edited by T.W. Schultz entitled *Investment in Human Beings*.<sup>3</sup> This path-breaking study included chapters on various aspects of human capital: Gary Becker on human capital theory, Larry Sjaasted on migration, Selma Mushkin on health, George Stigler on information in labor markets (job search), Burton Weisbrod on the non-pecuniary benefits of education, Edward Denison on education and economic growth, and Jacob Mincer on labor market experience. In this study, Mincer (1962) explicitly focuses on estimating the magnitude of on-the-job training, the rate of return from on-the-job training and the implications of on-the-job training for the distribution of earnings. Here he notes explicitly that earnings profiles imply a decline in on-the-job training

investments with age, which is attributed to the decline with age in the length of the remaining working life.<sup>4</sup> Among other findings, Mincer's estimates of the dollar magnitude of on-the-job training increase with the level of schooling. Although at the margin, schooling and on-the-job training can be alternative ways of acquiring skills (i.e., they are substitutes), overall school and experience investments are positively correlated across individuals. This is the first empirical demonstration of the positive relationship between these two forms of human capital.

Estimates of the value of the foregone earnings component of investment in on-the-job training made by workers were obtained by comparing earnings streams of workers that differ by level of schooling. Rates of return from the earnings streams were computed (Mincer 1962). By assuming that rates of return from schooling and on-the-job training were the same, and subtracting investments in schooling from the total investment, Mincer was able to estimate the investment in training. These estimates suggested that for males the dollar value of investments in on-the-job training were about the same as the value of investments in schooling.<sup>5</sup> Investments in schooling had increased over time in terms of years and dollar value, and investment in labor market experience did not seem to be any less and may have even increased in dollar value during the same period.

Mincer (1962) estimated rates of return from on-the-job training for several different occupations. For three occupations with apprenticeship programs (metal, printing and building trades), he assumes that their alternative employment would be operatives, and by comparing earnings as apprentices and as journeymen in contrast to those of operatives Mincer computes rates of return from on-the-job training. He estimates that the rates of return from investment in on-the-job training are about 9 to 13 percent (Mincer, 1962, p. 66). These are slightly higher than estimates of rates of return from college but given the numerous measurement issues with both types of estimates, they are in the same neighborhood.

Foreshadowing his later work, Mincer (1962, pp. 66–68) discusses investment in on-the-job training by women compared to men. The incentives for women to make these investments are less because “the average female expects to spend less than half her working life in the labor force,” and has a high probability of dropping out of the labor force for child-rearing. Mincer notes that for these reasons employers would be more reluctant to invest in firm-specific training for women than for men.

#### 10.4. MINCER AND BECKER

Although Jacob Mincer and Gary Becker did not have a publication co-authored with each other, they enjoyed a mutually beneficial intellectual relationship which each has often acknowledged.<sup>6</sup> At the July 15, 2002 conference Mincer referred to the “synergy between Gary and me,” while Becker referred to their “continuous unending intellectual collaboration” and their “great complementarity” during his years at Columbia University.

Jacob Mincer's theoretical and empirical work on human capital (schooling and on-the-job training) referred to above stimulated and influenced subsequent work in this area, including that of Gary Becker (1962, 1964, 1966, 1967 and Becker and

Barry R. Chiswick 1966), and Mincer's subsequent work was, in turn, influenced by that of Becker. The decade long workshop that they jointly operated at Columbia University, and their work at the NBER New York office, largely overlapping with the 1960's, served as a hotbed for research on human capital and the New Home Economics (see Chapter 7 by Shoshana Grossbard).

Gary Becker's major theoretical and empirical research on human capital are in his article in T.W. Schultz's edited volume *Investment in Human Beings* (1962) and in his book, *Human Capital* (1964). These studies further demonstrated the power of the human capital approach for understanding the theory of investment in human capital, and demonstrated a range of implications for the determination of earnings and, in the context of on-the-job training, job turnover in the labor market (quits and layoffs). Among other concepts, Becker expanded on the distinction between "firm specific" and "general" training, where the former is training useful only in the firm in which it was acquired, whereas the latter training is as useful in that firm as in other firms. This distinction regarding the specificity of types of on-the-job training or labor market experience offered many insights regarding labor market activities and investment in human capital.

Moreover, this distinction foreshadowed the distinction between "market specific" and "home specific" human capital on the one hand and skills useful in both sectors on the other hand, that proved so valuable in the analysis of female earnings, labor supply, and the New Home Economics (Mincer and Solomon Polachek 1974). Furthermore, the distinction between "country specific" and "internationally transferable" human capital has proved valuable in analyses for research on immigrants, and migrants in general (Chiswick 1978).

Becker and Chiswick (1966) reported on two inter-related strands of research in progress on human capital and the distribution of earnings.<sup>7</sup> One was a model of the supply and demand for funds for investment in human capital. While the basic idea that the individual's optimal level of human capital investment occurs where the marginal rate of return from the investment equals the marginal interest cost of funds had been developed earlier, the supply and demand functions for funds for investment were made explicit. Assuming differences in supply and demand conditions across individuals, and under alternative assumptions as to the correlation between individual supply and demand curves, implications were generated regarding investments in human capital and the distribution of earnings. The fuller analysis was presented in Becker's (1967) Woytinsky Lecture.<sup>8</sup>

#### 10.5. THE SCHOOLING-EARNINGS FUNCTION

The other strand in Becker and Chiswick (1966) was to present an alternative approach to estimating rates of return from human capital and to use it to understand the determinants of the distribution (inequality and skewness) of earnings.

Previous estimates of the profitability of investments in human capital used earnings streams and the net present value approach. In Friedman and Kuznets (1945), net present values of earnings streams were computed using a 4 percent discount rate. In

Mincer (1962), the net present value formula was converted into a ratio of a constant stream of benefits received indefinitely to the cost of the investment so as to obtain an estimate of the rate of return from on-the-job training. In particular, the rate of return was estimated from average annual earnings relative to the cost of the training. In Mincer (1962, p. 64), the formula was  $d/c = (1 + r)n$ , where  $r$  is the rate of return from the investment,  $c$  is the cost of the investment (measured by the annual forgone earnings during the training period),  $d$  is the increment in earnings over the alternative job after training is completed, and  $n$  is the number of years of training. The net present value formula collapses to this simple formulation for constant benefits and costs, and an infinite working life. Becker (1962, 1964) estimated the internal rate of return on the investment by computing the discount rate that set the present value of the stream of net earnings (benefits minus costs) equal to zero. These procedures were computationally awkward and limited by the scarcity of data, especially on dollars invested in human capital.

In the simplest formulation, in Becker and Chiswick (1966), earnings for person  $i$  in year  $j$  ( $E_{ij}$ ) were related to earnings if there were no investment ( $E_{io}$ ) plus the sum of the annual returns from past human capital investments,  $\sum_{j=1}^n r_{ij} C_{ij}$ , where  $r_{ij}$  is the  $i^{\text{th}}$  person's rate of return from this person's investment ( $C_{ij}$ ) in the  $j^{\text{th}}$  period. Defining  $k_j$  as the investment (forgone earnings and direct costs) in year  $j$  relative to what the earnings would have been if there were no investments in year  $j$ ,  $k_j = C_j/E_{j-1}$ . Then it can be shown,

$$E_{ij} = E_{io} + \sum_{j=1}^n r_{ij} C_{ij} = E_{io} + \sum_{j=1}^n r_{ij} k_{ij} E_{i,j-1}, \quad (1)$$

and using the principle of mathematical induction,

$$E_{ij} = E_{io} \prod_{j=1}^n (1 + r_{ij} k_{ij}). \quad (2)$$

Taking logarithms,

$$\ln E_{ij} = \ln E_{io} + \sum_{j=1}^n \ln (1 + r_{ij} k_{ij}). \quad (3)$$

Using the property that  $\ln(1 + \partial) \approx \partial$  if  $\partial$  is a small number,

$$\ln E_{ij} \cong \ln E_{io} + \sum_{j=1}^n r_{ij} k_{ij}. \quad (4)$$

Thus, the natural logarithm of earnings is expressed in terms of the rate of return from the investment ( $r_{ij}$ ), the investment ratio ( $k_{ij}$ ) and the number of periods of investment ( $n$ ). The product  $r_{ij} k_{ij}$  is referred to in Becker and Chiswick (1966) as the "adjusted rate of return,"  $r'$ .

If  $r'$  is constant for all levels of investment, equation (4) can be written as:

$$\ln E_{i,j} = \ln E_0 + r'_i n_i + U_i, \tag{5}$$

where the error term ( $U_i$ ) measures differences across individuals in the omitted variables that influence earnings, including other forms of human capital and luck.

Chiswick (1967, Chapter 2) notes that investment in human capital in the earnings equation can be separated into its components, namely, schooling, on-the-job training and other human capital. Using the notation above, he shows that equation (4) can be written as

$$\ln E_{ij} = \ln E_0 + \sum_{s=1}^{S_i} r'_{is} + \sum_{j=1}^{J_i} r'_{ij} S_{ij} + u'_i \tag{6}$$

where  $r'_{is}$  and  $r'_{ij}$  are the “adjusted rates of return,” that is  $r_s k_s$  and  $r_j k_j$ , respectively, from years of investment in schooling ( $S_i$ ) and years of investment in on-the-job training ( $J_i$ ), as defined above. Chiswick (1967) also shows how other forms of human capital can be incorporated into the earnings equation. Apart from this equation, Chiswick focuses on understanding rates of return from schooling, and the effects of rates of return from schooling and the distribution of schooling, among other factors, on the distribution of earnings.<sup>9</sup> The evaluation of the on-the-job training component had to wait for Mincer (1974).

Becker and Chiswick (1966, p. 364) write that “although the period of formal schooling is now known with tolerable accuracy...only bits and pieces are known about the periods of formal and informal on-the-job training and still less about other kinds of human capital. Unfortunately the only recourse at present is to simplify further: by separating formal schooling from other human capital.” Then using equation (4), assuming  $r'_{ij}$  is the same for all levels of schooling, and putting differences in  $r'_{ij}$  across levels of schooling, on-the-job training and other effects in the residual ( $u'_i$ ),

$$\ln E_{ij} = \ln E_{i0} + r'_i S_{ij} + u'_i \tag{7}$$

Then the regression of  $\ln E_{ij}$  on  $S_{ij}$  gives an estimate of  $r' = rk$ .<sup>10</sup> It was also demonstrated in Becker and Chiswick (1966) that estimates of rates of return for distinct levels of schooling can be obtained by creating separate variables, say, for years of primary, secondary and higher education.

When this work was initially undertaken microdata files were not yet available from the decennial census. Published cross-tabulations of earnings by education (schooling levels) were available, but not jointly by earnings, schooling and age. The regression of the natural logarithm of earnings on years of schooling, which has been referred to as the “schooling earnings function,” was used to estimate the adjusted rate of return from schooling, which, because  $k$  was estimated as close to unity, was an estimate of the rate of return (Becker and Chiswick 1966, Chiswick 1967). These

estimates were computed overall, by regions, and by states of the United States from the 1960 Census for the provinces of Canada from the 1961 Census of Canada, in addition to other countries, for analyses of the effect of schooling on the inequality and skewness of earnings across regions (Chiswick 1967, 1970, 1974).

This “schooling–earnings function” has been used to theoretically and empirically demonstrate several propositions about the distribution of earnings (Becker and Chiswick 1966, Chiswick 1967, 1970, 1974 Part B). These include: the relative inequality of earnings is larger the greater is the absolute inequality in schooling, the greater the rate of return from schooling, and the greater the inequality in rates of returns from schooling.<sup>11</sup> If rates of return are constant, a normal distribution of schooling generates a log normal (or positively skewed) distribution of earnings.<sup>12</sup>

Becker and Chiswick (1966, p. 365) discuss sources of possible upward and downward bias in the rates of returns from schooling estimated from the schooling earnings function.<sup>13</sup> Included in this discussion is the comment that “the correlation between years of schooling and years invested in other human capital...might well be negative. Certainly persons leaving school early begin their on–the–job learning early, and possibly continue for a relatively long time period.” It is noted in Becker and Chiswick (1966 p. 367) that the schooling–earnings function produces rates of return from schooling that are somewhat lower than the internal rates of return estimated from the present value method. They write (p. 367) that this suggests “a negative correlation between school years and the years invested in other human capital.”

#### 10.6. THE HUMAN CAPITAL EARNINGS FUNCTION

In 1974, Jacob Mincer published his classic study, *Schooling, Experience and Earnings*.<sup>14</sup> In a very real sense, this book extends the analysis from Mincer’s earlier work, especially Mincer 1957 and 1958, yet it also reflects the advances in, and the spirit of human capital theory that had been carried forward by Mincer and others in the intervening years. While it extends the analysis of the effect of human capital on the inequality and skewness of earnings developed in his earlier work, this has received less attention than the development of the human capital earnings function. In this study, Mincer shows that “the inclusion in the earnings function of even crude measures of ‘post school investments’ in addition to schooling lends a great deal of scope to the analysis of income distribution,” and he coins the term “the human capital earnings function” for this expanded relationship (Mincer, 1974, p. 2).<sup>15</sup>

In his discussion of investment in human capital, Mincer notes that full-time investment, which is primarily acquired in schools, precedes part-time investment which is generally conducted on the job. Moreover, for several reasons investments in on–the–job training would decline relative to earning potential and in absolute value as experience increases (see also Becker 1967 and Yoram Ben-Porath 1967).<sup>16</sup> These factors include the finiteness of the working life, that profitable investments (i.e., investments where the internal rate of return exceeds the discount rate) are more profitable if made sooner rather than later, and that the opportunity cost of investment rises as more skill is acquired. On the other hand, to the extent that the stock of

human capital due to prior investments in training increases the productivity of new investments in on-the-job training, additional investments are encouraged. If the interest cost of funds schedule has a non-negative slope, optimal investment occurs in the downward sloping portion of the marginal rate of return schedule. Mincer shows that the concave experience earnings profile we observe in the data is implied by declining investment ratios (i.e., investment relative to potential earnings).

Mincer also shows (1974, pp. 28–32) that there is an important distinction between age-earnings profiles and experience-earning profiles, where experience means years since leaving school.<sup>17,18</sup> If individuals differ in their level of schooling, they differ in the age at which post-school (on-the-job training) investments begin, and hence the two profiles differ. Mincer demonstrates that there would tend to be a positive correlation between schooling and on-the-job training investments, not because they are necessarily complements, but because “it reflects the dominance of individual differences in factors determining the scale of total human capital accumulation. Individuals who invest more in human capital, invest more in both forms of it” (Mincer 1974, p. 31).<sup>19</sup> That is, those with greater ability and a lower interest cost of funds would tend to have these characteristics for both schooling and on-the-job training.<sup>20</sup> Research suggests that there is a positive correlation in dollar investments among all forms of human capital, even though at the margin various types of human capital can be substituted for each other to attain the same earnings. In the absence of direct information on investments in on-the-job training or on years of labor market experience Mincer suggests “subtracting the age of completion of schooling from reported age” (Mincer 1974, p. 47). He recognizes that age is relevant if only because of the depreciation of human capital with age, but in the absence of a mechanism for measuring experience independent of age, experience is to be preferred. Using data that permit independent measures of age and experience, Mincer shows that the latter has a greater partial correlation with earnings (Mincer, 1974, pp. 78–80).

In addition to past work effort (labor market experience), Mincer also explicitly incorporates into the analysis current work effort, and in particular weeks worked. Rates of return from schooling are higher when weeks worked are not held constant. Weeks worked is, not surprisingly, positively correlated with annual earnings, but it is also positively correlated with years of schooling. If the latter positive correlation is due to labor supply effects (higher weekly earnings due to more schooling result in greater weeks worked), Mincer argues (1974 pp. 53–55) that rates of return should be estimated on the basis of weekly earnings.<sup>21</sup> On the other hand, to the extent that schooling raises weeks worked by lowering job turnover, unemployment and absenteeism, controlling for weeks worked biases downward the partial effect of schooling.<sup>22</sup> Unfortunately, the issue of the interpretation of the role of employment in the human capital earnings function has received too little attention either conceptually or empirically, whether earnings are measured on an annual, weekly or hourly basis.

To expand the earnings function in equation (6) into what we now refer to as the human capital earnings function, Mincer needed to make assumptions as to how the



investment in on-the-job training in each year declines as years of experience increase. Concerned with “mathematical simplicity and statistical tractability” he shows the development of four functional forms, one for each of the four cells defined by dollar investments ( $C_t$ ) vs. “time-equivalent” investments ( $k_t = \frac{C_t}{E_{t-1}}$ ), and linear vs. exponential forms of declines in investments (Mincer 1974, pp.84–89). Largely due to data availability (that is, the data on schooling and potential experience are available in years), time-equivalent investment ratios are preferred, and for simplicity the assumption of a linear decline is preferred to the exponential decline in investment, even though the latter would have greater consistency with economic theory.

The investment ratio/linear decline specification is that  $k_t = k_0 - \frac{k_0}{T^*} T_t$ , where  $k_t$  is the investment ratio in the  $T^{th}$  year of on-the-job training,  $k^0$  is the ratio in the initial year and  $T^*$  is the number of years of positive net investment in training beyond which  $k^t = 0$ . Then if  $\ln E_t$  is the log of earnings in year  $t$  and  $r_s k_s$  is the same for all levels of schooling,<sup>23</sup>

$$\ln E_{it} = \ln E_{i0} + r_s k_s S_i + (r_j k_0) T_i - \left( \frac{r_j k_0}{2T^*} \right) T_i^2 \quad (8)$$

where  $r_j$  is the rate of return from investments in on-the-job training. Then the logarithm of gross earnings (i.e., earnings in year  $t$  if there is no further investment in on-the-job training) can be expressed as a quadratic function of years of labor market experience. It is this functional form that has become the dominant specification in analyses of earnings:

$$\ln E_i = b_0 b_1 S_i + b_2 T_i + b_3 T_i^2 + U_i, \quad (9)$$

where  $E_i$ ,  $S_i$  and  $T_i$  are earnings, years of schooling and years of potential post-school labor market experience (age minus years of schooling minus six), the  $b$ 's are the regression coefficients and it is assumed that  $U_i$  is a normally distributed homoskedastic residual.

It may be noted that this specification provides two estimates of the rate of return from on-the-job training. If there are estimates of  $k_0$  and  $T^*$ , the rate of return from on-the-job training can be estimated from the coefficient of  $T$  or  $T^2$ . These two estimates tend to differ in part because the data are for earnings net of current investments, but perhaps more importantly because the investment ratio ( $k_t$ ) is assumed to decline linearly.<sup>24</sup> Although an exponential decline is a closer approximation of reality, it generates a computationally more complex function (Mincer, 1974, pp. 85–90).<sup>25</sup> The variables  $E$ ,  $S$  and  $T$  are available in a wide range of data across time and space and their coefficients can be estimated from multiple regression analysis.<sup>26</sup>

Using data on the annual earnings of white non-farm men from the 1960 Census public use microdata sample, Mincer (1974, p. 92, Table 5.1) estimates earnings functions for several specifications, including the linear and exponential decline in on-the-job training investment ratios, with and without holding constant the natural logarithm of weeks worked. He shows that the estimated coefficient of schooling is lower when experience and its square are not included in the earnings function (7 percent compared to 11 percent), but that there is little difference in the schooling coefficient, depending on whether it is assumed there is a linear or exponential decline in the experience investment ratios. The partial effect of schooling on earnings is shown to decline with higher levels of schooling for annual earnings, but it is approximately linear for weekly or hourly earnings.

The elasticity of annual earnings with respect to weeks worked is estimated at about 1.2, and is significantly greater than unity (Mincer, 1974, p. 92, Table 5.1). This suggests that weekly earnings are higher for those who work more weeks in the year.

Moreover, Mincer (1974, p. 92, Table 5.1) shows that whereas the explanatory power of the schooling-earnings function in these data is only 7 percent, the explanatory power of the function with the quadratic experience profile is 29 percent, which is increased to 53 percent when dummy variables are used for schooling and the log weeks worked variable is added to the equation. The explanatory power is increased even further when the analysis is computed at the “overtaking age,” that is, at the number of years of experience where the variance in earnings by experience level is smallest (about 8 to 10 years of experience). Thus, the human capital earnings function provides a high explanatory power for earnings in spite of the simple measures of investment in human capital, namely, years of schooling and years since leaving school.

Mincer (1974, Chapter 6) then proceeded to analyze the residual, that is, differences in earnings when years of both schooling and experience are held constant. These differences are attributable to differences in the intensity, quality and rates of return from schooling and experience investments, as well as variations in employment. He also considers the distinction between the permanent component and the transitory component (e.g., luck, random shocks) of earnings.

The functional form of the human capital earnings function also served as the basis for the analysis of earnings inequality across time and across space (Chiswick and Mincer 1972, Chiswick 1974 Part C). By taking the variance of both sides of equation (8) the relative variance in earnings is related to the absolute inequality in years of schooling and in years of labor market experience, as well as the rates of return from these investments. This structure explains most of the variation in earnings inequality over time and across countries and regions of countries.

The “human capital earnings function” has several distinct characteristics that make it particularly attractive:

- The functional form is not ad hoc. It is an identity based on the optimizing behavior of individuals, and represents the outcome of a labor market process.

- It converts “immeasurables” into “measurables,” that is, the dollar cost of the investment in human capital becomes converted into years of schooling and years of labor market experience.
- It is readily adaptable to the inclusion of other variables that affect earnings.<sup>27</sup>
- The coefficients of the regression equation have economic interpretations, they are pure numbers (devoid of units) and their standard errors can be estimated. This permits comparisons across time, space and demographic groups.
- Although earnings are positively skewed and the inequality of earnings rises with the level of schooling, by using the natural logarithm of earnings as the dependent variable, the residuals are closer to being normally distributed and homoskedastic.
- The functional form generates a commonly used measure of relative inequality, the variance of the natural logarithm of earnings, thereby facilitating the study of earnings and income inequality across time and space.

Thomas Lemieux (this volume) reviews the literature on alternative specifications of the earnings function to determine whether the simple structure in equation (9) is the most appropriate. He concludes that to a first approximation it is appropriate. He writes “the human capital earnings function remains a parsimonious and relatively accurate way of modelling the relationship between earnings, schooling and experience. Its status as the ‘workhorse’ of empirical labour economic research on earnings determination is well deserved.”<sup>28</sup>

#### 10.7. THE LASTING IMPACT

The human capital earnings function has not been static. Just as it evolved from earlier research, so too has it served as the basis for additional developments in theory and measurement.

The insight Mincer developed regarding the distinction between age and labor market experience has proved invaluable in terms of analyses for groups that are not in continuous attachment to a single labor market. Mincer and Polachek (1974), for example, analyze the earnings of women as a function of the timing and length of periods engaged in the labor market, the alternative activity being home production, largely related to child care.<sup>29</sup> This approach has proved invaluable in the New Home Economics literature, as well as demonstrating that adjusting for actual labor market experience and human capital depreciation, rather than only age or years since leaving school, the gender difference in earnings decreases substantially (June O’Neill and Polachek 1993).

Another modification, most useful in analysis for a very low skilled population and for less developed countries, is adjusting the measure of potential experience for those without schooling or who leave school as children. Potential experience is defined as the lesser of years since leaving school or years since the onset of labor market experience that is relevant for adult earnings. Thus, rather than assigning 19 years of experience to a 25 year old with no schooling, if labor market experience relevant for the adult labor market begins at age 15, then 10 years of potential experience would be assigned (Chiswick, 1991).

The human capital earnings function in equation (9) was developed in the context of wage and salary income.<sup>30</sup> Data are often available only for wage, salary and self-employment income combined. Moreover, self-employment is an important type of economic activity. Self-employment income includes the entrepreneur's implicit wage, return on the entrepreneur's investment of his or her own capital, and economic profit which may be positive or negative. One common solution to this problem is to exclude the self-employed from the analysis, as did Mincer, but this creates selectivity bias. To use selectivity correction techniques requires the modeling and estimation of an auxiliary equation to explain self-employment status. Moreover, in some circumstances, especially in rural areas of less developed countries, unpaid family workers are an important component of the labor force, and their productivity appears in the measured earnings or income of the self-employed person or household head. Following in the tradition, Carmel Chiswick (1983) has developed and implemented a methodology for explicitly incorporating the self-employed and the contribution to their income of unpaid family workers into the human capital earnings function.

The insight regarding the distinction between specific and general human capital and the insight regarding the location of labor market investment sparked a new literature on the earnings of immigrants (Chiswick 1978). Where labor market experience occurs matters. If skills are not perfectly transferable across labor markets, incentives for migration differ across individuals, and post-migration investments in skills relevant for the destination have higher rates of return, with implications for investments and earnings profiles in the destination. The literature on immigrant labor market adjustment and impacts emerged from these propositions.

These insights also had a major influence in subsequent research on the formation, duration and dissolution of marriage in the New Home Economics literature. Using a labor market analogy, the research on marriage made a distinction between human capital investments valuable in home production and human capital that is labor market specific (Becker, Lisa Landes, and Robert Michael 1976). This analogy was subsequently extended to distinguish between general marital and spouse-specific marital human capital, that is, between marital human capital that would be valuable in any marriage and investments that are relevant only for a specific mate (Chiswick and Evelyn Lehrer 1990).

The human capital earnings function has also become a technique accepted by the courts in analyses of earnings (Joseph Gastwirth 1988, Federal Judiciary Centre 1994). It is used to estimate the value of lost earnings due to injury, death or the result of discrimination.

One of the most important uses of the human capital earnings function has been the estimation of rates of return from schooling.<sup>31</sup> Hundreds of such estimates have been computed.<sup>32</sup> Most references to Mincer's *Schooling, Experience and Earnings* are to the specification of the human capital earnings function. In the year 2000, 26 years after the publication of the book, there were still a remarkable 44 citations listed in the Social Science Citation Index. Yet this substantially underestimates its impact as most users of the technique do not cite, and many may never have read, the source.

Perhaps far more telling of its impact is that it has made its way into textbooks in labor economics, personnel economics and econometrics.<sup>33</sup>

Indeed, perhaps the highest compliment that can be paid is that the structure of the equation has become a standard feature of research in labor economics, the economics of education and in labor market analyses by sociologists. Its origins are often taken for granted. This is unfortunate as the subtleties Mincer developed in *Schooling, Experience and Earnings* are too often lost on the users of the human capital earnings function.

## NOTES

1. A word search in June 2002 indicated that the term “human capital” first appeared in the title of an article in a journal covered by JSTOR in Mincer (1958). The term appeared in the text of an economics journal article in JSTOR in only 29 articles published in 1957 or earlier (starting with two articles on the meaning of capital by Irving Fisher in the *Economic Journal* in 1897), twice in 1958 (including Mincer’s article), in 188 articles in the decade 1959–1968, in 756 articles in the decade 1969–1978, in 1,137 articles in 1979–1988 and 1,713 in 1989–1998, even though not all of the included journals go through 1998.
2. Although there have been numerous studies that have examined the slopes of experience earnings profiles across groups (e.g., males vs. females, blacks vs. whites, immigrants vs. natives), this is distinct from estimating rates of return from investment in experience or on-the-job training.
3. It is fitting that this conference honoring Jacob Mincer’s intellectual contributions to economics was held in the 40<sup>th</sup> anniversary year of the publication of *Investment in Human Beings*.
4. For workers several decades away from retirement the effect of the finiteness of life on the rate of return from investment in on-the-job-training is small. Additional explanations, including the rising opportunity cost of time, are presented in Yoram Ben Porath (1967) and Mincer (1974).
5. In later research Mincer (1974, p. 74) shows that the dollar value of investments in on-the-job training rises with the level of schooling and that they are the equivalent of an additional 3 to 5 years of schooling.
6. They do have one unpublished co-authored paper. They each co-authored with several of their students, although up to this date I am the only person who co-authored with both of them.
7. The major products of this research were Becker (1967) and Chiswick (1967), as well as Becker and Chiswick (1966).
8. Becker (1967) uses the framework to analyze the effects on the distribution of income of differences in “ability” (demand conditions) and differences in “opportunities” (supply conditions), as well as the correlation between these conditions. Chiswick (1988) uses the framework to analyze differences in the levels of investment in human capital and differences in earnings across racial and ethnic groups in the United States.
9. Parts of Chiswick (1967) were published as Chiswick (1970) and Chiswick (1974, Part B).
10. Note that conceptually this coefficient is not the rate of return from investment in schooling, but rather is the product of the average rate of return and the average investment ratio. Only if it can be assumed that  $k = 1$  is this the rate of return. Nearly all estimates of rates of return from schooling using this procedure unwittingly assume that  $k = 1$ . This need not be the case. For example, if out of pocket costs and some forgone earnings costs of schooling are subsidized (as in the educational benefits under the post-WWII GI Bill of Rights or university education more generally in some countries),  $k$  is smaller than unity and  $r' = 1$  is an underestimate of the rate of return from schooling. Arleen Leibowitz (1976) presents theoretical arguments for why  $k$  and  $S$  may be correlated and demonstrates that they are positively correlated for higher education in the Terman sample. James Heckman and Edward Vytalil (1998) demonstrate an instrumental variable technique to correct for bias when the coefficient of a variable is correlated with the variable, and apply this technique to the schooling-earnings function.
11. For example, if  $\text{Ln}E_0$  and  $r'$  are constant across individuals, and if  $S_i$  and  $u'_i$  are uncorrelated,  $\text{Ln}E_{ij} = \text{Ln}E_0 + r'S_i + u'_i$ , and taking variances,  $\text{Var}(\text{Ln}E_i) = (r')^2 \text{Var}(S_i) + \text{Var}(u'_i)$ . If  $r'_i$  and  $S_i$  vary, but are independent of each other, the inequality in earnings is a function of the level and inequality of  $r'_i$  and  $S_i$  (see Leo Goodman 1960). The ratio of the explained variation in earnings

- $[(r')^2 \text{Var}S]$  to the total variation in earnings  $[\text{Var}LnE]$  is the coefficient of determination for log earnings.
12. If rates of return vary across individuals but are uncorrelated with the individual's level of schooling, even the natural logarithm of earnings has a small positive skewness. This skewness is greater if rates of return and schooling levels are positively correlated. The correlation would be positive if, as is likely, demand conditions vary more across individuals than supply conditions for funds for investment in human capital.
  13. See also Chiswick (1967, Chapter 2).
  14. This NBER book had circulated in manuscript form in 1972, two years prior to publication.
  15. For surveys of the literature see Mincer (1970), Robert Willis (1986) and Sherwin Rosen (1987, 1992).
  16. William Haley (1973) presents a model in which the decline in the specialization of investment in human capital begins even before the end of schooling. See also Leibowitz (1976).
  17. I recall someone asking Mincer where he came up with the fundamental insight regarding the distinction between age and labor market experience, and he replied that it was based on his own life experience.
  18. As discussed below, this was later expanded to a distinction between years since leaving school and years and timing of actual labor market experience.
  19. See Mincer (1974, pp.74–75) for his estimates of investment in schooling and on-the-job training by schooling level.
  20. At the investor's optimum, the marginal internal rates of return and the marginal interest cost of funds for all types of human capital investment should be equal.
  21. Moreover, if this is the case, weeks worked is endogenous and the coefficient of the log weeks worked variable in the human capital earnings function is biased. Seasonality in employment and a backward bending labor supply curve would tend to lower the elasticity of annual earnings with respect to weeks worked below unity.
  22. If  $LnE = b_0 + b_1S + b_2LnW$  where  $E$  is annual earnings,  $S$  is schooling and  $W$  is weeks worked,  $\frac{\partial LnE}{\partial S} = b_1 + b_2 \frac{\partial LnW}{\partial S}$ , and the coefficient of schooling ( $b_1$ ) needs to be augmented by the indirect effect of schooling through weeks worked to obtain its total effect.
  23. Using the continuous form, Mincer (1974) shows that the aggregate of the effects on log earnings of post-schooling training is  $\int_{t=0}^T rk_t dt = \int_0^T r(k_0 - \frac{k_0}{T^*}t) dt = (rk_0)T - \frac{rk_0}{2T^*} T^2$ , where  $r$  is assumed to be the constant rate of return from on-the-job training.
  24. To the extent that investments are made in the year for which the earnings data are available,  $Y_t = E_t - C_t = E_t(1 - k_t)$  or  $LnY_t = LnE_t + Ln(1 - k_t)$ , where  $Y_t$  is earnings net of current period investments and  $k_t = k_0(1 - \frac{t}{T^*})$ . The adjustment is small when  $T^*$  is a large number (Mincer, 1974, pp. 90–91).
  25. If an exponential decline rather than a linear decline in investment ratios is more appropriate, the human capital earnings function would understate earnings growth in the early period of investment and overstate earnings growth in mid-career. Kevin Murphy and Finis Welch (1990) use higher order polynomials in experience and find that this appears to be the case.
  26. Indeed, this earnings function has been used to estimate the partial effect of schooling on the log of earnings (interpreted as rates of return from schooling) for about 100 different countries (George Psacharopoulos and Harry Patrinos, 2002).
  27. For example, if  $E_{ij} = E_{ij}^*(1 + \gamma)^{D_i}$ , where  $E_{ij}$  is earnings,  $E_{ij}^*$  is earnings due to human capital,  $D_i$  is a dichotomous variable for some characteristic, and  $\gamma$  is the percent increase in earnings for those with characteristic  $D(D = 1)$  compared to those without it ( $D = 0$ ), then  $LnE_{ij} = LnE_{ij}^* + \gamma^* D_i$ , where  $\gamma^* = Ln(1 + \gamma)$ , which is approximately equal to  $\gamma$  if it is small.
  28. Heckman and Polachek (1974) came to a similar conclusion when the human capital earnings function was still quite new: "Evidence from several bodies of data suggests that among simple transformations the natural logarithm of earnings is the correct dependent variable while the best simple specification of the regressors is one advanced by Jacob Mincer on theoretical grounds." (p.350) Willis (1986, p. 526) writes: "As an empirical tool, the Mincer earnings function has been one of the great success stories of modern labor economics." Murphy and Welch (1990), however, show that higher order polynomials provide a better fit to the data than the quadratic specification. In more recent work in progress James Heckman, Lance Lochner and Petra Todd (2003) suggest that the human capital earnings function provides a better fit to the data for the 1940's to 1960's than in more recent decades.
  29. See also Mincer (1974, pp. 121–125) and Polachek (1973).

30. Mincer (1974, p. 125) notes that his study was focused on adult earners continuously attached to the labor market, with the empirical analysis on white non-farm males in the United States. The self-employed were explicitly excluded from consideration.
31. Since the 1970's the estimation of rates of return from schooling using the human capital earnings function has become commonplace as a result of its low and falling cost and public interest. The falling cost is due to the combination of the availability of micro data files from censuses and surveys that include questions on earnings, age and schooling, among other variables, the falling cost of computing, and the ease of estimation with the development of the human capital earnings function. While these factors also lowered the cost of estimating rates of return from on-the-job training, it is still more complex because of the lack of good data (in particular, the greater difficulty of estimating the amount of the investment) and there has been no similar explosion of research output.
32. For references to estimates of rates of return from schooling for nearly 100 countries, see Psacharopoulos and Patrinos (2002). These estimates have a remarkably narrow range, primarily from 5 to 15 percent.
33. See, for example, Ernst Berndt (1991, Chapter 5), Edward Lazear (1998, pp.164-165), George Borjas (2000, pp.264-268), and Bruce Kaufman and Julia Hotchkiss (2000, Appendix 7B, pp.401-405).

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## 11. THE “MINCER EQUATION” THIRTY YEARS AFTER *SCHOOLING, EXPERIENCE, AND EARNINGS*\*

BY THOMAS LEMIEUX

### ABSTRACT

*This paper evaluates the empirical performance of the standard Mincer earnings equation thirty years after the publication of *Schooling, Experience and Earnings*. Over this period, there has been a dramatic expansion in micro data and estimation techniques available to labor economists. How does the Mincer equation stand in light of these advances in empirical labor economics? Is it time to revise our benchmark model? On the basis of the existing literature and some new empirical estimates, I conclude that the Mincer equation remains an accurate benchmark for estimating wage determination equations provided that it is adjusted by (1) including a quartic function in potential experience instead of just a quadratic, (2) allowing for a quadratic term in years of schooling to capture the growing convexity in the relationship between schooling and wages, and (3) allowing for cohort effects to capture the dramatic growth in returns to schooling among cohorts born after 1950.*

### 11.1. INTRODUCTION

Thirty years ago, Jacob Mincer published his landmark book *Schooling, Experience, and Earnings* (Jacob Mincer, 1974) which had a profound and lasting influence on empirical work in the field of labor economics.<sup>1</sup> On the basis of both theoretical and empirical arguments, carefully reviewed in this volume's chapters by Barry Chiswick

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and Solomon Polachek, Mincer modeled the natural logarithm of earnings as a function of years of education and years of potential labor market experience (age minus year of schooling minus six). In the most widely used version of Mincer's "human capital earnings function," log earnings are modelled as the sum of a linear function of years of education and a quadratic function of years of potential experience:<sup>2</sup>

$$\log \gamma = \log \gamma_0 + rS + \beta_1 X + \beta_2 X^2, \quad (1)$$

where  $\gamma$  is earnings ( $\gamma_0$  is the level of earnings of an individual with no education and no experience),  $S$  is years of schooling, and  $X$  is years of potential labor market experience. Equation (1) has become the "workhorse" of empirical research on earnings determination. It has been estimated on thousands of data sets for a large number of countries and time periods, which clearly makes it one of the most widely used model in empirical economics.

What explains the popularity of the Mincer equation? One part of the answer lies in the fact that equation (1) is based on a formal model of investment in human capital (see the chapters by Chiswick and Polachek). Another part of the answer is that the Mincer equation provides a parsimonious specification that fits the data remarkably well in most contexts. In this regard, the key contribution of *Schooling, Experience and Earnings* was the introduction of potential experience as a standard regressor in the earnings regression. It was known prior to Mincer's work that earnings grew as a (concave) function of age.<sup>3</sup> In his early work, Mincer (1958) also pointed out that the resulting "age-earnings profile" was steeper for more educated workers than for less educated workers. In other words, log earnings are not a strictly separable function of education and age. There is no such thing as a single rate of return to education but rather a different rate of return for each age group.

By contrast, Mincer pointed out in *Schooling, Experience and Earnings* that the experience-earnings profiles were relatively parallel for different education groups. This point can be readily seen in Figure 11.1 that reproduces Mincer's original charts of earnings as a function of both age and potential experience (using data from the 1960 U.S. Census). Introducing potential experience as opposed to age in the earnings equation is, therefore, a parsimonious way of capturing both the shape of the age-earnings profile and the differential slope of the age-earnings profile across education groups. Another advantage of this additively separable model is that, conditional on years of potential experience, there is a single rate of return to education,  $r$ , in the labor market. From this point of view, the Mincer equation provides the foundation for the large and growing literature that attempts to estimate the causal effect of education on earnings (see David Card, 1999, for a review).

It is quite remarkable that, thirty years after *Schooling, Experience and Earnings*, most studies still tend to estimate earnings regression that are very closely related to equation (1). Though a list of other regressors are typically added to the basic Mincer equation, the three key variables in equation (1) still appear in most empirical estimates of earnings regressions. Furthermore, the logarithmic specification for earnings

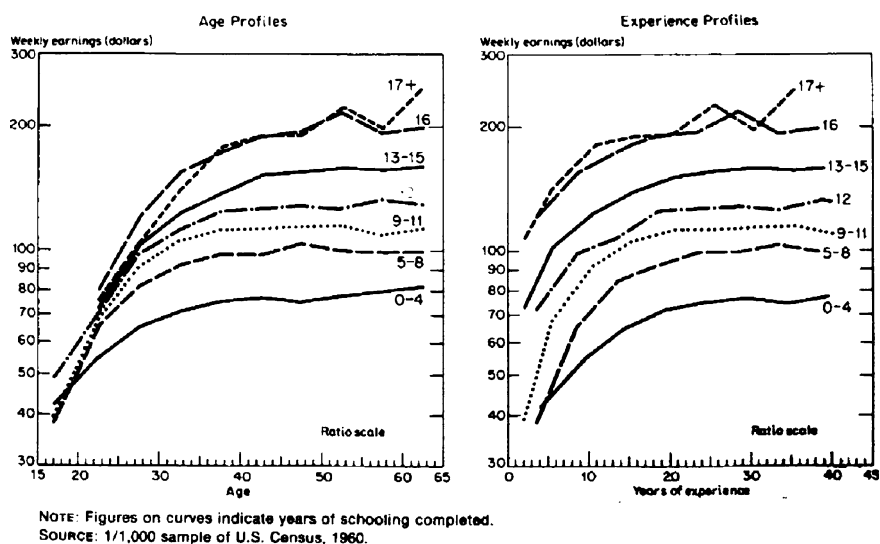


Figure 11.1. Age and experience profiles of relative weekly earnings of white, nonfarm men, 1959.

is almost always used in these models. Unless the Mincer earnings equation is really a *law* of earnings determination, it is difficult to believe that, for most data sets, equation (1) is truly the most parsimonious model of earnings determination that would be obtained through careful econometric specification testing. On the one hand, as long as the Mincer earnings regression remains a good approximation for the “true” earnings equation, it is quite valuable to keep estimating the same equation for the sake of comparability across studies. If, on the other hand, the Mincer equation is not, or is no longer, a good approximation, we may be getting a quite inaccurate picture of earnings determination from all these studies that all make the same mistakes.

The goal of this paper is to critically reappraise the standard Mincer earnings equation thirty years after the publication of *Schooling, Experience and Earnings*. Since those days, there has been a phenomenal expansion in the computer power and in the number of micro data sets available for empirical labor economic research. Sophisticated parametric and non-parametric procedures are now available to perform careful specification analyses. How does the Mincer equation stand in light of all these advances in empirical labor economics? Is it time to revise our benchmark model?

This chapter is a limited attempt at answering these specific empirical questions. I only focus on the issue of the robustness of Mincer’s original specification to complement the chapters by Chiswick and Polachek in this volume. Chiswick provides a detailed derivation of the earnings function, while Polachek discusses the implications and extensions of the earnings function. In this chapter, I only review the results of few recent studies that have implications for the choice of an accurate “benchmark”

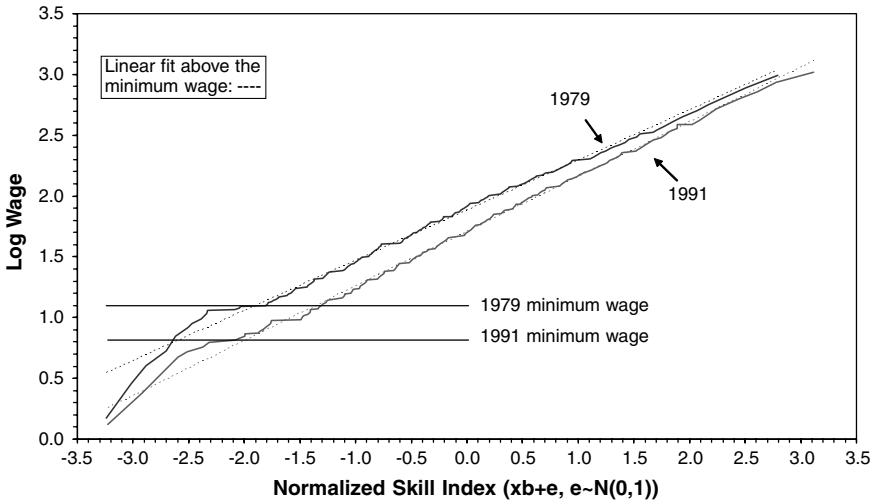
earnings equation *à la* Mincer, and supplement the main findings of these studies with some new empirical results based on the Current Population Survey (CPS) for the years 1979 to 2001. I make no attempt to cover the much larger literature on earnings determination that has been well surveyed elsewhere (see, for example, Solomon Polachek and Stanley Siebert, 1993).

The remainder of the paper is divided in five themes. In Section 11.2, I look at whether the natural logarithm is the appropriate transformation for earnings. In the following two sections, I discuss whether education should enter linearly (Section 11.3) and potential experience should enter as a quadratic function (Section 11.4) in a separable earnings equation. The issue of separability between schooling and experience is examined in Section 11.5, while Section 11.6 looks at whether cohort effects should be included in the earnings equation. I conclude in Section 11.7.

### 11.2. EARNINGS IN LOGS OR NOT?

As mentioned earlier, the dependent variable in the standard Mincer earnings equation is the log, as opposed to the level, of earnings. While logs are typically used in econometric models for reasons of convenience or fit, there is a strong theoretical rationale for using log earnings in a human capital earnings regression. As pointed out by Mincer (1958), education should have a *multiplicative* effect on earnings in a simple model where identical individuals maximize the present value of future income which is equalized for all education levels in equilibrium. The reason is that investments in human capital, like other investments, are only undertaken as long as the rate of return (not the absolute return) on the investment exceeds the discount rate. Log-linearity of earnings as a function of years of schooling is in fact a key empirical implication of the human capital model with identical individuals proposed by Mincer (1958).

The existing evidence generally supports the log-earnings specification. For example, James Heckman and Polachek (1974) estimate a Box-Cox model and could not reject the log specification. More recently, Nicole Fortin and Thomas Lemieux (1998) use a more flexible “rank regression” model in which earnings are specified as a relatively unrestricted monotonic transformation of a Mincer-type human capital index (sum of a linear function of education, polynomial function of potential experience, few other regressors and a normally distributed error term). Using large samples from the 1979 and 1991 outgoing rotation group (ORG) supplement of the CPS, they find that the log wage is close to a log-linear function of the human capital index for values of the wage above the minimum wage. Their findings are reproduced for men in Figure 10.2.<sup>4</sup> The human capital index appears to have a smaller effect on wages around the minimum wage, which is consistent with minimum wages compressing the wage distribution at the low end of the skill distribution.<sup>5</sup> Figure 11.2 shows, nevertheless, that the assumption of log-linearity is very accurate for most of the range of the wage distribution.



**Figure 11.2.** Transformation Model for Log Wages: Men in the 1979 and 1991 CPS.

### 11.3. LINEAR EDUCATION?

Though Mincer (1974) considered several functional forms for the earnings equation, the most commonly used is equation (1). There are several reasons, however, why a simple linear specification for years of education may be inaccurate. For example, log earnings will be a concave function of years of schooling in a simple human capital investment model in which individuals have different preferences (discount rates) but all face the same concave production function (the return to a year of schooling declines as years of schooling increase). More generally, Mincer (1997) shows that in a Becker (1975) type model where individuals are heterogenous in their preferences and earnings opportunities, average log earnings may either be a convex or a concave function of years of schooling.<sup>6</sup>

Another possibility is that in addition to years of schooling per se, educational credentials also have a direct impact on earnings. In the presence of “credential” or “sheepskin” effects, the return to a year of schooling should be higher between 11 and 12 years of education (high school credential effect) and between 15 and 16 years of schooling (college credential effect) than for other years of schooling. One simple way of testing the linearity of years of schooling is to estimate log earnings as an unrestricted (non-parametric) function of years of schooling and see whether this unrestricted function is approximately linear.

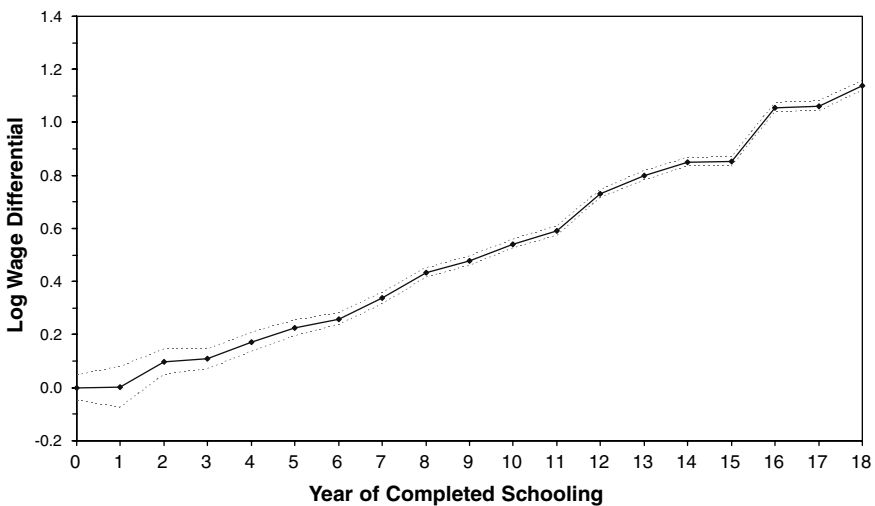
Card and Alan Krueger (1992) estimate such an unrestricted earnings function as part of their study of the impact of school quality on earnings.<sup>7</sup> Their results for three separate birth cohorts of white men (Figure 11.2, p. 7) show that log earnings appear to be a linear function of years of schooling for most levels of schooling. One exception is between 15 and 16 years of schooling where, consistent with credential

effects, the return to schooling is systematically higher than for other schooling levels.<sup>8</sup> Interestingly, however, there are no abnormal returns associated with high school completion. The other exception is at very low years of schooling where returns to schooling are relatively low. This phenomenon is particularly clear for the younger (and most educated) cohort born in 1940–49 for which returns below five years of schooling are essentially zero. Card and Krueger (1992) conclude from their analysis that log earnings are an approximately linear function of years of schooling except for the lowest two percentiles (for a cohort) of the schooling distribution.

Whether or not log earnings is a linear function remains an open debate. For example, using similar data as Card and Krueger (1992), Heckman et al. (1996) conclude that log earnings are a non-linear function of schooling because of the large increase in earnings between 15 and 16 years of schooling. Perhaps more importantly, however, Mincer (1997) and Olivier Deschênes (2001) show that since 1980, log earnings have become an increasingly convex function of years of schooling.

In Figures 11.3 to 11.5, I report some new estimates of effect of schooling on male wages for 1979–81, 1989–91, and 1999–2001, respectively. Unlike the aforementioned studies that use weekly earnings from the Census or the CPS, I use hourly wage from the ORG supplements of the CPS as dependent variable in the regression analysis.<sup>9,10</sup> For each time period, I estimate an OLS regression of log wages on an unrestricted set of year dummies for schooling, experience, and calendar year. The estimated coefficients on the year of schooling dummies, along with the estimated confidence intervals (at the 95 percent confidence levels), are reported in Figures 11.3–11.5.

The results for 1979–1981 (Figure 11.3) are qualitatively similar to those of Card and Krueger (1992) in the sense that they are approximately linear for most values of

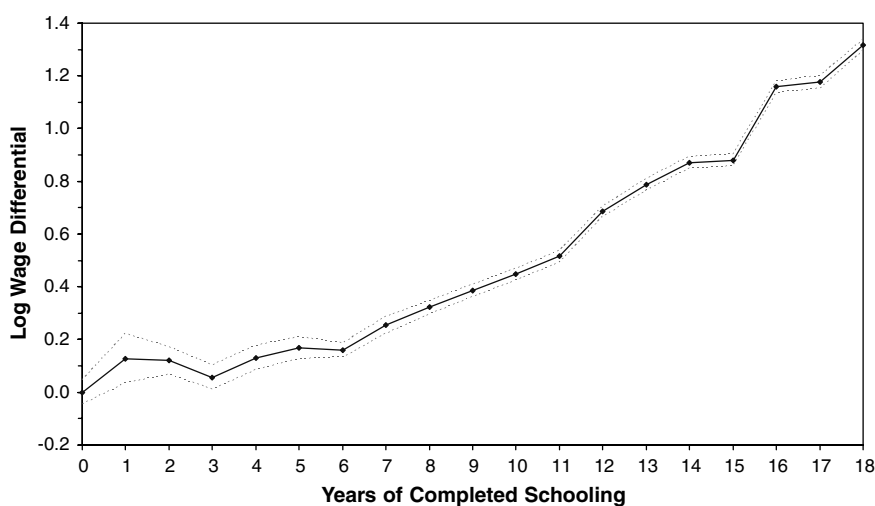


**Figure 11.3.** Return to Single Year of Schooling, 1979–81 CPS (dotted lines are 95% confidence intervals).

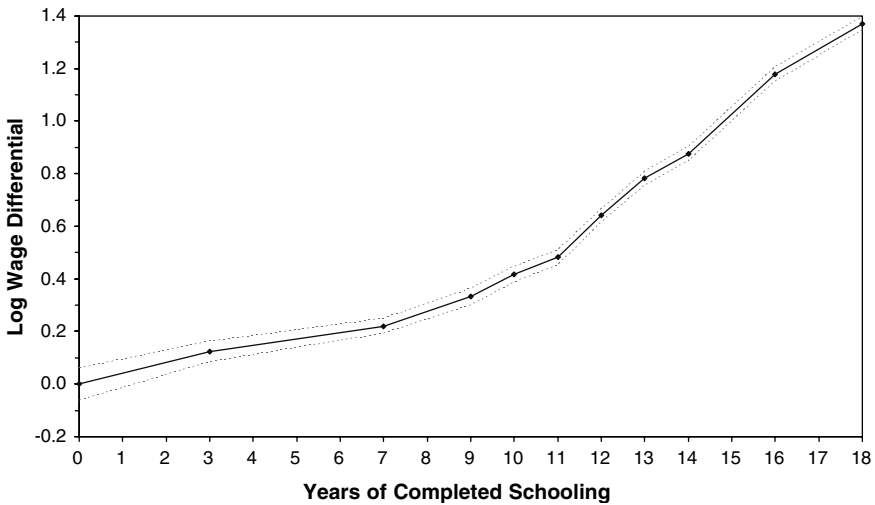
years of schooling. On the one hand, the estimated schooling wage relationship does not systematically depart from a linear specification. When a (weighted) quadratic regression is fit to these data, the quadratic term in schooling is positive but not statistically significant.<sup>11</sup> On the other hand, the linear approximation is clearly inaccurate for 15 (overpredicts) or 16 (underpredicts) years of schooling, as in Heckman et al. (1996). More generally, a goodness-of-fit test strongly rejects the linear or quadratic specification mostly (but not solely) because of the significant departures from linearity at 15 and 16 years of schooling.<sup>12</sup>

Figure 11.4 reports the same estimates of the schooling–wage relationship for the 1989–91 period. Consistent with Mincer (1997) and Deschênes (2001), Figure 11.4 shows that log wages are now clearly a convex function of years of schooling. When a (weighted) quadratic regression is fit to these data, the quadratic term in schooling is positive and statistically significant (t-statistic of 4.9). The magnitude of the estimated quadratic coefficient, 0.0031, is economically substantial. It implies that the return to a single year of education is three percentage points larger at 18 than 8 years of schooling. However, the quadratic specification still underpredicts wages at 15 year of schooling and overpredicts wages at 16 years of schooling. These departures are nonetheless not as visually important as the strong overall convexity in the schooling–wage relationship.

Figure 11.5 shows that by 1999–2001, returns to schooling are an even more convex function of years of schooling than they were in 1989–1991. The estimated coefficient on the quadratic term is now 0.0044 with a t-statistic of 5.9. Note also that because of the changes in the education question introduced in the 1992 CPS, it is no longer possible to identify workers with either 15 or 17 year of schooling. As a result,



**Figure 11.4.** Return to Single Year of Schooling, 1989–91 CPS (dotted lines are 95% confidence intervals).



**Figure 11.5.** Return to Single Year of Schooling, 1999-2001 CPS (dotted lines are 95% confidence intervals).

there is no longer much of a systematic departure from a linear or quadratic specification around 16 years of schooling. This helps clarify the earlier point that the growing convexity of the schooling-wage relationship, as opposed to local non-linearities around 16 years of schooling, is now the dominant source of non-linearity in these data.

Mincer (1997) argues that this growing convexity is readily explained by an increase in the relative demand for skilled labor in a Becker (1975) type human capital investment model with heterogeneous workers (heterogeneous preferences and earnings capacity). This model yields an hedonic equilibrium where marginal returns to schooling can either be an increasing or a decreasing function of years of schooling. In this model, an abrupt growth in relative demand that is not matched by a corresponding increase in relative supply of schooling increases the marginal return to schooling for more educated workers relative to less-educated workers. This results in a more convex schooling-wage relationship since the marginal return to schooling is just the slope of the schooling wage relationship reported in Figures 11.3 to 11.5.

This suggests that the linear approximation may only be accurate in a stable environment where the growth in relative demand is matched by a corresponding growth in relative supply. By contrast, studies such as Lawrence Katz and Kevin Murphy (1992) suggest that the post-1980 period has been unstable in the sense that relative supply did not increase enough to match the growth in relative demand. This has apparently resulted in both an increase in the returns to education (Katz and Murphy, 1992) and in the convexity of the schooling wage relationship (Mincer, 1997).

As it turns out, I will argue in Section VI that changes in relative supply and demand for different labor categories can also explain other recent “failures” of the



most simple version of the Mincer equation (equation (1)). In particular, experience profiles are no longer parallel in recent data (Section 11.5) because of systematic cohort effects (Section 11.6) that are linked to a slowdown in the rate of growth of educational attainment for workers born after 1950.

#### 11.4. QUADRATIC EXPERIENCE?

As mentioned earlier, the most popular version of the Mincer equation includes a quadratic function in years of potential experience to capture the fact that on-the-job training investments decline over time in a standard lifecycle human capital model. Mincer (1974) shows that the quadratic profile is implied by a model in which investments decline linearly over time. This choice of specification as the “preferred” empirical specification was mostly driven by practical considerations. It is indeed much easier to estimate a regression model with experience and experience squared included as regressors than to estimate the more complex non-linear experience profile implied by the assumption of a constant rate of decline in investments that is more consistent with economic theory.

Murphy and Finis Welch (1990) examine in detail whether the standard quadratic specification in years of potential experience captures well the empirical experience-earnings profile. Using March CPS data from 1964 to 1987, they conclude that a quadratic function is not flexible enough to capture the main features of the experience-earnings profile. The main problem is that the quadratic function understates earnings growth over the first 10 to 15 years of career. By contrast, they find that a quartic function in years of experience captures very well the main features of the empirical experience-earnings profiles.

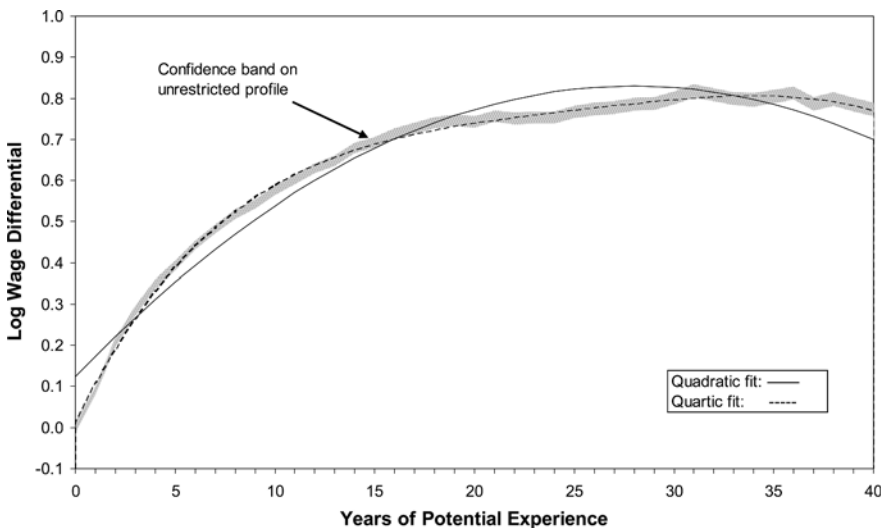


Figure 11.6. Experience Profiles for Men, 1979-81 CPS.

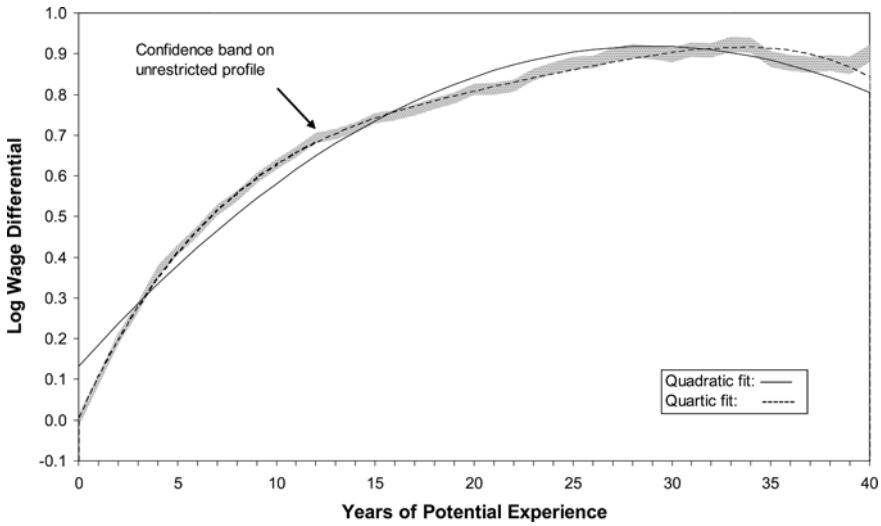


Figure 11.7. Experience Profiles for Men, 1989-91 CPS.

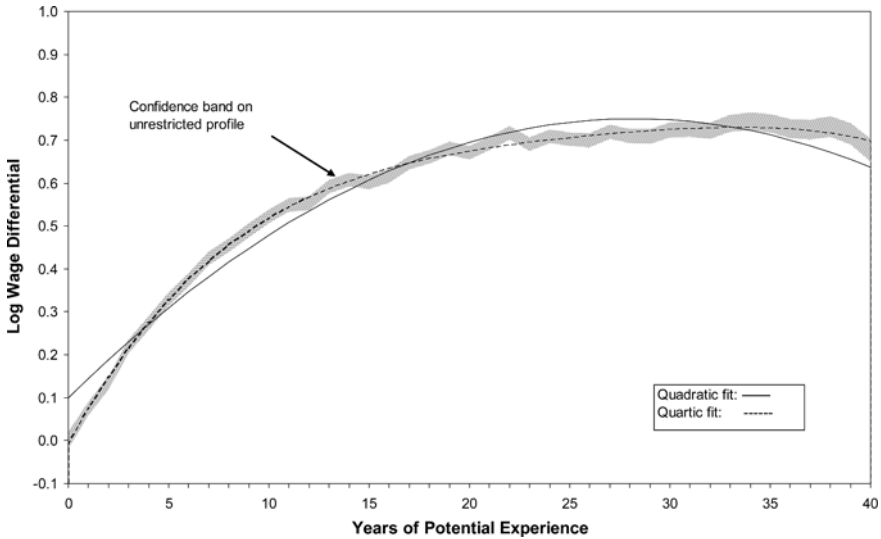


Figure 11.8. Experience Profiles for Men, 1999-2001 CPS.

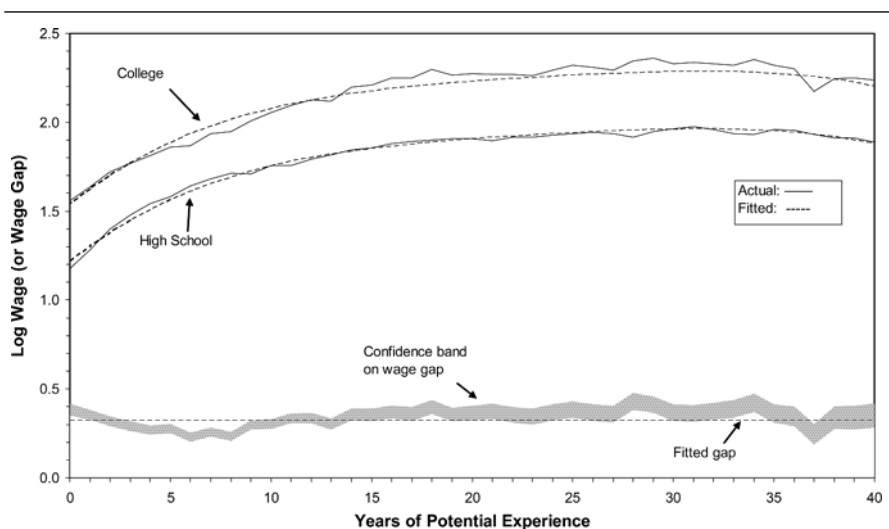
Figures 11.6 to 11.8 confirm the findings of Murphy and Welch using more recent CPS data on hourly wage rates. While Murphy and Welch estimate separate experience-wage profiles for four broad education groups, Figures 11.6 to 11.8 simply report estimates of the experience earnings profiles from a pooled specification

with all education groups included in. I first estimate regressions with a full set of education, experience, and year dummies for each of the three periods (1979–1981, 1989–1991, and 1999–2001). All three figures show the 95 percent level confidence bands around the unrestricted estimates of the experience–wage profiles. I then re-estimate two restricted versions of the model where the set of experience dummies is either replaced by a quadratic or a quartic function of experience.

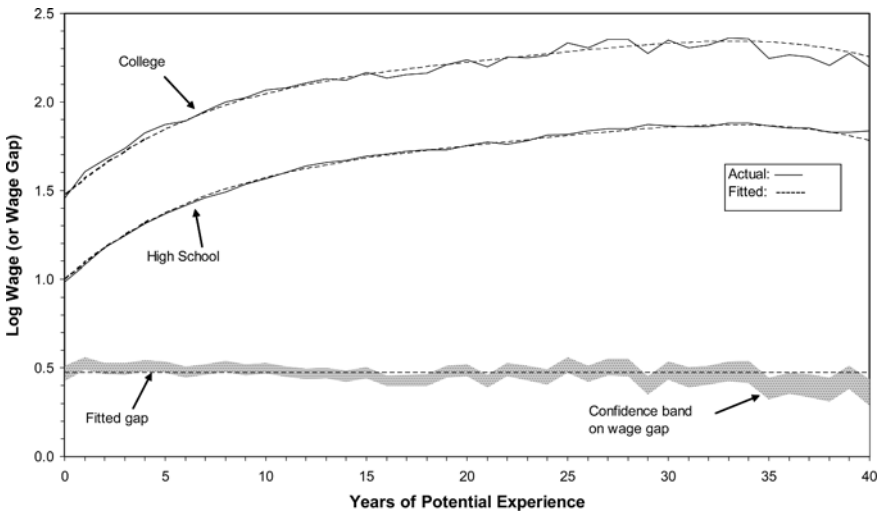
Consistent with Murphy and Welch (1990), the figures show that the standard quadratic specific is not flexible enough to capture important features of the data. In particular, it systematically understates the growth in wages for the first 10–15 years of experience. As a result, the quadratic predictions are systematically above the confidence band for workers with 3 or less years of experience, and systematically below the confidence bands for workers with about 4 to 14 years of experience. The quadratic also predicts too much of a decline in wages past 25 years of experience. In fact, the confidence bands show that wages are quite stable between 25 and 40 years of experience. The predicted decline in wages in the last 10–15 years of career is an artifact of the quadratic specification.

By contrast, Figures 11.6–11.8 show that the quartic specification rarely falls outside of the confidence bands for the unrestricted model. The only noticeable exception is around 35 years of experience in 1989–91 where there is an unusual (likely spurious) drop in the unrestricted confidence bands.

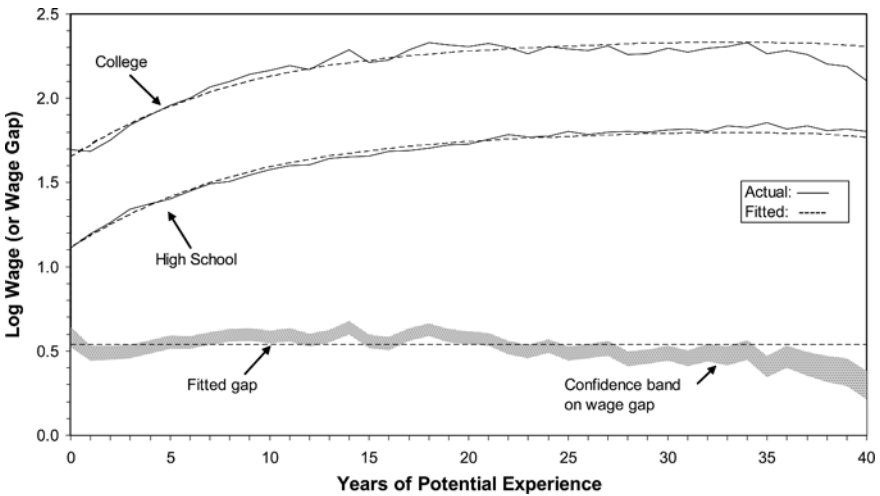
In summary, recent research and the new evidence presented in this paper show that it is important to “fine-tune” the standard Mincer equation by adding higher order polynomials in potential experience. Otherwise, the standard Mincer equation understates wage growth for younger workers. The quadratic specification also predicts a spurious decline in wages among older workers.



**Figure 11.9.** Experience Profiles and Wage Gap for College and High School Graduates, 1979–1981 CPS.



**Figure 11.10.** Experience Profiles and Wage Gap for College and High School Graduates, 1989-1991 CPS.



**Figure 11.11.** Experience Profiles and Wage Gap for College and High School Graduates, 1999-2001 CPS.

**11.5. ADDITIVE SEPARABILITY IN EDUCATION AND EXPERIENCE?**

As mentioned earlier, one main empirical innovation in Mincer (1974) was the introduction of a concave function of years of potential experience as a parsimonious way of capturing both the (concave) shape of the age-earnings profile and its

interaction with schooling. One may wonder, however, whether the empirical relationship identified for data from more than forty years ago (1960 U.S. Census) still holds in more recent data.

Figures 11.9 to 11.11 compare the empirical experience-wage profile for male college and high school graduates to the profiles predicted by a Mincer model where these two groups are constrained to have the same (quartic) experience-wage profile. The predicted profiles are obtained by fitting a regression to a pooled sample of men with exactly a high school or college degree for the same three time periods as before: 1979–1981, 1989–1991, and 1999–2001. The regressors used are a quartic function of experience, a dummy for college degree, and year dummies. For the sake of simplicity, I only look at college and high school graduates, which are the two largest education groups in these samples.

At the bottom of each graph, I plot the confidence intervals around the empirical college–high school wage gaps (the difference between the actual college and high school wages in the graph) and compare them to the gap predicted by the Mincer equation. The key empirical prediction of the standard Mincer model with additively separable experience and education effects, is that the college–high school gap should be a constant function of experience.

Figure 11.9 shows that in 1979–1981, the empirical (or actual) experience profiles for college and high school graduates look approximately parallel. Indeed, for most of the values of experience, the constant college–high school wage gap predicted by the model (0.323) is within or close to the confidence bands around the empirical wage gaps. A closer examination of the evidence indicates, however, that the empirical college high school wage gap tends to grow as a function of experience. For example, the empirical wage gap is significantly lower than predicted by the model around 3–9 years of experience, but higher than predicted around 27–35 years of experience. This systematic pattern is confirmed by a linear regression of the empirical college–high school wage gap on experience. The estimated coefficient (0.0018) is significantly different from zero (t-statistic of 3.1). This implies that the wage gap is 7–8 percentage points larger for workers with 40 years of experience than for young workers with no experience.

The results for 1989–1991 (Figure 11.10) and 1999–2001 (Figure 11.11) are markedly different from those for the earlier period. In both periods, the college–high school wage gap now tends to *decline* as a function of experience. The estimated coefficients in a simple regression of the wage gap on experience are now  $-0.0020$  (t-statistic of  $-4.8$ ) and  $-0.0042$  (t-statistic of  $-5.9$ ) for 1989–1991 and 1999–2001, respectively. The results imply that in 1999–2001, the college/high school wage gap is 15–20 percentage points larger for the youngest workers (0 years of experience) than for the oldest workers (40 years of experience). Figure 11.11 indeed shows that the empirical experience-wage profiles are no longer parallel in more recent data. The experience-wage profile has clearly become steeper for high school than college graduates over the last two decades.

In summary, the standard Mincer equation in which log earnings is an additively separable (no interaction term) function of schooling and potential experience does

not fit the recent data nearly as well as it used to do in the 1960 Census. This finding is confirmed by Card and Lemieux (2001a) and Heckman et al. (2003), who conclude that experience-earning profiles are no longer parallel in more recent data. I now look at potential explanations for this change in the next section.

### 11.6. COHORT EFFECTS?

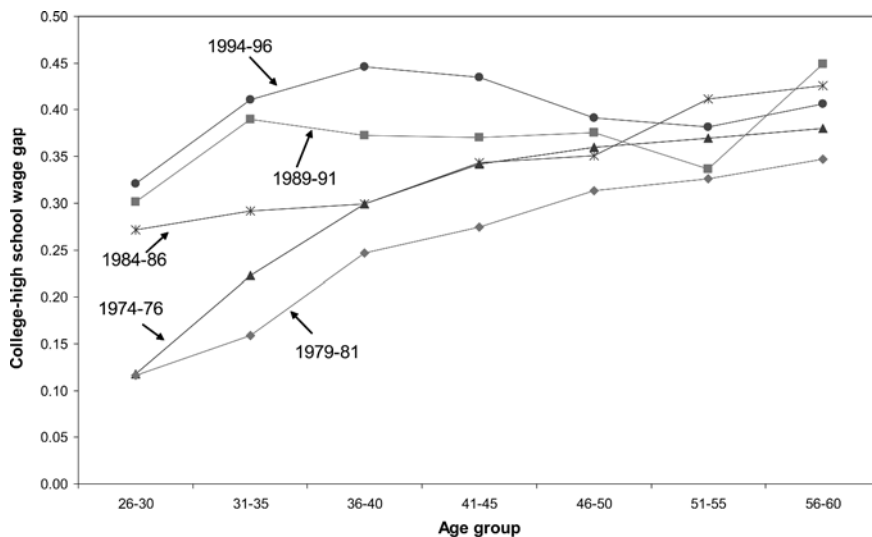
There has always been an important gap between the theory underlying the human capital earnings function and the data used to estimate it. On the theoretical side, the age-earnings profile pertains to the evolution of the earnings of a given individual (or cohort of individuals) over the lifecycle. By contrast, empirical age-earnings are typically based on a cross-section of individuals at different points in their lifecycle. Mincer was well aware of this problem in his early work (Mincer, 1958), and conjectured that the cross-sectional age-earnings profiles were probably understating lifecycle earnings growth since, in those days, there was substantial secular growth in average earnings.<sup>13</sup>

Interestingly, many researchers now believe that the cross-sectional age-earnings profile *overstates* lifecycle earnings growth. For example, Paul Beaudry and David Green (2000) conclude in their recent study on the earnings of Canadian men that the slope of the cross-sectional age-earnings profile has increased because new cohorts of men are entering the labor market at increasingly low earnings level. This highlights the well-known problem of distinguishing between age, cohort, and year effects in earnings growth. Since these three variables are linear combinations of each other, it is difficult to identify separately the effect of these three variables on earnings even when repeated cross sections are available.<sup>14</sup>

Another way of thinking about the problem is to simply ask whether one “needs” cohort effects to “fit” the empirical relationship among schooling, experience and earnings. On the one hand, Mincer (1974) analyzed this issue in detail and correctly concluded that, on the basis of the 1960 Census data, it was not necessary to include cohort effects to fit these data. On the other hand, the standard Mincer equation does not fit very well the more recent data for the 1980s and 1990s. Could the addition of cohort effects help improve the fit of the model?

Card and Lemieux (2001a) investigate this issue in detail while trying to understand the sources of change in the college-high wage gap for the United States, Canada, and the United Kingdom over the last three decades. In the case of U.S. men, they use the 1960 Census and a large number of March CPS supplements to study the evolution of the college-high school wage gaps by age groups (5-year age groups) between 1959 and 1996. For the sake of comparability with the other figures presented in the paper, I show the same college-high school wage gaps using hourly wages from the March CPS for the years 1975–76, 1979–81, 1984–86, 1989–91 and 1994–96.<sup>15</sup>

The wage gaps are reported in Figure 11.12. The figure shows how the age profile of the college-high school wage gap evolved from a positively sloped profile in the mid-1970s, which is consistent with Mincer’s model, to an essentially flat profile in



**Figure 11.12.** College-High School Wage Gap by Age Group and Year.

the mid-1990s, which is inconsistent with Mincer’s model.<sup>16</sup> Figure 11.12 strongly suggests that the profile became increasingly flatter because cohorts of men born after 1950 experienced increasingly high returns to schooling relative to older workers. Between 1975–75 and 1979–81, the entire profile of the college–high school gap shifted down, with the exception of the youngest age group (age 26–30 in 1980 i.e. born in 1950–54) for whom the gap remained constant. By the mid-1980s the gaps for older workers were back to their levels of the mid-1970s, but the gaps for the *two* youngest age groups were much higher. Moving to 1989–91, the gaps for the *three* youngest age groups were substantially higher than those in the mid-1970s, while those for other workers were not too different. Finally, in the mid-1990s, the gaps for the *four* youngest age groups were well above the levels of the mid-1970s, but the gaps for older workers were still comparable to those 20 years earlier.

Except for these four youngest cohorts, the data in Figure 11.12 are roughly consistent with the Mincer equation (positively sloped profile). In fact, Card and Lemieux (2001a) show more formally that a simple Mincer model explains well the data from 1959 to 1995 provided that cohort dummies are introduced for the four youngest cohorts. One promising avenue for understanding why the Mincer equation does not fit the recent data as well is, therefore, to understand what happened to the post-1950 cohorts.

Card and Lemieux (2001a) investigate this issue in detail and conclude that the dramatic increase in the college–high school wage gap for post-1950 cohorts is primarily a consequence of an equally dramatic break in inter-cohort trends in educational achievement. They show that, until 1950, each successive cohort of men was more educated than the preceding cohort. This secular trend abruptly stopped with

men born around 1950. As a result, men born in the late 1960s are no more educated than those born 20 years earlier.<sup>17</sup> The relative supply of highly educated workers is, therefore, much lower for post-1950 cohorts than what would have been predicted on the basis of the pre-1950 trend. As long as age groups are imperfect substitutes for each other, this relative decline in the relative supply for post-1950 cohorts should result in a higher college-high school wage gap for these cohorts in a standard supply and demand model of the labor market.<sup>18</sup>

The results of Card and Lemieux (2001a) can be viewed as a complement, rather than a substitute, to the basic human capital earnings model of Mincer. Until the mid-1970s, there was a smooth improvement in the level of schooling of each successive cohort of young men entering the labor market. This increase in the relative supply of highly educated labor was more or less enough to offset the increasing relative demand due, for instance, to skill biased technical change. This changed after 1975 with the entry of the post-1950 cohorts that were no more educated, and in some case less educated, than previous cohorts. Relative supply could no longer offset the rising demand for skilled young workers and, as a result, the college-high school wage gap started expanding dramatically for young workers.

In summary, recent evidence suggests that the basic Mincer human capital earnings model remains a parsimonious and accurate model in a stable environment where educational achievement grows smoothly across cohorts. Such an environment prevailed in the data analyzed by Mincer (1974) who correctly concluded that it was not necessary to control for cohort effects in an earnings regression. In a less stable environment, however, major shifts in the relative supply of different age-education groups can induce important changes in the structure of wages that have to be taken into account when estimating a standard Mincer equation. This can either be achieved by adding cohort effects to a standard Mincer equation, or by explicitly modeling the relative supply and demand for different groups of workers.

### 11.7. CONCLUSIONS

Two broad kinds of conclusions can be drawn from this paper. A first conclusion has to do with “fine-tuning” of the simple Mincer human capital earnings function. Though equation (1) is a good approximation in many cases, it may overstate or understate the effect of experience and schooling on earnings for some groups. In particular, it tends to understate the effect of experience on the earnings of young workers. This problem is readily fixed by adding higher order polynomials (up to a quartic) of potential experience to the basic model. The model also tends to overstate the effect of skills (either experience or schooling) on earnings at the very low end of the skill distributions, because, for example, of compression effects associated with the minimum wage.

A more substantial set of concerns is that the basic Mincer human capital earnings function does not appear to fit the data nearly as well in the 1980s and 1990s as it did in the 1960s and 1970s. The first problem is that wages are an increasingly convex function of years of schooling. The second difficulty is that experience-wage profiles are no longer parallel for different education groups. In particular, the college-high



school wage is now much larger for less experienced than more experienced workers. Existing research suggests, however, that these departures from the simple Mincer model are primarily a consequence of the fact that recent increases in the relative supply of educated labor have not kept up with the growth in relative demand. In particular, the educational achievement of men born in the 1950s and 1960s is no larger than for men born at the end of the 1940s.

On balance, the evidence suggests that the Mincer equation remains a useful and accurate benchmark in a stable environment where educational achievement grows smoothly over successive cohorts of workers, as it did in the time period originally studied by Mincer (1974). Thirty years later, the Mincer equation does not fit the data quite as well as it used to because we are no longer in a stable environment where educational achievement grows smoothly over successive cohorts of workers. In fact, it would have been truly remarkable if the dramatic changes in the wage structure that happened since the late 1970s had had no impact on the quality of the fit of the Mincer equation. It will be interesting to see whether the fit of the Mincer equation improves in the next decade or so, now that the wage structure appears to be stabilizing again (Card and John DiNardo, 2002).

In terms of econometric practice, these findings suggest that it is important to verify the robustness of the standard Mincer equation to the inclusion of a quadratic term in years of schooling and cohort effects. These considerations aside, the Mincer human capital earnings function remains a parsimonious and relatively accurate way of modelling the relationship between earnings, schooling and experience. Its status as the “workhorse” of empirical labor economic research on earnings determination is well deserved.

## NOTES

1. See Sherwin Rosen (1992) and the other chapters in this volume for a survey of Jacob Mincer’s major contributions to empirical labor economics.
2. Though the human capital earnings function is typically associated with the name and the work of Jacob Mincer, other authors also made important contributions to that line of research. In the words of Robert Willis (1986): “A major development in the literature, initiated by Gary Becker and Barry Chiswick (1966) and carried to full fruition by Mincer (1974), sought to use the theory to restrict the functional form of the earnings function ... This work was carried out with such ingenuity, sophistication, and care by Mincer (1974) that the resulting function is often referred to as ‘the’ human capital earnings function...” See also Chiswick (this volume) for an excellent survey of the historical and intellectual origin of the human capital earnings function.
3. See Herman Miller (1960) and Polachek (this volume) for a more extensive discussion.
4. Fortin and Lemieux (1998) divide the wage distribution into 200 intervals and estimate an ordered probit model for the probability that wages are in a given interval, conditional on the observables (as captured by education, a quartic in experience, and marital status). Figure 11.2 is simply a plot of average log wages in each interval as a function of the estimated thresholds in the ordered probit. If the true model was  $\log(\text{wage}) = xb + e$ , where  $e$  is normal (Mincer model with normal errors), then the function plotted in Figure 11.2 should be linear.
5. The function is flatter around the minimum wage because too many people with different skill levels are “bunched up” at the minimum wage. This suggests that some workers who would have earned less than the minimum in the absence of a minimum wage retained their jobs and are now paid the minimum wage, though they may be working less hours than in absence of a minimum wage. If all of these workers had lost their jobs (perfect disemployment effects), the function would simply be truncated at the minimum wage and log-linearity would be preserved.

6. This model was introduced by Becker in his 1967 Woytinsky Lecture that is reproduced in Becker (1975).
7. Card and Krueger estimate regression models for log weekly earnings using data for white men from the 1980 U.S. Census. The explanatory variables included in their regressions are a set of dummy variables for each single year of schooling plus standard controls for potential experience, marital status, and geographical location.
8. An alternative explanation to “sheepskin” or credential effects is selectivity in college completion and graduation. For example, youths entering college may expect a rate of return greater than or equal to their discount rate. During the college experience, some re-assess their expected rate of return downward and are more likely to drop out. Those doing as expected or better than expected go on to graduate. It is not possible to separate this “reassessment” hypothesis from the “sheepskin” hypothesis in Figures 11.3 to 11.5.
9. Samples include all men age 16 to 64 with 0 to 40 years of potential experience and non-allocated wages between \$1 and \$100 (in \$1979). Top-coded observations are adjusted by multiplying wages or earnings by 1.4. I pool three years of data for each period to increase sample sizes to 220,737 observations in 1979–1981, 211,759 observations in 1989–1991, and 153,265 observations in 1999–2001.
10. I use log hourly wages as dependent variable since Mincer’s human capital earnings function is a model for the determination of the hourly price of labor. Traditionally, the model has often been estimated using annual or weekly earnings because hourly wages were generally not available. Mincer (1974) in fact shows that some key results are sensitive to the choice of the earnings measure. For example, he rejects the hypothesis of parallel earnings profiles and linear education when using annual earnings, but fails to reject these restrictions when annual hours are controlled for. Note also that most workers report directly an hourly wage rate in the ORG supplement of the CPS. This limits potential measurement problems linked with defining hourly wages as earnings divided by hours. See Lemieux (2005) for more details on these measurement issues.

The relatively large confidence bands for levels of education of five years or less in Figure 11.3–11.5 reflect that fact that only few workers have such a low level of education. Immigrants represent a significant fraction of these low-education workers but cannot be identified in the ORG CPS.

11. The weights used are the inverse of the variance of the estimated coefficients from the micro-level wage regression (coefficients on years of schooling dummies).
12. The chi-square test statistic is 355, which largely exceeds the critical value at the 95 percent confidence level (17 degrees of freedom). The statistic is reduced by almost two thirds when the test is limited to years of schooling other than 15 and 16.
13. Mincer (1974) examines this issue in more detail and concludes that, apart from understating earnings growth rates by a constant, cross-sectional age-earnings profiles are a good approximation of the lifecycle profiles.
14. Examples of recent studies attempting to separate cohort from age and year effects are Thomas MaCurdy and Thomas Mroz (1991) for the United States, Amanda Gosling, Stephen Machin and Costas Meghir (1999) for the United Kingdom, and Beaudry and Green (2000) for Canada.
15. Most of the empirical analysis in Card and Lemieux (2001a) is based on the weekly earnings of full-time workers. Starting with the March 1976 CPS (earnings year 1975), however, it is possible to compute an hourly wage rate by dividing annual earnings by annual hours. Card and Lemieux present a brief analysis of these data (Table 5, p. 731) and find results very similar to the main results based on weekly earnings of full-time workers.
16. When log earnings are the same concave function of potential experience for high school and college graduates, the college-high school wage gap *must* increase with age. To see this, replace the quadratic function by a generic concave function  $f(\cdot)$  in equation (1):  $\log y = \log y_0 + rS + f(\text{age}-S-6)$ . The return to education is given by  $\partial \log y / \partial S = r - f'(\text{age}-S-6)$ . The return to education grows as a function of age since  $\partial^2 \log y / \partial S \partial \text{age} = -f''(\text{age}-S-6)$ , which is positive when  $f(\cdot)$  is concave ( $f'' < 0$ ).
17. See Card and Lemieux (2001b) for a detailed analysis of inter-cohort trends in educational achievement.
18. Welch (1979) shows that cohort relative supplies have a negative and significant effect on wages, which is consistent with imperfect substitution among age groups in production.

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**PART V. MINCER AND THE NEW HOME ECONOMICS**

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## 12. JACOB MINCER AND LABOR SUPPLY – BEFORE AND AFTERMATH\*

BY REUBEN GRONAU

### ABSTRACT

*This paper discusses the impact Jacob Mincer's 1962 paper "Labor-Force Participation of Married Women..." had on the analysis and empirical estimation of the supply of married women, and the supply of labor in general. It is argued that this paper has revolutionized the analysis of labor supply. The sharp increase in married women's labor supply still constitutes a challenge to labor economists who try to explain the phenomenon in terms of income and price effects, where these effects are derived from cross-section studies. It constituted a puzzle to labor economists in the 50s and the 60s, still captives of the notion of a backwards-bending supply of labor. Mincer combined a theoretical model distinguishing between three uses of time (leisure, work at home, and work in the market) and Friedman's distinction between permanent and transitory earning. He showed that the wage has a positive effect on married women's labor supply, and that this supply is more affected by transitory than by permanent income changes. The new theory serves as the scaffold on which Mincer builds the empirical estimation. The interplay between theory, data and empirical estimation, and the ingenuity of the empirical research using scant data sources, made this paper the object of emulation. The ideas first discussed in this paper generated many of the developments of the analysis of labor supply over the last four decades.*

### 12.1. INTRODUCTION

The second volume of Jacob Mincer's collected essays (1993) is devoted to studies in labor supply. It is divided into three parts: labor supply in the family context; labor supply, human capital and the gender gap; and labor supply with wage floors. The

\*I would like to thank Shoshana Grossbard, the participants of the conference, and two anonymous referees for their helpful comments

first part includes four papers: the 1962 paper, “Labor-Force Participation of Married Women...,” the 1963 paper, “Market Prices, Opportunity Costs and Income Effects,” the 1968 paper, “Trends in Labor Force Participation,” and the 1966 paper, “Labor Force Participation and Unemployment.” The second of these papers heralded the theory of home production, the last two papers address issues that are still the subject of hot debates. The focus of my paper is Mincer’s first paper – his analysis of the labor force participation of married women – which, I will argue, revolutionized the analysis of labor supply.

To place the paper in a historical perspective, one can check the reference list of some of the leading surveys of the topic: Mark Killingsworth and Jim Heckman’s survey of female labor supply in the 1986 *Handbook of Labor Supply* mentions 14 papers that preceded Mincer’s 1962 paper and 165 that followed it. John Pencavel’s survey (1986) of the labor supply of men includes 19 pre-1962 references and 169 post-1962 references. Mark Killingsworth’s 1983 *magnum opus* on labor supply includes a list of 661 references but only 50 of these preceded Mincer’s paper. If one ignores the general references (such as Adam Smith, William Stanley Jevons and Alfred Marshall), the pre-Mincer studies that figure prominently in these lists are those of H. Gregg Lewis, Clarence Long, Paul Douglas, Richard Rosett, John Durand, W.S. Woytinsky, and of course Lionel Robbins’ 1930 paper.

Lest it be argued that the ten-fold increase in the numbers of papers devoted to labor supply reflects just an exogenous increase in inputs, the number of AEA members (as proxy for economists’ inputs) increased in the period 1966–1984 by only one half. It should also be mentioned that during the period 1953–1969 the AEA membership increased by more than 150 percent. The increase in the AEA membership reflects the increased attractiveness of the economic discipline. The revolution in Labor Economics ushered in by Ted Schultz, Gary Becker, and Jacob Mincer played a major role in the increase of the discipline’s appeal.<sup>1</sup>

Over the last 15 years, the paper (already in its prime age) has been cited almost 300 times. In spite of the tremendous outpour of more “modern” versions of labor supply studies, at least twenty researchers each year pay homage to Mincer’s 40 year old paper, and many more are affected by its offspring.

## 12.2. BEFORE

To evaluate Mincer’s contribution one has to better understand the state of labor supply analysis in the U.S. in the early 60s. The motivation of many of these studies was the changing patterns in labor force participation: the decline in the labor force participation rates of men, and the sharp increase in the participation rates of women. Between 1890 and 1960 the participation of women (14 years or older) grew from 18 to 36 percent, and that of married women from 5 to 30 percent (Mincer 1962, p. 64). But whereas the decline in the labor force participation of men could be easily explained by Robbins’ theory of the backward-bending-supply-of-labor, a theory

supported by the cross-section findings, it was much more difficult to find support in cross-section studies for the increased participation of their wives.

Durand (1946) predicted a continuation of the trend, tying it with the decline in fertility, increased urbanization, the increased demand for female occupations and the “development of household conveniences and commercial services”. He had, however, to admit that he could hardly find anything in the cross section studies to explain this trend<sup>2</sup>. Rosett (1958) traced the trend to the upward shift in the life-cycle participation patterns of succeeding cohorts of married women. He qualified his single cross-section study predictive value of long time trends, acknowledging it depends on the stability of the cohort profile.

Clarence Long’s 1958 NBER study *The Labor Force Under Changing Income and Employment* was definitely the most comprehensive study of labor supply at the time. Long opens his book with the question: “Why do people work?” Going through a long list of reasons and factors that may affect labor supply, he concludes: “Such a lengthy list suggests that economic factors cannot completely explain labor supply behavior, and challenges the simple postulates of the classical economists: that people work less as wages increase, because higher wages enable them to satisfy their needs with less effort.” The second chapter of that book opens with a discussion of “Some Theories of Labor Supply Behavior.” It is almost as if the author feels he has to apologize for discussing the economic theory in this context: “The many reasons for working and the factors that nourish them are the product of social, cultural, or spiritual forces independent of – even at war with – economic motivation. Nevertheless, there are enough obvious roots in economic soil to warrant inquiring whether economic forces, such as employment opportunities or income, play an important role in determining the supply of labor.” Lionel Robbins’ paper is mentioned almost as an afterthought. Nowhere in this chapter does Long mention the distinction between the substitution and income effect.

The empirical analysis of females’ labor supply is contained in Chapters 5–7. The focus of the empirical analysis is the estimation of the effect of husbands’ income on their wives’ labor force participation. The analysis is based on grouped data derived from the 1940 and 1950 U.S census: he examines the schooling effect on participation, but he does not try to separate the wage effect from the income effect.

In his attempt to explain the secular changes in women’s labor force participation, Long uses data from the U.S. and four other countries (the U.K., Canada, Germany, and New Zealand). Trying to reconcile the cross section results with those of the time series analysis, he relies on technological developments (the increased use of home appliances, purchase of manufactured food, clothing, and market services), the decline in family size, and the rise in women’s schooling. The author notes that, though data on the gender wage ratio are scarce, there is nothing in these data to suggest that increased labor force participation of women is associated with the narrowing of the wage gap.

The reconciliation of the trend in married women’s labor force participation and the cross section results is a major theme of Jacob Mincer’s 1962 paper.

In Mincer's words: "The search for an answer to this puzzle lent a great deal of excitement to research on the labor-force in the late 1950s. The stakes were obviously high: the need for better understanding of the concepts of the theory of labor supply, and for an explanation of the most significant labor-force trend since the turn of the century.

I became convinced that what was missing in previous studies was a broader decision unit, the family, and a broader concept of non-market activity to replace leisure. Moreover, the study of labor supply behavior of married women actually provided an opportunity to yield separate estimates of income and substitution effects, as own wage and the relevant income (of the family) were conceptually and statistically separable".

The inspiration for this paper must have come from Milton Friedman's attempt five years earlier (1957) to reconcile the time series and cross-section patterns of consumption. Friedman's distinction between "permanent" and "transitory" income plays a major role also in Jacob's paper. But the paper is far from being a mere application of Friedman's theory to labor supply. It bears the distinctive Mincer trademark, typical of his other contributions to the theory of home production, the theory of human capital and the theory of immigration.

### 12.3. THE PAPER

The best summary of Mincer's 1962 paper can be found in his own introduction to the collected essays' second volume (1993, pp. x-xi).

In this work, the theory of labor supply is recast with several formulations: As in the usual analysis of consumer demand, the household, or family, in which income is pooled, is specified as the appropriate decision unit.

The leisure- market-work dichotomy of Robbins' treatment is abandoned with the recognition that the complement to market activity is not merely leisure but all non-market activities, including leisure, household work, childcare and education.

In determining labor supply behavior of family members, the family income variable is common to all members, but the substitution which determines the allocation of labor between the market and the non-market depends on individual market wages and household productivities, which differ among family members. The labor supply function can, therefore, be specified as a function of family income and of individual wage rates of family members. Since these are not very strongly correlated among family members separate estimates of income and substitution effects are feasible and were obtained for the first time.

The problem of timing of labor supply responses applies to secondary (intermittent) earnings in families, as the family head is assumed to be specialized in continuous market activity. This problem is analyzed in terms of the distinction between permanent and transitory levels or changes in income and in terms of fluctuating family demands for household production. The empirical estimates were obtained in a variety of data sets, including micro-data sets, area averages, and



time series. In a simplified formulation, the labor-supply function for married women was specified as a function of family income, own wage rate and other variables such as education, unemployment, and fertility. The findings showed negative income effects, that are a reduction of market work resulting in an increase in leisure, but not necessarily by the same amount of time. The substitution, or wage effect (with income held constant) was positive and in contrast to the previous conjectures of a ‘backward-bending’ supply curve, it exceeded the negative income effect, being almost double the latter in absolute value. Thus, the net effect of women’s wages is positive, and therefore, consistent with the upward trend in wives’ labor-force participation, as the secular rise in income and in wages was roughly parallel. The previous contradictory findings in cross-sections turned out to be due to a misspecification in which substitution variables were left out.

An answer to the question why the substitution effect was so much larger for wives than for husbands rests on difference in non-market activities, full-time market activity of husbands left less time for non-market activities mainly of a leisure type. For wives, household production was the major alternative to market work, a much more substitutable activity for market work than is leisure.

This brief summary does not explain what made the paper so influential. Perhaps the main reason is the role economic theory plays in this paper as a guide to empirical estimation. Empirical theory served in Long’s study merely as backdrop scenery. Mincer builds a theory of his own on the Robbins foundations, and theory and empirical estimation are strongly intertwined.

The Robbins static “two-sector” model is abandoned for a more realistic model where the family faces a three-way choice between paid work, unpaid work and leisure. The static one-period model is replaced by a lifecycle framework. Mincer does not present a formal model where labor supply functions are derived from a utility maximization scheme. (Mincer’s reluctance to engage in theoretical analysis is one of the reasons his collaborations with Gary Becker were so productive), but the lack of a mathematical formulation does not diminish from its power. The new theory serves as the scaffold on which Mincer builds the empirical estimation. The interplay between theory, data and empirical estimation made this paper the object of emulation.

#### 12.4. DATA AND EMPIRICAL METHODS

Mincer’s basic model can be formulated as

$$m = \beta_p \gamma_p + \beta_t \gamma_t + \gamma w + u$$

where  $m$  denotes married women’s labor supply,  $\gamma_p$  – the household’s permanent income,  $\gamma_t$  – the household’s transitory income and  $w$  – the wife’s wage rate. It is assumed that  $\gamma_p = x_p + w$ , and  $\gamma_t = x_t$  where  $x$  stands for husband’s earnings. Throughout the analysis the measure of labor supply ( $m$ ) is labor force participation.

The observations are always aggregate or grouped data, and  $m$  measures the group's participation rate (in percentage points).

To estimate the basic relationship and isolate the parameters  $\beta_p$ ,  $\beta_t$  and  $\gamma$  a wide variety of sources is used: The 1950 US Census of Population, several current Population Reports ranging from 1955 to 1958, and a special sample of white husband-wife families derived from the 1950 BLS survey of Consumer Expenditures. The choice of data source is never accidental, and the data are always tailored to the theory.

In the absence of panel data (which were non-existent at the time), the major challenge posed by the cross section surveys was the separation of permanent and transitory earnings. To isolate the effect of transitory earnings and estimate the wage effect, Mincer follows Long and uses the SMSA means. Using a sample of 57 Northern SMSAs derived from the 1950 census, he argues that the community averages can be interpreted as approximations of the long-run levels, and hence should yield unbiased estimates of the long-run wage effect ( $\gamma$ ) and permanent income effect ( $\beta_p$ ). The OLS estimate of the wage effect proves to be positive and to be twice as large as the negative income effect, leading Mincer to the conclusion that the supply of labor of married women is positively sloped (in sharp contrast to the backward bending supply of labor of males). The positive wage effect, observed for the first time in cross section studies, seemed to be the clue to the secular increase in married women's labor force participation.

The second theme of the paper is the claim that cross-section studies tend to inflate the importance of the negative income effect because they do not separate the permanent income effect (which is also relevant for the secular change) from the transitory effect, which does not affect the secular trend. Unfortunately, the transitory component of measured income is unobservable and Mincer has to rely on circumstantial evidence to evaluate its effect. It is here where the researcher's ingenuity substitutes for "hard" data. To isolate the transitory effect, he employs several tests.

The first test focuses on the effect of husband's schooling on their wives' participation, where husband's earnings are held constant (at a low level of earnings). Estimating  $m = b_1x + b_2s$ , where  $s$  denotes schooling, and  $x = x_p + x_t$  and it is assumed that  $\partial x_p / \partial s > 0$ . Observing a positive schooling effect ( $b_2 > 0$ ), the finding is interpreted as support of the hypothesis  $|\beta_t| > |\beta_p|$ . An increase in husband's schooling, accompanied by an increase in his permanent earnings should have led to a decline in wife's participation unless it is offset by the stronger effect generated by the decline in transitory earnings.

A second piece of evidence is provided by a comparison of the participation rates of women married to men working only part of the year and those married to men working the full year. Since the two groups do not differ in the husband's weekly wage rate, the difference in husband's earnings is due to temporary constraints on his supply of labor. The increased labor force participation of women married to men working only part of the year is interpreted as a reaction to their husband's increased negative transitory income.

The elasticity of participation with respect to transitory earnings is derived from the partial regression coefficient of participation on weeks worked, where earnings are

held constant. Defining  $x_p = 52 w_h$ , where  $w_h$  denotes the husband's wage rate, and given that observed earnings  $x = nw_h$ , where  $n$  stands for weeks worked, transitory earnings equal

$$x_t = x - x_p = (n - 52)w_h.$$

Estimating  $m = b_1x + b_2n$ , the coefficient  $b_2$  reflects the relative magnitudes of the permanent and transitory earnings effects. Given earnings, the greater the permanent component, the smaller the transitory component of earnings. A negative coefficient of  $b_2$  is, therefore, indicative of a negative transitory earnings effect that exceeds the negative permanent earning effect.

At that time the current population reports of the Census Bureau (as well as the decennial censuses) were published in the form of one-way, or less frequently, two-way tables. As Mincer himself attests:

These gross relations between labor force rates and the classifying variables are manifold and bewildering. A literal reading of such relations as separate effects of the particular classifying variables is confronted with puzzling differences among various sets of cross-sectional data and leads to apparent contradictions with time series.

But the “puzzles” and “apparent contradictions” do not discourage him. They rather seem to invigorate him. A battery of tests is applied to these crude data to show that the wage effect offsets the permanent income effect, and that the transitory earnings effect on participation exceeds that of permanent earnings. The cruder the data the more sophisticated the tests employed.

Mincer borrows the Friedman's consumption function technique to interpret the gross effects that he observes. The numerous variations on the same theme attest to the author's artistry. He examines the wives' participation rates by their own schooling and the husband's income, their participation by husband's labor force status and age, by husband's occupation and earnings. He compares the participation rates in the survey week with the long-run work experience (i.e., years worked since marriage), and the effect of husband's earnings with and without children. In each case he is able to find the special angle that will allow him to separate the permanent income effect from the transitory effect and the income effect from the wage effect. By the end of the day, Mincer provides almost 20 pieces of evidence to support his hypotheses—a productivity record given the paucity of the available data.<sup>3</sup>

## 12.5. THE AFTERMATH

The dictionary defines “aftermath” as “1. a result (especially, a disastrous one); 2. a new growth of grass”. In this case clearly the second definition applies. Mincer's 1962 paper dominated the literature of labor supply throughout the 1960s. The two most comprehensive studies of the topic in that decade, Glen Cain's study of the labor

force participation of married women (1966) and William Bowen and Thomas Finegan's study of the US labor force (1969) were written in the Mincer spirit. It took a decade before the Mincer assumptions came into closer scrutiny.

Mincer, as already mentioned, never bothered to write down a formal model. Using labor force participation rate as a measure of labor supply, he explained: "In a broad view, the quantity of labor supplied to the market by a wife is the fraction of her married life during which she participates in the labor force. Abstracting from the temporal distribution of labor force activities over a woman's life, this fraction can be translated into a probability of being in the labor force in a given period of time for an individual, hence into a labor force rate for a large group of women" (Mincer 1962, p. 68).

Thus, according to Mincer, the choice of timing, given the lifetime probability of participation, is random. It was Yoram Ben Porath (1973) who questioned this assumption, arguing that one cannot abstract from the temporal distribution of labor force activities over a woman's life.<sup>4</sup> He points out that an alternative explanation for the differences in participation behavior of observationally identical individuals is unobserved differences in the value of home time. If this is the case, regressions of labor force participation on income and wages will not reflect the Hicks-Slutsky income and substitution effects, but rather the distribution of the value of time at home (i.e., the distribution of the reservation wage). Heckman (1978) denoted the two alternative hypotheses "*the life cycle model of labor supply*," and the "*one period model of labor supply*."

This distinction played an important role in the development of the analysis of labor supply in the 70s. Gilbert Ghez and Becker (1975), Heckman (1976), and Sherwin Rosen (1976) rose to the challenge to explain the life cycle profile of labor supply in a framework of consumption, investment in human capital and earnings.<sup>5</sup> This line of theoretical work led to Thomas MacCurdy's (1981) empirical model of labor supply in a life cycle setting. It is worth noting, however, that all these studies dealt primarily with males, and the timing of women's labor force participation (so closely related with the timing and spacing of child birth) has received a much less satisfactory theoretical and empirical treatment.

Which of the two explanations is more realistic is, of course, an empirical question and triggered several investigations (Yoram Ben Porath 1973; Heckman and Robert Willis 1977; Mincer and Haim Ofek 1982). Even those who rejected Jacob's version of the life cycle model and estimated the participation function to trace the distribution of the reservation wage, adopted his terminology, interpreting the results as the distribution of the housewives' value of time (Gronau, 1973a, 1973b; and Heckman, 1974).<sup>6</sup> This emphasis on the unobservable gave birth to the extensive literature on self-selection biases, and the proper way to isolate potential differences in the unobservable variables. Needless to say, this topic still generates heated controversies today.

A second offspring of Mincer's paper is the class of family supply models. Orley Ashenfelter and Heckman (1974) tried to estimate separate supply functions for husband and wife in a family context. Their specification of (what is called nowadays)

a “unitary” utility function defined over consumption and the husband and wife home time, was the forerunner of a whole new literature on family utility functions. The latest manifestation of these are the “collective” models of labor supply (Pierre-André Chiappori 1992, 1997).<sup>7</sup>

Mincer’s model of a three-way allocation of time between leisure, work at home and work in the market, and his analysis of married women as dual job holders (at home and in the market) were generalized by Becker, using a multi-activity framework (1965). It took a decade before it was formalized in its original three-way partition (Gronau 1977).

Mincer’s quest for reconciliation between the time series trends and the cross-section elasticity estimates did not end in 1962. He returned to the topic in 1985, this time heading an international “task force”. The study was based on the experience of 11 countries (the US, UK, France, Spain, Germany, The Netherlands, Sweden, Italy, Israel, The USSR, and Japan). Mincer’s introduction to the JOLE volume reporting these studies summarized the diverse experiences, and resolved at least some of the puzzles in the international data.

Finally, the entire empirical work of the 1962 paper was based on aggregate or grouped data. Even where disaggregate data were available – i.e., the 6,766 consumer units derived from the 1950 survey of Consumer Expenditures, Mincer had them stratified into 24 cells according to the husband’s schooling, age and employment status. The participation rate in each cell was regressed (using OLS) on the explanatory variables. Mincer’s study preceded by five years Thomas Lisco’s first use of Probit in empirical studies in economics.<sup>8</sup> Six more years passed before Probit was used in the study of labor supply (Gronau 1973a). The use of disaggregate data and the adoption of non-linear models of bivariate choice allowed for a much more accurate measurement of the explanatory variables, and a much richer set of explanatory variables. All these developments made Labor Economics the testing ground for new econometric techniques. They made, perhaps, some of Mincer’s “art” obsolete; they did not diminish, however, from the profound insights of his seminal paper.

## NOTES

1. Lest it is argued that the ratio of post/pre Mincer papers reflects just the obsolescence of knowledge (or memory censoring), Glen Cain’s 1966 study of the labor force participation of married women cited only 18 previous studies of labor supply. It may also be argued that the explosion of publications on the topic of labor supply reflects the sharp increase in the number of economic journals (and, specifically, journals specializing in labor economics). I would argue that the increase in the number of journals is a natural supply response to the increase in demand.
2. Twenty-two years later, in his comprehensive study of the U.S. labor force in the 20<sup>th</sup> century John Durand (1968) attributed the increase to “the autonomous influence of the development of custom” and “the succession of generations as a mechanism of change.”
3. The Consumer Expenditure sample used by Mincer included 6766 observations. For comparison, a recent paper on the effect of children on their mothers labor force participation (Joshua Angrist and William Evans 1998) was based on two samples of over a quarter of a million observations, each. (The observations were restricted to mothers with two or more children.)
4. Gregg Lewis questioned Mincer’s implicit assumptions six years earlier, but he kept it to himself (1967) (and to few privileged Spanish readers, 1968).

5. These studies owe as much to Mincer as they owe to Ben Porath's (1967) study of the optimal investment in human capital.
6. This work was, of course, also influenced by Mincer's later study on the opportunity cost of time (1963), and Becker's theory of the allocation of time (1965).
7. This literature gained impetus following Becker's path-breaking *Treatise on the Family* (1981).
8. Lisco (1965) employed probit to study modal choice in his study of the demand for transport.

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### 13. HOUSEHOLD PRODUCTION AND HEALTH

BY MICHAEL GROSSMAN

#### ABSTRACT

*This paper highlights the influence of the new home economics in general and Jacob Mincer's work in particular on the field of health economics. I begin by considering the value of time as a determinant of adult health and medical care utilization. I then turn to a similar treatment in the case of children's health and medical care utilization. I conclude with alternative explanations of the positive relationship between years of formal schooling completed and health, a topic that deals with complementary relationships between the two most important components of the stock of human capital.*

I took Jacob Mincer's two-semester labor economics course at Columbia University during the academic year 1965–66. Two of the first items that I read for the course during the first semester were his papers entitled "Labor Force Participation of Married Women: A Study of Labor Supply" (Jacob Mincer, 1962) and "Market Prices, Opportunity Costs, and Income Effects" (Mincer, 1963). Jacob devoted much of the second semester of the course to material that he eventually would publish in a book entitled *Schooling, Experience, and Earnings* (Mincer, 1974). The two papers and the book are in my view three of the most important contributions to labor economics in the last half of the twentieth century.

Given the identity of the author, it is not surprising that I learned a striking empirical fact from each of the three items that I have just mentioned. From the first, I learned that an increase in the wage rate of married women leads to an increase in their labor force participation rate, if their husband's income is held constant. From the second, I learned that an increase in the wage rate of married women leads to a reduction in the number of children to which they will give birth, again if their



husband's income is held constant. From the third, I learned that higher levels of schooling and on-the-job training are the major cause of higher wage rates.

As opposed to their distinct empirical contributions, the three items share a common theoretical theme: namely, the dichotomy between work and leisure is much too simple. This theme highlights that the labor/leisure decision is complicated by the presence of other uses of time. Individuals allocate time to many activities including food preparation, child-care, other types of production of goods and services for the home and the family, and the acquisition of knowledge and skills or human capital via formal schooling and on-the-job training. Since "time is money," women with higher wage rates simultaneously allocate more time to work in the market and less time to child-care by having fewer children. But since time sacrificed from the market now can raise market productivity in the future, there are powerful incentives to forego current earnings in favor of investments in human capital. Thus, these three papers have a dual message. On the one hand, an increase in the value of time elicits a variety of responses by consumers. On the other hand, increases in the value of time result from human capital investment decisions made by consumers.

In addition to taking Jacob's courses in labor economics, I witnessed much of his collaboration with Gary S. Becker at the now famous Columbia University labor economics workshop during the decade of the 1960s. Although they never published research together, their interaction with each other and with students at the workshop and the publications that emerged from those interactions (especially the three by Jacob mentioned above and Becker, 1964, 1965, 1981) resulted in the new home economics.

For three reasons, the new home economics has had profound impacts on the field of health economics. First, time is required to produce health and to obtain medical care. Second, health, like knowledge, is a durable capital stock; and both may be viewed as components of the stock of human capital. With one modification, insights from human capital theory developed by Jacob and others can be applied to this stock. The modification pertains to the nature of the returns. Investments in knowledge raise productivity in the market sector, where money earnings are produced, and may also raise productivity in the nonmarket or household sector, where commodities that enter the utility function are produced (Robert T. Michael, 1973). By contrast, investments in health by reducing morbidity and prolonging life increase the amount of time available to produce money earnings and commodities (Michael Grossman, 1972a, 1972b).

The third impact of the new home economics on health economics is a direct offshoot of Jacob's work on fertility. The finding that women with higher wage rates have fewer children suggests that they may have a smaller number of higher quality children, especially if part of the wage differential is due to schooling (Robert J. Willis, 1973; Gary S. Becker, 1981). Since children's health is one aspect of their quality, theoretical and empirical work in this area owes much to Jacob's insights on the determinants of optimal family size.

In the remainder of this paper, I highlight the influence of the new home economics in general and Jacob's work in particular on the field of health economics.

I begin by considering the value of time as a determinant of adult health and medical care utilization. I then turn to a similar treatment in the case of children's health and medical care utilization. I conclude with a discussion of alternative explanations of the positive relationship between years of formal schooling completed and health. It is natural to discuss the last topic in a paper of this nature because it deals with complementary relationships between the two most important components of the stock of human capital.

### 13.1. THE VALUE OF TIME, ADULT HEALTH, AND MEDICAL CARE UTILIZATION

Jacob Mincer's emphasis on decisionmaking based on the value of time is especially relevant to investments in health because both the benefits and the costs of these investments are positively related to the consumer's wage rate. Benefits rise because these investments reduce morbidity and mortality and thus increase the amount of time available to engage in a variety of productive activities. The monetary value of this expanded amount of time is greater the greater is the wage rate. Costs rise because the consumer's time is an input into the production of health investments and also may be required to obtain medical care and other market inputs. As long as some of the market goods in the health production function have positive money prices, the marginal monetary return on an investment in health is positively related to the wage rate. Hence, in a pure investment model of the demand for health—one in which health does not enter the utility function directly—the optimal quantity of health is a positive function of the wage rate or value of time (Grossman, 1972a, 1972b, 2000). This prediction becomes ambiguous in a pure consumption model in which health is demanded solely because it enters the utility function. In the latter model the relative price of health would rise with the wage if time costs were relatively more important in the production of health than in the production of other commodities (Grossman, 1972b, 2000).

In both models, higher wage individuals have incentives to substitute medical care for their own time in the production of a given amount of health. In a pure investment model this substitution in production effect is reinforced by an output effect. In a pure consumption model the output effect may go in the opposite direction. Both models, however, point to the wage rate as an argument in the demand function for health and in the demand function for medical care. Both models also contain the prediction that an increase in the amount of time required to travel to the physician's office or to wait in the office before receiving services will lower the quantity of medical care demanded. Finally, under some circumstances, persons with high wage rates will be less responsive to variations in the money price of medical care than those with lower wage rates since a given percentage change in money price represents a smaller percentage change in the total or "full" price of health or medical care.<sup>1</sup>

Considerable empirical support for the above propositions has accumulated during the past three decades. In my work on the demand for health, I find positive effects of the wage rate on self-rated health and negative effects on work-loss and restricted-activity days due to illness or injury in two micro data sets (Grossman, 1972b, 1975).

I also find that an increase in the wage lowers mortality in an analysis of variations in age-adjusted death rates across states of the United States (Grossman, 1972b). These results control for schooling, family income, and a number of other variables. Adam Wagstaff (1986) replicates them using a survey conducted in Denmark and health indicators based on non-chronic health conditions that reflect physical mobility, mental health, respiratory health, and presence of pain. Manfred Erbsland, Walter Ried, and Volker Ulrich (1995) report a similar finding in a West German survey in which health is measured by degree of handicap, self-rated health status, sick leave, and chronic complaints.

The studies just cited support a pure investment model of the demand for health. On the other hand, Christopher J. Ruhm (2000b) provides evidence in favor of a consumption model. Using a time series of states of the United States for the period from 1972 through 1991, he shows that total mortality and eight of ten sources of fatality are inversely related to state unemployment rates. His interpretation of this procycle behavior of mortality is that the value of time and the relative price of health are negatively related to the unemployment rate. His accompanying analysis of micro data indicates that obesity increases and physical activity declines during business cycle expansions.

Most estimates of the demand for medical care that focus on the value of time do so in data in which travel time to the source of medical care and waiting time at the source are available. These variables either are multiplied by the wage rate or are entered as separate regressors. Jan P. Acton (1975, 1976) shows that travel and waiting time are important rationers of the demand for outpatient medical services in several samples of New York City residents. Thomas R. McCarthy (1985) reports an elasticity of the number of physician visits demanded with respect to in-office waiting time of approximately  $-1$  in a national U.S. sample. Avi Dor, Paul Gertler, and Jacques van der Gaag (1987) and Paul Gertler, Luis Locay, and Warren Sanderson (1987) show that increased travel time discourages demand for medical care services in the Ivory Coast and Peru, respectively. The latter study contains the finding that the money price elasticity of demand for medical care falls in absolute value as income rises, presumably because the indirect or time price component of care represents a larger fraction of the full price of care at higher income levels.

The role of the value of time in the demand for medical care provides an explanation of a somewhat puzzling phenomenon on the supply side of the market: "the availability effect." By this is meant the notion that physicians or dentists can directly influence the demand for their services. Evidence comes from studies showing that an increase in the per capita number of physicians or dentists in an area increases the per capita number of physicians' visits or dentists' visits made by the residents of the area, with income and the money price of a visit held constant. Additional evidence is that the relationship between money price and the number of providers is positive, with demand determinants held constant (see Thomas G. McGuire, 2000 and the references that he cites). Many studies that find a positive provider effect in the demand function fail to control for travel and waiting time. As pointed out above, these variables are demand rationers and are likely to be negatively related to provider availability.

Arthur S. De Vany, Donald R. House, and Thomas R. Saving (1983) show that the positive relationship between money price and provider availability disappears once office waiting time is held constant in the market for dental services. Waiting time by patients is negatively related to the number of dentists in an area, and a reduction in waiting time is accompanied by an increase in fees. The last effect arises because more inputs are required to increase service capacity. De Vany, House, and Saving's results are consistent with a model in which consumers who value their time highly are willing to tradeoff a reduction in waiting time for an increase in money price and in which dentists make location decisions to accommodate this tradeoff. Curt D. Mueller (1985) provides additional evidence of this tradeoff in the market for physicians' services. In a national sample money price rises and waiting time falls as patient income rises.

### **13.2. THE VALUE OF TIME, CHILDREN'S HEALTH, AND MEDICAL CARE UTILIZATION**

The pure investment model of the demand for health that I constructed using many elements of the new home economics facilitates relatively simple analyses of the determinants of adult health (Grossman, 1972a, 1972b, 2000). Models of the demand for child health derived from the new home economics cannot be characterized in the same manner. One must confront a nonlinear budget constraint due to the nature of the child quality-quantity interaction, uncertainties as to whether the number of children and their quality are substitutes or complements, and the possible simultaneous determination of the number and quality of children and the wife's wage rate (Willis, 1973; Jacob Mincer and Solomon Polachek, 1974; Becker, 1981). For these reasons, especially the last, much of the literature dealing with child health has focused on female schooling levels rather than on female wage rates. While an increase in schooling raises the market wage rate, it also may increase efficiency in the production of child health. Hence, although the new home economics highlights the relevance of mother's schooling, the empirical effects of this variable are subject to more than one interpretation.

Michael Grossman and Robert Kaestner (1997) review many studies that document negative relationships between infant mortality and parents' schooling and positive relationships between various measures of child and adolescent health and parents' schooling. These studies suggest that the effect is causal because they control for genetic endowment in a variety of ways and because they report larger effects for mother's schooling than for father's schooling. The latter finding is important because equal effects would be expected if the schooling variables were simply proxies for unmeasured genetic endowments. On the other hand, if the effect of schooling is primarily environmental, one would expect the impact of mother's schooling to be larger because she was the family member most involved with children's health during the periods in which the studies were conducted.

Hope Corman and Michael Grossman (1985) provide estimates of the quantitative importance of mother's schooling by using cross-sectional regression results to

explain U.S. trends in race-specific neonatal mortality (deaths of infants within the first 27 days of life per thousand live births) mortality between 1964 and 1977. In addition to schooling, they consider poverty, abortion, neonatal intensive care, family planning, and maternal and infant care project availability; and variables pertaining to the Medicaid and WIC programs. The increase in white female schooling makes the largest contribution to the 46 percent decline in white neonatal mortality and the increase in black female schooling makes the second largest contribution to the 42 percent decline in black neonatal mortality. Schooling explains 7 percent of the white reduction and 6 percent of the black reduction.

Ann D. Colle and Michael Grossman (1978), Fred Goldman and Michael Grossman (1978), and Rosanna Coffey (1983) provide direct evidence that the value of mother's time rations physicians services related to infants and children. The first two studies include the time price of a pediatric care physician visit—travel time multiplied by the mother's potential market wage rate—as a regressor in demand functions for these visits. Both find negative coefficients. In addition Goldman and Grossman point out that the time price is a fixed cost since it does not depend on the number of services received per visit. They show that mothers with large fixed costs obtain more services per visit by using more highly trained physicians, as reflected by their specialty, board certification status, age, and other characteristics. Coffey (1983) reports that the time price of care rations demand in the market for prenatal care and family planning services.

Ruhm (2000a) provides empirical evidence that a reduction in the opportunity cost of time allocated to the production of infant health, with little or no change in income, increases the quantity of health demanded. Using aggregate data for nine European countries for almost three decades, he shows that entitlements to parental leave following delivery lower postneonatal mortality (deaths between 28 days and 1 year) and child mortality (deaths between 1 and 5 years of age). Presumably, the presence of a paid leave and an increase in its length lower the relative price of infant and child health because its production is a time-intensive activity.

### 13.3. HEALTH AND SCHOOLING

An extensive review of the literature conducted by Grossman and Kaestner (1997) suggests that years of formal schooling completed is the most important correlate of good health. This finding emerges whether health levels are measured by mortality rates, morbidity rates, self-evaluation of health status, or physiological indicators of health, and whether the units of observation are individuals or groups. In a broad sense, this correlation between health and schooling may be explained in one of three ways. The first argues that there is a causal relationship that runs from increases in schooling to increases in health. The second holds that the direction of causality runs from better health to more schooling. The third argues that no causal relationship is implied by the correlation; instead, differences in one or more “third variables,” such as physical and mental ability and parental characteristics, affect both health and schooling in the same direction.

Causality from schooling to health results when more educated persons are more efficient producers of health. This efficiency effect can take two forms. Productive efficiency pertains to a situation in which the more educated obtain a larger health output from given amounts of endogenous (choice) inputs. This is the effect that I have emphasized in my research. Allocative efficiency, discussed in detail by Donald S. Kenkel (2000), pertains to a situation in which schooling increases information about the true effects of the inputs on health. For example, the more educated may have more knowledge about the harmful effects of cigarette smoking or about what constitutes an appropriate diet. Allocative efficiency will improve health to the extent that it leads to the selection of a better input mix.

Alternatively, the direction of causality may run from better health to more schooling because healthier students may be more efficient producers of additions to the stock of knowledge (or human capital) via formal schooling. Furthermore, this causal path may have long lasting effects if past health is an input into current health status. Thus, even for non-students, a positive relationship between health and schooling may reflect reverse causality in the absence of controls for past health. Health also may cause schooling because a reduction in mortality increases the number of periods over which the returns from investments in knowledge can be collected.

Kaestner and I (Grossman and Kaestner, 1997) conclude from our extensive review of the literature that schooling does in fact have a causal impact on good health. In drawing this conclusion, we are sensitive to the difficulties of establishing causality in the social sciences where natural experiments rarely can be performed. Our affirmative answer is based on the numerous studies in the U.S. and developing countries that we have summarized. These studies employ a variety of health measures, many different estimation techniques, and controls for a host of third variables.

In the remainder of this section, I want to address one challenge of the conclusion that the role of schooling is causal: the time preference hypothesis first proposed by Victor R. Fuchs (1982). Fuchs argues that persons who are more future-oriented (who have a high degree of time preference for the future) attend school for longer periods of time and make larger investments in health. Thus, the effect of schooling on health is biased if one fails to control for time preference.

The time preference hypothesis is analogous to the hypothesis that the positive effect of schooling on earnings, explored in detail by Mincer (1974), is biased upward by the omission of ability. In each case a well-established relationship between schooling and an outcome (earnings or health) is challenged because a hard-to-measure variable (ability or time preference) has been omitted. Much ink has been spilled on this issue in the human capital literature. Attempts to include proxies for ability in earnings functions have resulted in very modest reductions in the schooling coefficient (for example, Zvi Griliches and William M. Mason, 1972; John C. Hause 1972). Proponents of the ability hypothesis have attributed the modest reductions to measurement error in these proxies (for example, Arthur S. Goldberger, 1974). More recent efforts have sought instruments that are correlated with schooling but not correlated with ability (for example, Joshua D. Angrist and Alan B. Krueger, 1991).

These efforts have produced the somewhat surprising finding that the schooling coefficient *increases* when the instrumental variables procedure is employed. A cynic might conclude that the way to destroy any empirical regularity is to attribute it to an unmeasured variable, especially if the theory with regard to the relevance of this variable is not well developed.<sup>2</sup>

Nevertheless, the time preference hypothesis is important because it is related to recent and potentially very rich theoretical models in which preferences are endogenous (Gary S. Becker and Casey B. Mulligan, 1997). Differences in time preference among individuals will not generate differences in investments in human capital unless certain other conditions are met. One condition is that the ability to finance these investments by borrowing is limited, so that they must be funded to some extent by foregoing current consumption. Even if the capital market is perfect, the returns on an investment in schooling depend on hours of work if schooling raises market productivity by a larger percentage than it raises nonmarket productivity. Individuals who are more future-oriented desire relatively more leisure at older ages. Therefore, they work more at younger ages and have a higher discounted marginal benefit on a given investment than persons who are more present oriented. If health enters the utility function, persons who discount the future less heavily will have higher health levels during most stages of the life cycle. Hence, a positive relationship between schooling and health does not necessarily imply causality.

Since the conditions that generate causal effects of time preference on schooling and health are plausible, attempts to control for time preference in estimating the schooling coefficient in a health outcome equation are valuable. Fuchs (1982) and J. Paul Leigh and Rachna Dhir (1997) find that indexes of time preference have insignificant effects on health status and little impact on schooling coefficients. These results must be regarded as preliminary because they are based on small samples and on exploratory measures of time preference.

Mark C. Berger and J. Paul Leigh (1989) and others employ instrumental variables (IV) to obtain consistent estimates of the causal effect of schooling on health (see Grossman, 2000 for a detailed discussion of these studies). In most cases the IV coefficients are larger than the ordinary least squares coefficients. These results are inconsistent with the time preference hypothesis and consistent with the hypothesis that schooling causes health. This conclusion rests on the assumption that the instruments used to predict schooling are uncorrelated with time preference and other unobserved determinants of health. The validity of this assumption may not be plausible with regard to certain instruments used in these studies such as parents' schooling and parents' income.

Very recent work by Jeremy Arkes (2001), Scott J. Adams (2002), Janet Currie and Enrico Moretti (2003), Adriana Lleras-Muney (2004), and Jacob N. Arendt (2005) address the schooling-health controversy by using compulsory education laws, unemployment rates during a person's teenage years, or college openings to obtain consistent estimates of the effect of schooling on health. Lleras-Muney (2004) employs compulsory education laws in effect from 1915 to 1939 to obtain consistent estimates of the effect of education on mortality in synthetic cohorts of successive

U.S. Censuses of Population for 1960, 1970, and 1980. This instrument is highly unlikely to be correlated with unobserved determinants of health, especially because she controls for state of birth and other state characteristics at age 14. Her ordinary least squares estimates suggest that an additional year of schooling lowers the probability of dying in the next ten years by 1.3 percentage points. Her IV estimate is much larger: 3.6 percentage points.

Adams (2002) uses the same instrument as Lleras-Muney in the first wave of the Health and Retirement survey, conducted in 1992. He restricts his analysis to individuals between the ages of 51 and 61 and measures health by functional ability and self-rated health. He finds positive and significant effects of education on these positive correlates of good health and larger IV coefficients than the corresponding OLS coefficients.

Arendt (2005) capitalizes on compulsory school reform in Denmark in 1958 and 1975 to study the impact of schooling on self-rated health in the 1990 and 1995 waves of the Danish National Work Environment Cohort Study. Respondents were between the ages of 18 and 59 in 1990. His results are similar to those of Adams.

Arkes (2001) focuses on white males aged 47 to 56 in the 1990 Census of Population. His instrument for schooling is the state unemployment rate during a person's teenage years. With state per capita income held constant, he argues that a higher unemployment rate should lead to greater educational attainment because it reduces the opportunity cost of attending school. From two-stage least squares probit models, he finds that an additional year of formal schooling lowers the probability of having a work-limiting condition by 2.6 percentage points and reduces the probability of requiring personal care by 0.7 percentage points. Both estimates exceed those that emerge from probit models that treat schooling as exogenous.

Currie and Moretti (2003) examine the relationship between maternal education and birthweight among U.S. white women with data from individual birth certificates from the Vital Statistics Natality files for 1970 to 2000. They use information on college openings between 1940 and 1990 to construct an availability measure of college in a woman's 17th year as an instrument for schooling. They find that the positive effect of maternal schooling on birthweight increases when it is estimated by instrumental variables.

The results of the five very recent studies just reviewed certainly suggest causality from more schooling to better health. The finding that the IV estimates exceed the OLS estimates may arise because the instruments are based on policy interventions that affect the educational choices of persons with low levels of education (David Card, 2001). If different individuals face different health returns to education, IV estimates reflect the marginal rate of return of the group affected by the policies (Joshua D. Angrist, Guido Imbens, and Donald B. Rubin, 1996). Whatever the interpretation of the findings, they do not support the hypothesis that the observed effect of schooling on health is due to time preference.



### 13.4. CONCLUSION

I conclude with an acknowledgment and a plea. My acknowledgment is to Jacob Mincer. His superb skills in research and teaching inspired me to select labor economics as my field of specialization at Columbia University in 1965. When I perhaps disappointed him by changing my specialization to health economics, I was only taking seriously something that he taught me. From my perspective, in 1967 an investment in health economics paid the best interest. As I hope this paper has demonstrated, I did not stray very far from Jacob and his flock because my research and related research in health owes a great debt to the new home economics.

My plea is for the development of comprehensive theoretical models in which the stocks of health and knowledge are determined simultaneously. The rich empirical literature treating interactions between schooling and health underscores the potential payoffs to this undertaking. A model in which both the stock of health and the stock of knowledge (schooling) are endogenous does not necessarily generate causality between the two. Individuals, however, typically stop investing in schooling at relatively young ages but rarely stop investing in health. I have a “hunch” that a dynamic model that takes account of these patterns will generate effects of an endogenously determined schooling variable on health in the health demand function if schooling has a causal impact on productive efficiency or time preference.

### NOTES

1. For a detailed treatment of the propositions developed in the first two paragraphs of Section II and some necessary qualifications, see Michael Grossman (2000).
2. See Grossman and Robert Kaestner (1997) for a model in which ability should be omitted from the reduced form earnings function even though it enters the structural production function and has a causal impact on schooling.

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## 14. HOUSEHOLD PRODUCTION AND CHILDREN

BY ARLEEN A. LEIBOWITZ\*

### ABSTRACT

*This paper adapts Mincer's ideas about informal training, best exemplified by on-the-job training (OJT), to investments that families make in children before formal schooling begins. Like OJT, in-home training (IHT) occurs in informal settings, requires costly time inputs and is complementary with formal schooling. In addition to choosing among home production, leisure and market work, parents also choose which particular home activities to pursue. That working mothers dramatically reduce the time they devote to leisure, sleep, and other home activities in order to preserve their time in human capital-building activities with children, illustrates and validates the home production framework.*

When we consider all the important topics that have engaged Jacob Mincer's attention over the years—women's labor force participation and wages, schooling experience and earnings, migration—children were rarely an explicit focus. Yet I believe that the issue of children and investment in them was always implicitly in his work and that many of Mincer's breakthrough approaches opened up ways of thinking and studying important issues relating to children. This paper builds on Jacob Mincer's seminal work on the choices women make about how much time to supply to the market and how much to the home (Mincer 1962), his work relating to

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on-the-job training (Jacob Mincer, 1962), and Gary Becker's formulation of theories about home production (Becker 1965) in order to examine how a mother's time allocation choices affect her children.

Mincer's redirection of attention from the prevailing dichotomy of market work versus leisure to a consideration of a choice set that includes home production in addition to market work and leisure, provided the foundation for understanding fertility choices as well as women's labor supply to the market and, implicitly to understanding time inputs to children (Mincer, 1962). Since the time that Jacob Mincer first wrote about these issues in the early 1960's, a time when only one-third of married women participated in the paid work force, women's participation rates have doubled.

Many women adjusted to their rising opportunity costs of time in home production by reducing their fertility. But lower fertility only partially explains women's increased market work. Work outside the home is now prevalent, even for mothers of small children. By 2003, over half (56.5 percent) of married women whose youngest child was under three were in the labor force (US Bureau of the Census, 2004) and rates were even higher for unmarried mothers.

In an analysis of the CPS data, Jacob Klerman and I explored the reasons for the increases over the period 1971 to 1990 in labor force participation by married mothers whose child was under three years old (Arleen A. Leibowitz and Jacob Alex Klerman, 1995). For the period 1971–1990, we found that demographic characteristics (maternal education, maternal age, family size, paternal age) changed in ways that promoted labor supply of new mothers, but that these factors accounted for less than 20% of the observed growth in participation. Predicted wages of the husband and the wife (based on individual characteristics as well as local market conditions) were strong predictors of market labor supply and explained an additional 25% of the increased participation. Not only have women's own higher earnings prospects been a major factor pulling them into the work force, but the strength of this effect has also increased over time. By 1990, women were more responsive to their own wage prospects and less responsive to their husbands' (worsening) wage prospects than they had been 20 years earlier (Leibowitz and Klerman, 1995). Throughout the period, mothers of infants under one year old were less likely to be labor force participants than mothers of one and two year olds, but the inhibiting effect of newborns under 1 year old on their mothers' market work eroded significantly over these two decades.

#### **14.1. HOUSEHOLD PRODUCTION OF CHILD HUMAN CAPITAL**

In order to better understand what mothers' high levels of market work mean for their children's health and development, it is useful to expand the household production framework to distinguish among time spent in the labor market, in leisure, developing the human capital of children and in other household production.

### 14.1.1. Sources of Utility

The utility framework is expanded as well to include the human capital of the child ( $H$ ) as one of the arguments in the utility function, along with the consumption of goods and services, ( $X$ ), and parental leisure ( $L$ ).

$$U = U(X, L, H) \quad (1)$$

### 14.1.2. Production of Human Capital at Home

Human capital, in this case, encompasses children's physical health as well as cognitive and emotional development. A child is born with a certain stock of human capital, which may partially result from prenatal investments. Additions to this stock are produced through household production with inputs of parental time ( $t_h$ ), child time ( $t_c$ ), and purchased goods that affect child development ( $X_c$ ). These purchased goods may include childcare supplied by someone other than the parent, as well as other goods, such as books. The goods include both those with a positive effect on human capital development and those, such as secondhand smoke, with negative effects. The productivity of time spent in human capital investment in any time period depends on the child's stock of capital at the beginning of the period  $H_{t-1}$ , as well as on genetic endowments ( $G$ ) and the efficiency of parental time inputs in human capital production ( $E$ ):

$$\Delta H_t = H(t_h, t_c, X_c; H_{t-1}, G, E) \quad (2)$$

Parents' time is strictly constrained: the sum of their time at work, with children, in other home production, and in leisure cannot exceed the total time available in the period:

$$T_{it} = t_{hit} + t_{oit} + t_{wit} + t_{lit} \quad (3)$$

Where  $T_{it}$  is the total amount of time available to parent  $i$  in time period  $t$  and  $t_{hit}$  is the time spent with children by parent  $i$ . The amount of time spent by parent  $i$  in other home production (including commuting to work) is  $t_{oit}$ , the amount of time spent at work is represented by  $t_{wit}$  and  $t_{lit}$  represents time spent in leisure activities.

Similarly, the family's expenditure on consumption goods in any period is limited by the amount of earned income, non-earned income available in the period and by the family's ability to borrow:

$$(\sum w_i t_{wit} + V_t) - C_{kt} = S_t \quad (4)$$

Where  $w_i$  is the wage rate of parent  $i$  so that  $\sum w_i t_{wit}$  represents the sum of parents' earnings during period  $t$ . Income also includes non-labor income,  $V_t$ . Consumption expenditures in period  $t$  ( $C_{kt}$ ) consist of all consumption expenditures, including spending on goods that affect child development and those that affect only parents. Although this formulation allows for positive or negative savings in

period  $t$  ( $S_t$ ), it is likely that most parents are constrained by the amount of their earned and non-earned income because most are at the start of their earning lives, with few savings and facing substantial borrowing constraints.

This simplified model captures a number of relevant factors about child development:

1. Nurture in the form of investments in children combines with nature (the genetic endowment) in determining child human capital levels at any point in time.
2. Prior investments in human capital in the child affect the productivity of later investments.
3. Parental time contributes directly to the development of children's human capital.
4. Parental time devoted to developing child human capital has an opportunity cost in terms of market work, other home production, and parental leisure.
5. Child time inputs matter. Thus how children spend their time affects the development of their human capital.
6. Childcare is productive of child development, and therefore may be valued and purchased even if it is not required to free the mother for market work.
7. In choosing a particular source of childcare, parents trade-off its developmental potential against other considerations, such as its cost and convenience (Anne S. Johansen, Arleen A. Leibowitz, Linda J. Waite, 1996).

A child's human capital stock grows continuously throughout childhood since the investments that parents and children make typically exceed depreciation or loss due to accidents, which are generally negligible during this time. A child whose initial stock of human capital is low (perhaps as a result of preterm birth), is likely to have lower levels of human capital at age three than a child with full term birth who experiences the same level of parental investments (Peggy J. McGauhey, et al. 1991).

## 14.2. IN-HOME TRAINING

The production of human capital in the home has a great many parallels with on the job training (OJT). Like OJT, in-home training (IHT), occurs outside of the formal schooling sector and requires costly time inputs. Like OJT, IHT is complementary to schooling.

### 14.2.1. IHT is Informal Training

IHT is similar to OJT in that both develop human capital outside of a formal schooling setting. As their names suggest, IHT occurs primarily in the household and OJT in an employment situation. Mincer's work on OJT emphasized the continuing production of human capital in the informal sector after the completion of schooling. Equally important is the production of human capital in the informal, household sector, prior to acquiring formal schooling. Initially, the child has such low levels of

human capital that specialization in human capital production is likely to occur. Even activities that appear to be consumption—such as eating—contribute to the child’s development of human capital. For example, the responsiveness of the caretaker to the child’s cries for food build the child’s sense of competence and ability to control the environment (Barry Zuckerman and Robert S. Kahn, 2000) and the amount and quality of the caretaker’s communication affect the child’s mastery of verbal skills (Janellen Huttenlocher, et al, 1991; Jeanne Brooks-Gunn et al, 1996). This may be a classic example of “learning by doing”.

Both OJT and IHT occur as byproducts of other activities and these investments are difficult to measure. This may explain why their contributions to human capital have not received as much attention as the impact of formal schooling on human capital development (James J. Heckman and Lance Lochner, 2000; Pedro Carneiro et al., 2002).

#### 14.2.2. IHT Requires the Parent’s Time

As Jacob Mincer wrote at the start of his book, *Schooling, Experience, and Earnings* (1974), “Investments in people are time consuming.” The difference between OJT and IHT is that IHT requires the time of at least two people—the child and the caretaker. The adult caretaker has to choose among alternative ways of spending time. First there is the choice between market work and remaining at home with an infant. Even if she is not participating in the labor market, a parent still must choose between spending time in home production with children (e.g., reading to the child), producing other goods at home (e.g., gourmet meals), and spending time in her own consumption (e.g., reading a novel or watching a soap opera on TV). The fact that, even within the home, the caretaker can choose to spend time in producing child development, in own consumption, or other household production, renders problematic the hiring of substitutes for parental time in caring for an infant. Parents who leave their child in someone else’s care while they work find it difficult to monitor whether the nanny or babysitter is spending her time investing in the child’s human capital or enjoying her own consumption at the expense of the child. This is particularly the case for newborns who cannot report on how they spent their day.

The IHT model suggests that the mother need not reduce her time with children by an hour for every hour she works, since there are other activities that can be substituted for work time as well. Indeed, time use data show that working mothers selectively reduce their own leisure time, sleep and time in producing commodities other than child care as compared to non-working mothers (Suzanne M. Bianchi, 2000). As a result, mothers working outside the home averaged nearly as many hours in direct child interaction as did non-employed mothers (27 versus 31 hours per week; see John F. Sandberg and Sandra L. Hofferth, 2001; Lindsay Chase-Lansdale, et al., 2003).

If working mothers value the human capital produced through interacting with children, they should preferentially preserve time in activities that promote human capital growth at the expense of other activities that do not. Time budget data from



the 1960's reveal that more educated women are better at allocating their time to the activities that produce human capital (Arleen Leibowitz, 1975). Mothers with more schooling spent more time in the labor market and less time in most household activities than less educated women, as one would predict from the opportunity cost of their time. However, they spent more time with children, particularly in activities that could be expected to produce human capital, such as reading with or talking to children. Several factors could account for this unexpected result: a high income elasticity for time with children, the difficulty of substituting purchased inputs for parental time, or the increased productivity of educated mothers in child care relative to other activities (Leibowitz, 1975).

Still today, more-educated mothers spend more time with children in activities that enhance the child's human capital. Data from the 1996 National Household Education Survey confirm that 3 to 5 year old children whose mothers are college graduates were more than twice as likely to be read to every day than children whose mothers did not have a high school degree (77% vs. 37%) (Lisa M. Lynch, 2000). More educated mothers also read more to their children who were less than 3 years old (Pia Rebelli Britto, et al., 2001).

These early experiences appear to have the greatest impact on child outcomes (Britto, et al., 2002). Direct measures of how mothers interact with children are strong predictors of children's verbal scores at age five and six. The National Commission on Reading concluded that reading with children is the factor most closely related to the development of literacy skills (as reported in Zuckerman and Kahn, 2000). Children whose mothers read to them daily have significantly greater verbal skills than children whose mothers do not read to them, as do children whose mother involves them in learning activities outside the home, and who have a mother with a less harsh and more nurturing disciplinary style (Meredith Phillips et al., 1998). Including these direct measures of time investments in children renders both maternal I.Q. and maternal and paternal education insignificant as predictors of a child's verbal skills (Phillips et al., 1998). This strongly suggests that the relationship between maternal education and child outcomes reflects educated mothers' greater allocation of time to human capital-enhancing activities and possibly their greater productivity in developing human capital in any particular activity, and not merely the genetic endowment passed on to the child.

#### **14.2.3. Substituting for Parental Time**

In terms of the substitutability of purchased inputs for parental time, childcare centers appear to be as productive or more productive than mothers in developing human capital for children between the ages of two to four. The evidence indicates that toddlers in day care settings develop better both socially and cognitively than children raised entirely at home (Allison Clarke-Stewart, 1991; Elizabeth Harvey, 1999; Jennifer Hill, Jane Waldfogel, and Jeanne Brooks-Gunn, 2002).

However, the findings on substitution are less positive for children under one year of age—the group for whom maternal employment has been growing most rapidly. Several studies find that maternal employment negatively affects children's outcomes

in the first year of life (Sonalde Desai, et al., 1989; Nazli Baydar and Jeanne Brooks-Gunn, 1991; Francine Blau and Adam J. Grossberg, 1992; Jane Waldfogel et al., 2002). In understanding the factors underlying this result, it is useful to consider the work of psychologists who find that a key factor in children's later social behavior and school achievement is the quality of the relationship with a supportive adult in infancy (Martha Erickson, L. Alan Stroufe, Byron Engeland, 1985; Martha F. Erickson, Karen Kurz-Riemer, 1999). Neurobiologists have recently documented a physiological basis for these findings. Caretaking that is sensitive to a child's needs alters neural pathways in the brain (Rima Shore 1997). Experiences in the early years determine which of a child's neural connections are reinforced and which are pruned as no longer necessary (Sharon L. Ramey and Craig Ramey, 2000). Thus, a child who experiences an environment that is rich in stimuli builds a better physiologic basis for later learning. This applies not only to the acquisition of verbal skills, but also to the child's ability to regulate emotional responses. (Jack P. Shonkoff and Deborah Phillips, 2000). The metaphor "investment in human capital" has proved to be very apt because imaging studies can now document that early stimulation of infants results in physical changes in the structure of the child's brain (Heidelise Als, et al., 2004; Paul M. Thompson, et al., 2000).

The fact that newborns absorb lessons from the way routine caretaking is performed suggests that substitutes for parental time are even harder to find for infants than for toddlers, where physical care and educational activities can be more clearly delineated. Differences between the types of learning done by infants and by toddlers perhaps contribute to the negative impact of maternal work during the first year of a child's life, in contrast to the neutral or benign effect of work when the child is older.

#### **14.2.4. IHT Requires the Child's Time and Human Capital as Inputs**

A child builds human capital over time by participating in activities that enhance knowledge or health. Much empirical evidence suggests that certain types of activities (e.g., reading with children) enhance children's verbal and cognitive skills. Other activities (e.g., watching T.V.) are presumed to have neutral or negative effects on a child's human capital.

Economists have tended to ignore the time input by young children to the development of their own human capital because markets for children's labor are limited in this country. In developing countries, the trade-off between children's work and human capital investments is more apparent (Duncan Thomas, et al., 2004; Rajjeev Dehejia, 2005)

In the United States, there has been concern that adolescents' market work detracts from their ability to accumulate human capital. Time spent in employment by teenagers is negatively correlated with time spent studying (see Christopher Ruhm, 1997) for a review and critique of the selection problems). Surprisingly, moderate amounts of work during high school are positively associated with future earnings (Ruhm, 1997; Audrey Light, 2001), indicating that some employment experience during high school may enhance human capital.

Like adults, children have a fixed amount of time available in a day and must choose among a variety of ways to spend the time that they are not in school or at work. Studies of children's time use suggest a trade off between educationally productive uses of time and educationally unproductive uses of time. These studies show parental education has a strong positive effect on the amount of time a child allocates to reading or studying and strong negative effect on time watching television (Suzanne Bianchi and John Robinson, 1997). Time budget studies of children's time use have found that the amount of time children spend in "productive" activities such as reading correlates positively with their scores on standard achievement tests (Sandra L. Hofferth and John F. Sandberg, 2001). Drawing causal inferences from this type of cross-sectional data is hazardous. However child care interventions that employ random assignment of children to different treatments provide a more persuasive means of assessing the effects of increasing the amount of time children spend in more structured, educationally oriented environments.

The Infant Health and Development Program found that children born at low birth weight who were randomly assigned between age one to three to receive high-quality child care had significantly greater cognitive development than the control group of low birth weight infants (Marie McCormick et al, 1992; Jeanne Brooks-Gunn et al, 1994). In the Perry Preschool Project, black children who were already developmentally delayed at age 3 or 4 were assigned to receive an intensive program of stimulation in a developmental nursery school or usual care. At age nineteen the intervention group scored higher on school achievement tests, compared to the control group, even though there were no differences in measured IQ between the two groups.

Working with healthy, full-term infants from economically disadvantaged families, the Abecedarian Project randomly assigned the children to either an intensive developmental intervention or to a control group. Children remained in the study until they reached kindergarten. Even during infancy, children in the Abecedarian intervention group were able to learn new tasks more quickly than children randomly assigned to the control group (Sharon Ramey and B.J. Smith, 1977). Intensive, early investments appear to have long-lasting effects on educational outcomes, consistent with the idea that early additions to a child's human capital increase the productivity of later schooling investments. For example, the Abecedarian Project documented long-run declines in special education placement and grade retention (Ramey and Ramey, 2000), despite a reduction of the IQ advantage for the intervention group by age 14.

A recent evaluation of the Early Head Start Program documented that the 3000 children randomly assigned to attend Early Head Start from birth to age 3 had better cognitive and language development as well as greater ability to concentrate, compared to a control group of children (Administration for Children and Families, 2002).

Choices that parents make even prior to the child's birth can affect an infant's initial stock of capital. For example, a pregnant woman may or may not choose to forgo pleasurable consumption activities such as smoking or drinking alcohol that have

could have a negative impact on the child's health, but provide utility to the mother. Children born with greater stocks of human capital in terms of birth weight have a health advantage over low birth weight infants that persists through at least age 11 (McGauhey, et al., 1991). However, there is evidence that low birth weight infants with more educated parents receive health investments that compensate for their children's initially low levels of health capital. Low birth weight infants in moderate and high socio-economic status families catch up to their normal birth weight peers, whereas low birth weight children in high-risk social environments have increased likelihood of poor health outcomes that persists throughout childhood (McGauhey, et al., 1991).

### 14.3. IHT IS COMPLEMENTARY TO SCHOOLING

The allocation of time in early childhood is important because the human capital developed through human-capital-enhancing time use affects the productivity of a child's time in later investments. Thus, children tend to follow developmental trajectories that are higher over time if they benefited from substantial early human capital development, and lower if their initial stocks were low due either to poor genetic endowment or to lack of early investment (Janet Currie and Rosemary Hyson, 1999; Neal Halfon et al., 2000; Anne Case et al., 2002). Not only does the child with greater endowments and early investments have more human capital at all ages, but the stock also grows more in each period because the child's own human capital is a necessary input to producing increments to the stock.

For the school-age child, the quality of the school inputs affects the amount of human capital development. However, educators have been disappointed to find that, although enhancing school inputs improve outcomes, the effects are not large quantitatively. A production function framework helps to make sense of the finding that simply increasing school inputs may yield only modest improvements in school outcomes. The production of human capital in schools requires both school inputs and a student with sufficient levels of human capital (both cognitive and behavioral) to absorb what the school provides. Some psychologists have postulated that only 10% of today's elementary school students are motivationally ready and able to learn (Howard Adelman and Linda Taylor, 1994). The remainder of children face deficiencies in prerequisite skills, disabilities, or motivation to learn. It is not surprising that the marginal product of the school inputs is low if the levels of human capital that the students bring to the process remain fixed.

Like OJT, IHT is complementary to formal schooling. Just as employees with more schooling are also more likely to obtain OJT (Jacob Mincer, 1997), there is evidence of a virtuous circle between IHT and schooling—with greater levels of IHT related to more schooling. Because the child's existing stocks of human capital are an input to the production of additional capital, early investments in the child's human capital enhance the value of later schooling. Katarina Nordblom (2003) argues that the complementarity between formal schooling and private, home investments in children may lead to the perverse result that increasing public schooling may widen

disparities in outcomes because those children with the greatest home investments can benefit most from additional formal schooling.

One might argue that the positive relationship between IHT and schooling is not causal, but results from the influence of omitted variables, such as family income, or genetically determined intelligence, that are common determinants of IHT and formal schooling levels. However, the interventions that employ random assignment indicate that at least part of the effect is causal. For example, when tested at age nineteen, children in the Perry Preschool Project intervention group not only scored higher on school achievement tests but they also exhibited better behavioral outcomes. Intervention participants were significantly more likely to have graduated from high school and significantly less likely to have been arrested or to have received welfare. The girls were half as likely to have been pregnant (John R. Berrueta-Clement et al, 1984).

Lynn A. Karoly et al. (1998), reviewing a number of developmental programs with young children, conclude that the interventions produced cognitive gains during or immediately following the intervention, but these gains were short-lived. However, the intensive, early interventions appear to have developed human capital that was complementary to formal schooling and related to longer run outcomes such as high school completion.

Because of the relationship between early investments and completed schooling, some of the gains to early investments are captured by the child in the form of returns to schooling. However, the benefits to society may be even greater than the individual returns. For example, an analysis of the Perry Preschool Project finds that half of the total discounted present value of the program's benefits accrue to the public sector. Not only are there reductions in schooling expenses, welfare, and criminal justice costs, but there are also increased tax revenues derived from higher levels of earnings and employment. These public benefits amount to twice the cost of the program. An additional 21% of total benefits is attributable to a reduction in losses by victims of crime (Karoly, 1998). Private returns to the child account for about 27% of total returns, for a benefit/cost ratio only slightly greater than one. These estimates suggest that early investments in children may yield significant positive externalities. Investments in human capital directly enhance the wellbeing of children, and they also make current school investments more productive by reducing grade retention and special education costs. Early investments also appear to reduce juvenile crime and teen pregnancy—some of the most intractable problems our society faces (Leibowitz, 1995).

#### 14.4. CONCLUSION

The idea that human capital can be developed in informal settings—outside of school—was originally articulated by Jacob Mincer in his case for on-the-job training. This paper has argued that there is a parallel set of investments that occurs before formal schooling begins. Infants provide a classic example of “learning by doing.” Like OJT, IHT not only occurs in informal settings, but it also requires costly

time inputs and is complementary with formal schooling. The fact that working mothers, particularly highly educated working mothers, dramatically reduce the time they devote to leisure and to other types of home production in order to preserve their time with children, illustrates and validates the home production framework.

In the past 40 years, mothers of preschool children have returned to the labor market in large numbers. What does this substantial transfer of time away from childcare and into market work portend for children? Although increasing hours in the labor market have led women to reduce their time inputs to most household tasks, mothers act to protect their time with children in human capital-producing activities, even at the expense of their own sleep and leisure.

Purchased substitutes for the mother's time, such as formal childcare, appear not to harm most children and may enrich the environment for some, particularly children from less privileged families. Additions to family income brought about by mothers' work increase the available market goods to both parents and children. Thus, there is little evidence to date that working mothers disadvantage their children. However, there is a need for more thorough investigation of how effects on children differ with the timing and intensity of maternal work. Emerging research suggests later cognitive and behavioral difficulties among children whose mothers returned to work full time during the child's first year of life. Thus, it is a concern that such a large percentage of mothers work before their child's first birthday, a time when children are building the foundation for their later human capital development.

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## APPENDIX A: COMPLETE LIST OF PUBLICATIONS BY JACOB MINCER

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**APPENDIX B: FROM THE PROGRAM OF THE ANNUAL MEETINGS  
OF THE SOCIETY OF LABOR ECONOMISTS (SOLE), 2004**

**PRIZES AND AWARDS**

**The Career Achievement Award for Lifetime Contributions  
to the Field of Labor Economics**

This award was established to acknowledge a lifetime of contributions to the field of labor economics. The inaugural awards will go to Jacob Mincer and Gary S. Becker. The award will henceforth be known as the **Mincer Award**.



Jacob Mincer is the Founding Father of modern empirical labor economics. His fundamental contributions to the field make him its outstanding pioneer.



Gary S. Becker's research extending the sphere of economic analysis to new areas of human behavior and relations earned him the Nobel Prize in 1992.

The Society of Labor Economists recognizes a lifetime contribution on the part of Mincer and Becker that changed the face of labor economics. The concepts of human capital and labor supply, as expanded by Jacob Mincer and Gary Becker, had enormous potential for elaboration. They and the extraordinary students who worked with them expanded on their ideas to create a major subfield of economics. The SOLE Nominating Committee is pleased to honor them with these inaugural awards.

The Nominating Committee: Larry Katz (chair), John Bound, Janet Currie, Hank Farber, Audrey Light, Steve Rivkin, Robert Willis, Finis Welch (ex-officio).

The Executive Board: Orley Ashenfelter, Francine D. Blau, Derek Neal, John Pencavel, Finis Welch.

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## BIOGRAPHICAL SKETCHES

**Gary S. Becker** received his BA degree from Princeton University, and has Masters and Ph.D. degrees in economics from the University of Chicago. He taught at Columbia University for twelve years before returning to the University of Chicago in 1968. He has honorary degrees from Harvard, Princeton, Columbia, and many other universities. He won the Nobel Memorial Prize for Economic Science in 1992, and the National Medal of Science in 2000. He is a University Professor of Economics and Sociology at the University of Chicago, and is Professor at the Graduate School of Business. He is also a Senior Fellow at the Hoover Institute. He is recognized for his expertise in human capital, economic incentives, economics of the family, economic analysis of crime, discrimination, and population. For almost 20 years he was a featured monthly columnist for *Business Week* magazine. He and Judge Richard Posner have recently started a blog at <http://www.becker-posner-blog.com/>, where they weekly discuss public policy issues. He has written over ten books and almost 100 professional articles. His books include *Human Capital*, *The Economics of Discrimination*, *The Economic Approach to Human Behavior*, *A Treatise on the Family*, *The Economics of Life* (with Guity Nashat Becker), *Social Economics* (with Kevin Murphy), and *Accounting for Tastes*. He is a member of the Economic Council that advises Governor Schwarzenegger of California, the Energy Advisory Board organized by Accenture, the Board of Faster Cures, dedicated to speeding up medical cures, the Board of the Manhattan Institute, and the Advisory Committee on Financial Innovation of the Chicago Mercantile Exchange. He was an adviser to Senator Robert Dole's presidential

campaign in 1996. He has lectured to many groups of academics, business executives, and government officials.

**Barry R. Chiswick** is a Distinguished Professor at the University of Illinois at Chicago, where he has been on the faculty since 1978 and Head of the Department of Economics since 1987. He is also Founding Director of the UIC Center for Economic Education. He was a student at Columbia University from 1962 to 1966. He was a Senior Staff Economist at the President's Council of Economic Advisers (1973-1977). Chiswick has had regular and visiting appointments at UCLA, CUNY, Columbia, Princeton, Stanford, Chicago, Haifa, Hebrew University (Jerusalem), and Tel Aviv Universities. While at Columbia, he co-authored an article with Jacob Mincer. He received a Fulbright Fellowship for Research and is Program Director for Migration Studies at IZA, Institute for the Study of Labor (Bonn). Chiswick has published 12 books and monographs, over 140 journal articles and book chapters, as well as magazine and newspaper articles on the economics of human capital, income distribution, hospital/nursing home utilization, immigration, language, racial and ethnic minorities, and religion. His most recent book is *The Economics of Immigration* (Edward Elgar, 2005). He has won numerous awards for his research, including the Distinguished Alumnus Award from Brooklyn College.

**Reuben Gronau** is Professor of Economics at the Hebrew University at Jerusalem (Israel). He studied with Jacob Mincer at Columbia University in the years 1963-1967, and received his Ph.D in 1967. He served as Visiting Professor at UCLA, Stanford University, MIT, The University of Chicago, Columbia University, Princeton, Northwestern, and The New School (Moscow). He has published several books and articles in the area of theoretical and empirical household behavior, labor market participation, transportation economics, and public utilities regulation. He is a Research Associate of the National Bureau of Economic Research, a Fellow of the Econometric Society (since 1987) and of the Society of Labor Economics (SOLE), and served as President of the Israeli Economic Association in 1999.

**Shoshana Grossbard** is Professor of Economics at San Diego State University and past Fellow at the Center for Advanced Study in the Behavioral Sciences at Stanford. She obtained her training in labor and household economics at the University of Chicago from 1972 to 1976 from Jacob Mincer as well as from Gary Becker, James Heckman, Edward Lazear, H. Gregg Lewis, and T.W. Schultz. She has had regular or visiting appointments at Columbia, Bar-Ilan, and Tel Aviv Universities, and at UCSD. She has authored or edited four other books, including *Marriage and the Economy* (Cambridge University Press, 2003), and published over 50 journal articles and book chapters. The major theme of her research is the economics of marriage, an outgrowth of the *New Home Economics*, of which Jacob Mincer is one of the pioneers. She is also founding editor of *Review of Economics of the Household*, published by Springer Verlag.

**Michael Grossman** is Distinguished Professor of Economics at The City University of New York Graduate School and University Center and Research Associate and Program Director of Health Economics Research at the National Bureau of Economic Research. He benefited greatly from his interactions with Jacob Mincer at Columbia University from 1964–1970 and received his PhD in 1970. He is the author of four books and close to 90 journal articles and book chapters. His research has focused on economic models of the determinants of adult, child, and infant health in the U.S.; economic approaches to cigarette smoking and alcohol use by teenagers and young adults; empirical applications of rational addiction theories; the demand for pediatric care; the production and cost of ambulatory medical care in community health centers; the determinants of interest rates on tax-exempt hospital bonds; and the economics of obesity. He is a co-editor of the *Review of Economics of the Household*, an associate editor of the *Journal of Health Economics*, a series co-editor of *Advances in Health Economics and Health Services Research* (published by Elsevier), and a member of the Institute of Medicine of the National Academy of Sciences.

**James Heckman** received his B.A. in mathematics from Colorado College in 1965 and his Ph.D. in economics from Princeton University in 1971. He is currently the Henry Schultz Distinguished Service Professor of Economics at the University of Chicago where he has served since 1973 and where he directs the Economics Research Center and the Center for Social Program Evaluation. He is also a Senior Research Fellow at the American Bar Foundation, and is affiliated with University College London and Peking University. Heckman's work has been devoted to the development of a scientific basis for economic policy evaluation, with special emphasis on models of individuals and disaggregated groups, and to the problems and possibilities created by heterogeneity, diversity, and unobserved counterfactual states. Heckman has published over 200 articles and several books. His most recent books include: *Inequality in America: What Role for Human Capital Policy?* (with Alan Krueger), *Evaluating Human Capital Policy*, and *Law and Employment: Lessons From Latin America and the Caribbean* (with C. Pages). Heckman has received numerous awards, including the John Bates Clark Award of the American Economic Association in 1983, the 2000 Nobel Memorial Prize in Economic Sciences (with Daniel McFadden), and the 2005 Jacob Mincer Award for Lifetime Achievement in Labor Economics. In 1970, Jacob Mincer hired Heckman at Columbia University. They visited the University of Chicago together from 1973–1974. Heckman's work in labor economics was inspired by Mincer, and he is especially pleased to be the recipient of the 2005 Mincer Award.

**Arleen Leibowitz** is Professor of Public Policy in the UCLA School of Public Affairs. Jacob Mincer chaired her dissertation committee when she obtained her Ph.D. in Economics at Columbia University in 1972. She was a Senior Economist at RAND, where her work centered on investments in human capital and in health. She has examined the role of maternal education in investments in children, educational outcomes for children, the demand for child care, the effect of education on women's



labor force participation, secular trends in women's labor supply, and the effect of maternity leave on new mothers' return to work. She has also worked extensively in health economics and policy, studying cost-sharing and children's health care use, birth rates, and expenditures for prescription and over-the-counter drugs. Dr. Leibowitz's current research examines how public policies, such as Medicaid, and private policies, such as managed care, affect the amount and quality of health care obtained by children and by persons living with HIV. She has served on the Committee on National Statistics and is a member of the editorial board of the *Journal of Policy Analysis and Management*.

**Thomas Lemieux** is a Professor of Economics and a Distinguished University Scholar at the University of British Columbia. He received his PhD from Princeton University and has held positions at MIT and the Université de Montréal prior to joining the faculty at UBC in 1999. Lemieux was a visiting professor at Princeton and Berkeley and a National Fellow at the Hoover Institution. He is a Research Associate at the National Bureau of Economic Research and the director of the Team for Advanced Research on Globalization, Education, and Technology at UBC. Lemieux has received awards for his research, including the Canadian Economic Association's Rae Prize, UBC's Killam Senior Research Prize, and the Minnesota Award. He is a co-editor of the B.E. Journal of Economic Analysis and Policy and an associate editor of several other scholarly journals. Lemieux has published 40 articles and two books on a variety of topics in labor economics and applied econometrics, including the underground economy, the impact of collective bargaining on wages and employment, the determination of wage differentials between ethnic groups and men and women, and the estimation of sectoral choice models. Most of his recent research has focused on the determinants of the structure of wages in industrialized economies and on the causes and consequences of secular changes in educational attainment.

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understanding worker well-being. This was stimulated by his dissertation research and subsequent interactions with Jacob Mincer. Second is the integration of economics and political science to explain political conflict and cooperation among nations. While not directly related to Mincer's work in labor economics, this research is strongly influenced by the analytical training he received while a student of Mincer's at Columbia.

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