Estimating the Human Capital and Screening Effects of Schooling on Productivity in U.S. Manufacturing Industries, 1979-1996*

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ABSTRACT

A classic issue in labor market studies is whether the correlation between an individual's education and her socioeconomic rewards reflects increased productivity (i.e., human capital), labor market screening or credentialism. All three explanations predict an association between education and socioeconomic status, but they differ in regard to the precise underlying causes of such a relationship. While previous research has usually avoids the challenge of empirically testing these three competing explanations, we provide some relevant findings using productivity data for U.S. manufacturing industries from 1976 to 1996. Our results indicate that, contrary to the credentialist hypothesis, mean years of schooling has a strong and robust net effect on industrial productivity. In contrast to the screening explanation, a measure of relative educational among the workers in an industry has no positive net effect on industrial productivity. Our findings most strongly support the human capital interpretation in that years of schooling has a large net effect on industrial productivity even after controlling for relative educational attainment.

INTRODUCTION

A well-known fact is that schooling is clearly associated with greater socioeconomic status, and this correlation has been noted across various units of analysis. More educated workers of course tend to have higher wages (Card 1998) and more rewarding occupations (Featherman and Hauser 1978). American metropolitan areas and states with more highly educated residents report higher average incomes (Chiswick 1974; Hale and Main 1977; Hirsch 1978). Industries with more educated workers have greater productivity (Galle et al. 1985) and earnings (Dickens and Katz 1987; Hirsch 1982), a fact which has led economists to argue that educational expansion significantly contributes to economic growth (Jorgenson 1984; Jorgenson and Fraumeni 1995a).[1] The prestige rankings of occupational titles are greater for workers with higher levels of schooling (Duncan 1961). Thus, the positive association between schooling and socioeconomic status is generally observed in different units of analysis.

Although this association between schooling and socioeconomic status is widely observed in a variety of contexts, considerable disagreement still exists when it comes to the precise causal nature of this association. In this paper, we seek to clarify some of the substantive differences among these theoretical disagreements. Specifically, we investigate the effects of different measures of schooling on productivity and provide systematic evidence to empirically draw distinctions between the three different perspectives. Given this objective, we organize the theoretical perspectives into three basic views: (1) the technical-functional view; (2) the market-signal view; and (3) the credentialist view. In the following, we summarize these three perspectives and derive testable hypotheses which seek to disentangle their substantive differences.

[1] The analysis of Walters and Rubinson (1983) suggests, however, that these effects may have been somewhat more disparate during the first part of the twentieth century.

THEORETICALBACKGROUND

The technical-functional view. According to the technical-functional view (Collins 1971), education directly augments economic productivity, not to mention the potential of workers; workers with more education are inclined to be more productive on account of their schooling experiences. This view recognizes that while there are also other sources of worker productivity, education is very important in providing workers with the crucial components of the training and skills required for competency in more complex jobs. As noted by Collins (1971, p. 1004) in his discussion of the assumptions of the technical-functional view, "…formal education provides the training, either in specific skills or in general capacities, necessary for more highly skilled jobs."

More specifically, based on this theory, education improves an individual's productivity in several ways. First, education increases a person's cognitive skills, such as in mathematics and writing. Second, education normally provides training in work skills by increasing one's familiarity and facility with the technology involved in production, such as that with machines, materials, computers or technical instruments. Third, education can increase an individual's productivity by conditioning important social skills, like the ability to communicate, to work with others and to be reliable and disciplined.

According to Collins (1971, p. 1004), the technical-functional view can be interpreted as being consistent with the general functional theory of social stratification as discussed by Davis and Moore (1945). In brief, this functional theory states that education provides substantial components of the greater skills and training that are required for the competent performance of more complex jobs. In order to motivate people to endure the various costs and bother of completing additional schooling and training, jobs that are more complex and more important (or at least their higher demand in the economy) seemingly offer greater socioeconomic rewards. Given this, higher rewards for more complex jobs have now become accepted as legitimate and necessary.

An economic version of the technical-functional view is the human capital theory (Becker 1975; Rubinson and Browne 1994), and the assumptions discussed above are generally applicable here, as well. The major additional theoretical elements in the human capital theory, as typically espoused by economists, are the general presumptions that labor markets are highly competitive in the same way that product markets are and that differences in workers' productivities (which reflect their varying amounts and stocks of human capital) are the driving forces underlying differences in wages (Sorensen and Kalleberg 1981). Common to both the sociological technical-functional view and the economists' human capital theory, however, is the fundamental idea that education directly augments the individual's productive capacities; education, in other words, enhances productive human capital.

One important implication of this concept is that a *prima facie* general solution to the problem of poverty and inequality exists, and that is that increases in the education of the poor and of the working-class will correspondingly bring about increases in their incomes (Aaron 1978, pp. 70-71; Bluestone 1977, p. 337; Schiller 1984, p. 117; Sorensen and Kalleberg 1981, p. 69). To state this in a more general way, and as discussed by Becker (1975, p. 86), a reduction in the inequality in the distribution of schooling will lessen the degree of inequality in the distribution of wages.

The Market-Signal View. According to the market-signal view, education certifies which people have greater ability and trainability but, in what may seem paradoxical, schooling does not significantly reinforce those traits in any direct way. The main value of education *per se* is to serve as a signal in a labor market where information about a person's abilities is highly imperfect. Education is typically correlated with a person's productivity and thus with his or her socioeconomic attainment, but as a rule, education *per se* does not directly enhance the economic productivity of a firm (Thurow 1975).

A major assumption in the market-signal view--which clearly differentiates it from the technical-functional view--is that most work skills are learned on the job and in the workplace rather than in school. That is, students do not learn very much in school that actually enhances their economic performance. Actual work skills are said to be too far removed from the activities that come with schooling. Instead, work skills are developed through job experience and the on-the-job training that is informally provided by senior workers (Sorensen and Kalleberg 1981; Thurow 1975). However, education is still valued by employers because it serves as a valid signal or certification of the extent to which an individual has discipline, trainability and a general capacity to learn.

As noted by Thurow (1975, p. 88), these are all important traits that employers value in workers because of the salient role of on-the-job training in the development of work skills. Thus, an individual's education is a market-signal that provides strong *prima facie* evidence to an employer that s/he can readily be trained to become a more productive worker (Spence 1981). Simply put, in accordance with the market-signal view, education is associated with productivity, but it does not directly cause it. The association arises because people with more education tend to have more of those traits that make a person economically productive--discipline, trainability and ability--but those traits are not significantly enhanced by education. Thus, the bivariate association between education and economic productivity is said to be spurious: their association stems from a common cause (i.e., the individual's discipline, trainability and other productive traits).[2]

[2] One strand of research in the human capital tradition which may implicitly recognize some role for the market-signal value of schooling is the economic research on "ability bias" in the estimation of the returns to schooling. Recent studies using sibling data, however, do not seem to yield estimates that are substantially less than those

The market-signal view, for the most part, also assumes that a worker's productive traits and capacities are often difficult to directly assess. This, therefore, reinforces the reliance upon education as a market-signal or certifying device. This may simply reflect the fact that information about workers' abilities, trainability and potential productivity are just too difficult to accurately ascertain, measure or observe. These problems of assessment or evaluation may especially be pronounced in firms where the production process is highly interdependent and is characterized by non-constant returns to scale, or when senior workers are crucial in providing training to junior workers (Thurow 1975).

Another typical presupposition of the market-signal view is that the labor market consists of a set of job slots that firms seek to fill with people who pose the least risk of necessitating higher training costs--that is, with people who will quickly learn to do the job well (Thurow 1975). One important implication of this assumption, in the context of the market-signal view, is that in determining the socioeconomic status of a job, a person's relative educational attainment is more important than his or her absolute educational attainment because relative educational attainment actually determines his or her place in the labor queue. In other words, although education is the primary screening device that employers value most in that it most accurately certifies who requires lower training costs, "it is a person's relative position in the distribution of education that counts" (Sorensen and Kalleberg 1981, p. 69).

In contrast to the technical-functional view, the market-signal view does not predict that the distribution of wages is much affected by changes in the distribution of education (Sorensen and Kalleberg 1981, p. 69). In regard to the problem of eliminating poverty wages in the distribution, Levin (1977, p. 168) observes that "in a way, we are describing a game of

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obtained using more conventional methods and data sets (Ashenfelter and Kreuger 1994; Ashenfelter and Zimmerman 1997).

musical chairs" because the fundamental problem of not having enough good-paying jobs is not substantially affected by the distribution of education from the market-signal viewpoint. This means that changing the distribution of education will likely change who gets the better jobs but the poverty rate for the economy will not be significantly reduced because "there are still fewer chairs than there are people" (Levin 1977, p. 168). In sum, the market-signal view of education is not optimistic vis-à-vis the notion that education can do a lot to reduce poverty or equalize the distribution of wages because the key assumption is that education is only a certifying device that does not directly contribute to economic productivity.

The Credentialist View. The credentialist view is related to the market-signal view in that both share the assumption that what students learn in school does not actually improve their economic performance in the workplace very much. While both approaches agree that education does not directly augment one's productivity (at least not significantly), the credentialist view differs from the market-signal view since it goes one step further by claiming that education is not even correlated with productive abilities or overall productivity (Collins 1979). According to the credentialist view, the reason for the association between education and socioeconomic attainment is not due to any relationship with economic productivity.

To the contrary, the association is said to derive from class conflict. This perspective is similar to discussions of cultural capital. As Farkas (1996) suggests, a key feature of the conflict synthesis is the theory of cultural capital, which builds with its own status culture controlling access to the rewards and privileges of group membership. In other words, cultural capital, along with economic, social and symbolic capital, serves as a power resource or a way for groups to either remain dominant or gain status. Also as stated by Burris (1983, p.465), "Employers rely on educational credentials in hiring and promoting not because of the technical skills these represent, but as a means of selecting people who are socialized into the dominant status culture."

In general, the credentialist view maintains that education serves to legitimize and reinforce inequality in the labor market both in terms of authoritative relations and the distribution of wages (Bowles and Gintis 1976). Jobs which pay higher wages to more educated workers do so not because those workers are actually more productive but because their higher education has established them as being a member of a morally superior status group that deserves to not only be in power but also enjoy greater rewards (Berg 1970; Bourdieu 1977; Collins 1971, 1979).

An additional reason for the association between education and socioeconomic attainment, according to the credentialist view, is that education serves the interests of dominant social classes as far as the intergenerational transmission of inequality goes. That is, education is a mechanism by which higher status groups can reinforce and pass on some of their higher status to their offspring. Owing to inequalities with regard to educational opportunities--needless to say, in favor of the wealthy and powerful--the dominant social classes are able to ensure that their children are much more likely to obtain a high level of educational attainment. The association between education and socioeconomic rewards, therefore, helps to promote the intergenerational perpetuation of inequality (Bowles and Gintis 1976).

SCHOOLING, PRODUCTIVITY AND UNITS OF ANALYSIS

The distinctions among the aforementioned three perspectives could certainly be discussed at greater length, but for the purposes here, we contend that the most critical substantive difference among them is that they differ with respect to the predictions they make about the relationship between schooling and productivity. To be more specific, according to the technical-functional view, an increase in schooling should directly result in greater productivity because education is deemed to represent human capital. On the other hand, the credentialist view predicts that an increase in schooling does not increase productivity because the educational system serves to perpetuate class inequality and exploitation; the observed association between education and socioeconomic status is simply symptomatic of the fundamental economic irrationality of capitalism. The intermediate position here is represented by the market-signal view which predicts that firms which hire workers with more schooling should indirectly increase productivity because such workers have lower training costs and are more disciplined (although, in contrast to the technical-functional view, these latter qualities do not derive from their schooling *per se*).

While one might argue that, for an analysis of productivity and schooling, the individual is the most desirable unit of analysis (Rubinson and Browne 1994, pp. 583-584), objectively-defined productivity statistics are not available for a broad representative sample of workers. In the modern economy, whole products are usually not produced separately by individuals. For this reason, only for a limited number of jobs, e.g., in some sales occupations and some blue-collar jobs, can output be directly measured in objective economic terms at the individual-level (Sorensen 1994, pp. 515-518). We argue, however, that an aggregate unit of analysis is appropriate for the investigation of our underlying theoretical questions.

Each of the three theoretical perspectives discussed above implies a corresponding aggregate-level relationship between productivity and schooling. From the standpoint of the technical-functional approach, workers who have more schooling should have developed more human capital. At the level of the firm, productivity is greater (*ceteris paribus*) if its workers have a higher average level of human capital. We believe that this aggregate relationship is indeed the motivating the use of the term “human capital.” In any event, the argument that an aggregate measure of human capital increases productivity measured at some aggregate unit is well formulated in the literature in the field of economics and represents some of the classic statements of human capital theory (Griliches 1970; Jorgenson and Fraumeni 1995a; Schultz 1961b).

From the point of view of the market-signal approach, the theoretical basis of an aggregate-level analysis is less well developed. We believe, however, that the essence of this perspective is the assumption that the primary role of schooling is to certify rather than directly augment the productivity of an individual. This assumption is fundamental because it clearly differentiates the market-signal approach from the technical-functional view. According to the market-signal approach, employers value workers who are more highly certified because in fact such workers do tend to be more productive and have lower training costs. However, because schooling does not directly augment productivity, the total years of schooling *per se* is not the most appropriate indicator of a person's level of certification. Rather, greater relative educational attainment is the relevant measure because, in contrast to the technical-functional view, schooling *per se* is irrelevant to economic productivity.

The value of the signal derives from a person's relative standing on the ladder of educational competitiveness because his or her relative standing reveals his or her productive potential. Because schooling is a signal or certification of an individual's productivity or trainability, the output of a firm should be greater (*ceteris paribus*) to the extent that its workers have higher relative educational attainment (i.e., are more highly certified or are providing a stronger signal) than do those of other firms. Thus, at the level of the firm, the market-signal view does imply that a more highly educated workforce contributes to increased productivity, but in contrast to the human capital approach, the appropriate measure for the market-signal view is a higher level of relative educational attainment rather than the mean number of years of schooling *per se* (although the latter measure is often used in human capital studies of economic productivity).

As for the credentialist view, the concept of a credential (at least as used in this literature) is that it helps sustain class inequality rather than economic efficiency or productivity. In other words, the fundamental assumption here is that schooling does not specifically relate to economic productivity. Schooling is hypothesized to be uncorrelated with productivity. The implication of this line of reasoning with respect to the level of a firm is that the economic output of firms with more highly educated workers is not necessarily greater than that of firms with less educated workers (*ceteris paribus*). Because an individual worker is no more productive for having gone to school longer, it seems reasonable to infer that firms are no more productive (*ceteris paribus*) for having hired a more educated workforce. They may be more accepting of the social and economic inequality of the firm, but they are not regarded as being more economically productive. In sum, these three theoretical perspectives give rise to different predictions regarding the relationship between firm-level productivity and the schooling characteristics of the workforce.

HYPOTHESES ABOUT SCHOOLING AND PRODUCTIVITY

There are no publicly available data sets that contain data on the productivity of particular firms along with information on the schooling of their workforce. In lieu of firm-level data, we therefore use data on industries which represent groups of firms that produce similar products.

Our data consist of two-digit manufacturing industries for which there is an established tradition of economic statistics and data collection on productivity. We use an objectively-defined measure of productivity, namely the dollar value of the output produced per employee-hour in the two-digit manufacturing industries. In order to provide a more methodologically conservative test of our theoretical concerns, we restrict our study to manufacturing industries because productivity data are more likely to be valid and reliable for the manufacturing sector than for others, such as services where the output is sometimes less directly measured or quantifiable. Restricting the analysis of productivity to one sector also reduces the number of complications that might arise from the high degree of technological heterogeneity across sectors. In our analysis, we estimate the net effects of measures of educational attainment on labor productivity using the two-digit manufacturing industry as the unit of analysis. To do so, our model is developed from the Cobb-Douglas production function which, in various formulations, is well known and widely used in economics (and is also used by Walters and Rubinson 1983).

where $\boldsymbol{A}$ is a constant reflecting the scaling of the measures; $\boldsymbol{Q}$ is the quantity produced during the given time period in which $\boldsymbol{K}$ units of capital are used and $\boldsymbol{L}$ units of labor are employed; educational attainment, as discussed earlier. At the level of the individual worker, let $\boldsymbol{s}$ refer to his or her years of schooling and $\boldsymbol{r}$ to the percentile ranking associated with that number of years of schooling (where the percentiles are based on the distribution of years of schooling for all workers in the labor force). At the level of the industry, let $\boldsymbol{S}$ refer to the mean years of schooling completed by workers in a particular industry and $\boldsymbol{R}$ to the mean of the percentiles associated with the years of schooling completed by the workers employed in a particular industry. Thus, industries with a larger value of $\boldsymbol{S}$ are those in which the workers have, on average, spent more time in school, while industries with a larger value of $\boldsymbol{R}$ are those in which the workers have, on average, achieved a relatively higher level of educational attainment. While $\boldsymbol{s}$ and $\boldsymbol{r}$ can be expected to be highly correlated, there is nonetheless a crucial difference between $\boldsymbol{S}$ and $\boldsymbol{R}$. Across the labor force as a whole, the mean of $\boldsymbol{S}$ increases over time as the Taiwanese education system expands and the average levels of educational attainment increase. By contrast, the mean of $\boldsymbol{R}$ across the labor force as a whole cannot increase because, by construction, the mean for a distribution of percentiles is always approximately 50%. This latter feature is consistent with the fundamental assumption of the market-signal view which is that education serves to certify which people have greater ability and trainability and that schooling *per se* does not directly augment those traits significantly in ways that are pertinent to economic productivity.

S and ***R*** may be both included to Equation (1) to derive a model that can be estimated to test the relative predictive power of these theories of the role of education in the labor market. Once Equation (2) is estimated with actual data, the two empirical results that would most strongly support the technical-functional (i.e., human capital) view of education would be: (1) reject ; and (2) fail to reject . This set of results would underscore the importance of the absolute amount of education obtained by workers in influencing productivity and would, consequently, be consistent with the interpretation of education as representing stocks of human capital. Such results would also be contrary to the expectation of the market signal view which places a great deal of emphasis on relative educational attainment as an indicator of one's potential productivity.

Empirical results that would support the market signal view would be: (1) fail to reject ; and (2) reject . This set of results would indicate that the mean number of years of schooling *per se* has no net effect on productivity---that schooling does not really constitute productive human capital. However, education would still be important in explaining inter-industry variations in productivity because the finding that implies that productivity is greater in those industries which employ workers who have a relatively higher educational attainment. In other words, the empirical results that would support the market signal view are exactly opposite those that would support the technical-functional view. Nonetheless, the human capital and market signal views are not necessarily mutually exclusive. It might be argued that if the empirical results rejected both and , then both theories are supported, to some degree.

The credentialism view can also be evaluated on the basis of the empirical results obtained from the estimations from Equation (2). Specifically, the credentialism view would be supported if the results indicated that we should fail to reject both and simultaneously. This result would support the credentialism view which assumes that productivity is uncorrelated with education in terms of either years completed or percentile rank. In this case, education is neither productive human capital nor an accurate market signal about a worker's productive capacities; educational attainment is simply irrelevant to economic productivity.

Empirical Results

DISCUSSION AND CONCLUSIONS

Our primary research concern has been to empirically evaluate the relationship between educational attainment and labor productivity since the nature of this relationship has important implications for understanding how economic inequality is generated in the labor market. Previous literature on this topic may be organized into three major theories of the role of education in the labor market: (1) the technical-functional view; (2) the market-signal view; and (3) the credentialism view. Each of these theories has different implications as to how indicators of educational attainment affect labor productivity. As we have mentioned, these perspectives are not necessarily mutually exclusive in real labor markets. The employment system, for example, may provide advantages to those with more education both because their education has raised their productive capacities (human capital) and they have latent traits, such as the capacity to learn new things easily, that are signaled by more years of educational attainment (screening). We interpret this result as providing strong *prima facie* evidence for the technical-functional view. Contrary to the credentialist claim that education has no economic value, labor productivity in manufacturing industries is clearly and directly increased when workers have more years of schooling. Furthermore, this increase is still obvious and substantial even after controlling for any indicator of the extent of relative educational attainment completed by workers. That is, increased schooling *per se* increases labor productivity independently of the extent to which the educational levels of some workers may be ranked more highly than those of other workers. Thus, this finding is inconsistent with the market-signal view which emphasizes the importance of relative educational attainment due to the assumption that schooling does not directly augment human capital but rather only certifies those who possess greater abilities.[13] In other words, of the three major theories that we have discussed, our results most strongly support the technical-functional view since the mean number of years of schooling is consistently the most important education variable in the regression analyses.

Strong and simplistic versions of the market-signal view--according to which only relative educational attainment matters and schooling does not directly augment labor productivity--most probably need to be reconsidered. Further theoretical developments may require a model which incorporates aspects of both the technical-functional view as well as the market-signal view. This contention may be consistent with the view of Bidwell and Friedkin (1988, p. 454) who state that “What is learned and what is certified as having been learned on average are strongly related, making it very difficult to determine the degree to which labor markets are responsive to workers’ capabilities or credentials. It may be more judicious to regard learning and gaining credentials as tightly linked mechanisms through which schooling affects employability.” The need for this sort of model has also been argued for by Weiss (1995, p. 134) who states that “Sorting models [i.e., the market-signal view] of education can best be viewed as extensions of human capital models.” We believe that future theoretical work on this topic should more fully incorporate the interrelations among educational attainment, employer and firm practices regarding hiring and remuneration and market conditions related to the degree and nature of competitive pressure.

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Table 1. Descriptive Statistics

year		Prodctvty*	Invest*	Equipment*	Schooling	Rel.Sch.	%female	%white	%black	%hisp	%other	%metro
Total	Mean	78.9046	5.8791	48.5686	12.4806	0.47042	0.31359	0.80862	0.09654	0.06667	0.02815	0.68638
	s.d.	68.9931	7.7240	55.1141	0.8818	0.09326	0.16196	0.08210	0.05389	0.04956	0.02688	0.16630
	Min	15.0731	0.3270	3.2284	10.2500	0.24831	.00000+	0.25000	.00000+	.00000+	.00000+	0.08387
	Max	826.1949	83.3281	597.9926	15.7500	0.78178	1.00000	1.00000	0.36263	0.71428	0.25000	1.00000
1979	Mean	42.7434	3.5895	34.0388	11.9743	0.47919	0.29664	0.83016	0.09413	0.05652	0.01917	0.67369
	s.d.	29.2024	4.0221	35.8335	0.8428	0.09166	0.17055	0.06545	0.04529	0.04354	0.02553	0.16408
	Min	15.0731	0.3270	3.2284	10.4935	0.30746	0.03225	0.60000	.00000+	.00000+	.00000+	0.14942
	Max	229.3444	28.1748	215.8637	14.6000	0.71600	0.84066	0.93370	0.23529	0.23529	0.20000	1.00000
1985	Mean	62.9599	5.1864	45.4422	12.3557	0.46644	0.30960	0.80760	0.10379	0.06443	0.02416	0.68534
	s.d.	36.2341	5.0775	49.7356	0.8027	0.09101	0.15940	0.07390	0.05122	0.04717	0.02437	0.16744
	Min	24.9775	0.5131	4.1873	11.0198	0.31089	0.03731	0.54545	0.02380	.00000+	.00000+	0.14159
	Max	241.7399	35.2513	330.6118	14.4753	0.69623	0.81178	0.92929	0.27272	0.23595	0.13636	0.95319
1990	Mean	90.1423	6.5898	50.7067	12.6130	0.46868	0.32370	0.78892	0.10033	0.07671	0.03402	0.70405
	s.d.	75.6497	8.3002	52.9332	0.9265	0.10119	0.16132	0.10181	0.05704	0.05153	0.03850	0.16186
	Min	28.6554	0.5819	4.2455	11.1848	0.30779	0.05882	0.25000	0.03125	.00000+	.00000+	0.15686
	Max	551.6187	53.1112	349.6676	15.7500	0.78178	0.81178	0.91735	0.25000	0.27777	0.25000	1.00000
1996	Mean	120.6038	8.8558	62.9243	12.9670	0.47484	0.32632	0.78878	0.08900	0.08781	0.03439	0.73680
	s.d.	108.6562	10.6991	81.1446	0.8346	0.09554	0.14946	0.08989	0.04888	0.05770	0.02797	0.16114
	Min	37.4215	0.7783	5.2645	11.2222	0.26401	0.09740	0.48651	.00000+	.00000+	.00000+	0.10389
	Max	826.1949	77.3363	597.9926	15.0483	0.71267	0.75245	0.93375	0.21750	0.24387	0.14285	0.96306

Table 2. OLS Regression Estimates of Education on Industrial Productivity

	OLS Model 1	OLS Model 2	OLS Model 3	OLS Model 4	OLS Model 5	OLS Model 6
Schooling		5.84629 ***	10.17405 ***		3.08543 ***	7.51568 ***
		(0.16674)	(0.42197)		(0.14262)	(0.29860)
Rel.Sch.	1.68103 ***		(1.65435) ***	0.61792 ***		(1.63554) ***
	(0.06812)		(0.14938)	(0.05278)		(0.09934)
Investment				0.50016 ***	0.35394 ***	0.28073 ***
				(0.02668)	(0.02537)	(0.02345)
Equipment				0.00980	0.09046 ***	0.15705 ***
				(0.02471)	(0.02270)	(0.02099)
Constant	5.46892 ***	(10.57407) ***	(22.76798) ***	3.91577 ***	(4.42242) ***	(16.99222) ***
	(0.05455)	(0.42054)	(1.17199)	(0.07136)	(0.36631)	(0.83271)
R^2	0.32527	0.49344	0.53804	0.70484	0.76144	0.80360
N	1262	1262	1262	1262	1262	1262

Notes: * p<0.05, ** p<0.01, *** p<0.001 (2-tail)
Numbers within parenthesis are standard errors.

Table 3. OLS Regression Estimates of Education on Industrial Productivity

	OLS Model 7	OLS Model 8	OLS Model 9
Schooling	3.06288 ***		7.77008 ***
	(0.19814)		(0.31424)
Rel.Sch.		0.23481 ***	(1.80285) ***
		(0.06820)	(0.09959)
Investment	0.33417 ***	0.45346 ***	0.28445 ***
	(0.02549)	(0.02661)	(0.02286)
Equipment	0.13002 ***	0.08817 ***	0.17030 ***
	(0.02340)	(0.02524)	(0.02096)
Experience	0.03632	-0.77009 ***	0.31342 **
	(0.12287)	(0.12371)	(0.11049)
%Female	0.08208 ***	0.07523 ***	0.05852 ***
	(0.01104)	(0.01207)	(0.00992)
%Black	0.00469	0.00044	0.00788 *
	(0.00380)	(0.00412)	(0.00339)
%Hispanic	0.00075	-0.00204	-0.00341
	(0.00292)	(0.00319)	(0.00261)
%OtherRace	-0.00899 ***	-0.00728 ***	-0.00887 ***
	(0.00158)	(0.00172)	(0.00141)
%Metro	0.03493	0.24679 ***	0.16377 ***
	(0.03200)	(0.03559)	(0.02937)
Constant	-4.50003 ***	5.98060 ***	-18.68795 ***
	(0.76979)	(0.36362)	(1.04125)
R^2	0.77703	0.73696	0.82317
N	1262	1262	1262

Notes: * p<0.05, ** p<0.01, *** p<0.001 (2-tail)
Numbers within parenthesis are standard errors

Table 4. Fixed Effects Model Estimates of Education on Industrial Productivity

	FE Model 1	FE Model 2	FE Model 3	FE Model 4	FE Model 5	FE Model 6
Schooling	7.87816 ***		11.20888 ***	3.89358 ***		8.35001 ***
	(0.18316)		(0.14072)	(0.18429)		(0.21359)
Rel.Sch.		0.21301	-3.09198 ***		0.08069	-2.30631 ***
		(0.15308)	(0.07362)		(0.08312)	(0.08215)
Investment				0.37163 ***	0.52403 ***	0.15915 ***
				(0.01787)	(0.01926)	(0.01579)
Equipment				0.39411 ***	0.59485 ***	0.23690 ***
				(0.02382)	(0.02570)	(0.01930
Constant	-15.6967 ***	4.33041 ***	-26.49189 ***	-7.55027 ***	1.41241 ***	-19.7274 ***
	(0.46179)	(0.11906)	(0.38983)	(0.42615)	(0.10630)	(0.54530)
σ_u	0.401819	0.469055	0.4390315	0.388007	0.553757	0.258874
σ_e	0.200358	0.320066	0.1271594	0.147352	0.172783	0.114261
R^2	0.585083	-0.058831	0.8328743	0.775583	0.691433	0.86506
Bic	-537.219	645.0764	-1678.717	-1300.65	-898.791	-1936.53
N	1262	1262	1262	1262	1262	1262

Notes: * p<0.05, ** p<0.01, *** p<0.001 (2-tail)
Numbers within parenthesis are standard errors.

Table 5. Fixed Effects Model Estimates of Education on Industrial Productivity

	FE Model 7	FE Model 8	FE Model 9
Schooling	3.99158 ***		9.08668 ***
	(0.20082)		(0.23008)
Rel.Sch.		0.00443	-2.45324 ***
		(0.08372)	(0.08303)
Investment	0.36855 ***	0.49271 ***	0.14498 ***
	(0.01783)	(0.01942)	(0.01550)
Equipment	0.38581 ***	0.57968 ***	0.20473 ***
	(0.02395)	(0.02537)	(0.01917)
Experience	0.11990	-0.46558 ***	0.52344 ***
	(0.08060)	(0.08745)	(0.06264)
%Female	0.02490 **	0.01412	0.01125
	(0.00756)	(0.00877)	(0.00576)
%Black	-0.00107	-0.00219	0.00028
	(0.00232)	(0.00268)	(0.00176)
%Hispanic	0.00457 **	0.00288	0.00175
	(0.00167)	(0.00194)	(0.00127)
%OtherRace	-0.00012	0.00092	0.00004
	(0.00108)	(0.00125)	(0.00082)
%Metro	0.02546	0.12709 **	0.07247 *
	(0.04035)	(0.04663)	(0.03064)
Constant	-8.08354 ***	2.99009 ***	-23.15330 ***
	(0.60931)	(0.28702)	(0.68825)
σ_u	0.375945	0.512891	0.2619487
σ_e	0.146463	0.169196	0.1110848
R^2	0.778281	0.704114	0.8724573
Bic	-1279.47	-915.3012	-1971.233
N	1262	1262	1262

Notes: * p<0.05, ** p<0.01, *** p<0.001 (2-tail)
Numbers within parenthesis are standard errors.

Table 6. Fixed Effects Model Estimates of Education with Interaction Terms on Industrial Productivity

	FE with Interaction 1	FE with Interaction 2	FE with Interaction 3
Schooling	1.67367 **		8.76232 ***
	(0.60507)		(0.88356)
Rel.Sch.		-0.35070	-2.46974 ***
		(0.27512)	(0.32728)
Investment	1.55762 **	0.27006 ***	-3.12317 **
	(0.49788)	(0.07036)	(1.09206)
Equipment	-1.81323 **	0.74127 ***	1.03481
	(0.56710)	(0.07051)	(1.02158)
Sch * Invest	-0.46978 *		1.18604 **
	(0.19689)		(0.38961)
Sch * Equip	0.85937 ***		-0.30421
	(0.22223)		(0.36917)
RS * Invest		-0.28876 **	-0.34951 *
		(0.08763)	(0.15041)
RS * Equip		0.21529 *	0.11578
		(0.09695)	(0.13223)
Experience	0.13060	-0.42153 ***	0.46738 ***
	(0.08105)	(0.08815)	(0.06264)
%Female	0.02407 **	0.01467	0.00767
	(0.00753)	(0.00874)	(0.00571)
%Black	-0.00150	-0.00217	-0.00015
	(0.00231)	(0.00268)	(0.00174)
%Hispanic	0.00475 **	0.00360	0.00137
	(0.00167)	(0.00194)	(0.00126)
%OtherRace	-0.00009	0.00080	-0.00002
	(0.00108)	(0.00125)	(0.00081)
%Metro	0.02576	0.11497 *	0.06683 *
	(0.04013)	(0.04678)	(0.03054)
Constant	-2.17303	2.60073 ***	-22.08935 ***
	(1.57389)	(0.34530)	(2.45616)
sigma_u	0.353709	0.510428	0.2727478
sigma_e	0.145565	0.168564	0.1094006
r2_a	0.780991	0.70632	0.8762955
bic	-1282.85	-912.6047	-1985.517
N	1262	1262	1262

Notes: * p<0.05, ** p<0.01, *** p<0.001 (2-tail)
Numbers within parenthesis are standard errors