Physical Capital, Human Capital and the Distribution of Earnings

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Abstract — The relationship between physical capital, human capital and the distribution of earnings is examined empirically using cross-sectional microdata within SMSAs. Comparative advantage in workers and a scale-of-resources effect among firms is predicted to lead to a relationship between capital and earnings. The level of earnings is found to be positively related to capital intensity and negatively related to capital dispersion. Earnings inequality appears to be greater the larger the dispersion in capital. The results support the view that industry structure and the distribution of physical capital have direct effects on the structure and distribution of earnings, after controlling for differences in human capital.

INTRODUCTION

While the relationship between human capital and earnings has been studied extensively, the relationship between physical capital and the distribution of earnings has received relatively little theoretical or empirical attention. A well-known article by Griliches (1969) proposed the capital-skill complementarity (CSC) hypothesis, which implies that the elasticity of substitution between capital and high-skill labor is less than between capital and low-skill labor. A number of recent empirical studies estimating cost (or production) functions have lent support to the hypothesis of capital-skill complementarity. Brogan and Erickson (1975), examining the monopoly-wage hypothesis, provided some direct evidence that greater capital intensity rather than concentration per se leads to higher earnings, and suggested that capital-skill complementarity provided the explanation for their results. Despite this work, the large empirical literature utilizing micro- or aggregate human capital earnings functions generally has ignored the effects of capital on the earnings distribution.

Recent work by Sattinger has provided some theoretical analysis and empirical evidence regarding the relationship between the distribution of earnings, capital intensity and comparative advantage. Sattinger has demonstrated that more productive workers will tend to work at more capital-intensive jobs and that the distribution of earnings will be more unequal the more unequally capital is distributed among workers, with everything else the same. This results, Sattinger proposes, because of comparative advantage and a scale-of-resources effect in the job-assignment process. In addition, he has examined the conditions under which earnings inequality increases with the level of capital intensity in a labor market.

The purpose of this article is to test further some hypotheses associated with Sattinger’s work. In particular, it examines the relationship of a labor market’s earnings level and earnings dispersion with its dispersion in capital among workers and its mean capital-to-labor ratio. Detailed microdata within 48 U.S. metropolitan areas are utilized, thus allowing differences to be accounted for across labor markets in human capital and in earnings-function parameters. As recently argued by Hanushek (1981), significant differences across labor markets in earn-

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ings structure (parameters) makes the use of micro-data within labor markets particularly advantageous.\(^5\)

The empirical results generally support Sattinger's hypothesis of a positive relationship between the dispersion in capital and the dispersion in earnings. In addition, earnings levels are found to be positively related to capital intensity and negatively related to capital dispersion. Because of the quality of the capital stock data and some inherent methodological problems, the results in this article are regarded as suggestive rather than conclusive.

**THE ASSIGNMENT PROCESS**

Sattinger is most interested in the relationship between capital and the distribution of earnings. Utilizing a demand-supply framework, he focuses on the assignment problem whereby an equilibrium matching of workers and machines is determined. The predicted positive relationship between the dispersion in capital among workers and the dispersion in earnings results from comparative advantage in individuals and from a scale-of-resources effect among employers. Sattinger (1980, Ch. 5) shows that if a comparative advantage exists such that more productive (more highly schooled) workers have a comparative advantage in more difficult jobs, they will be found working at these jobs. In addition, a scale-of-resources effect exists such that employers maximize profits by matching more productive workers with greater resources or cooperating factors. It then follows that the greater the resources with which more productive labor is combined the greater will be the value of productivity differences among individuals. The scale-of-resources effect exists even in the absence of comparative advantage; that is, where workers differ in absolute but not relative productivities among jobs. It should be noted that the scale-of-resources effect is similar to, but distinct from, capital–skill complimentarity. CSC concerns the reaction of firms with fixed production functions to differences in factor prices, while the scale-of-resources effect concerns how firms with different production functions behave in response to similar factor prices.\(^6\)

If comparative advantage exists along with the scale-of-resources effect, a sufficient but not necessary condition for the matching of more productive workers with relatively larger amounts of capital is that these workers possess a relative advantage in more capital-intensive jobs. If skilled individuals have a comparative advantage at less capital-intensive jobs, the matching of high-skill workers may be with either more or less capital, whichever assignment maximizes the net value of output. If, as seems likely, more able workers are found generally at jobs with greater capital, it is clear that the inequality in earnings in a labor market will be greater the more dispersed is the distribution of capital among jobs, even after accounting for differences in workers' human capital. While personal characteristics (human capital) may account for all (most) earnings differences within a single labor market, its earnings structure is determined by both demand and supply.

The assignment process implied by comparative advantage and the scale-of-resources effect can be illustrated by some simple numerical examples. Assume that we have two workers and two jobs, where worker 1 is more productive than worker 2 and where the jobs are characterized by the machine size that complements these workers. We know that workers (machines) will be assigned so as to maximize the value of output or earnings. Suppose that the matrix of output values over a time period is as follows:

<table>
<thead>
<tr>
<th>Machine</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker 1</td>
<td>$10</td>
<td>$6</td>
</tr>
<tr>
<td>Worker 2</td>
<td>$5</td>
<td>$3</td>
</tr>
</tbody>
</table>

In the case where there exists no comparative advantage (\(10/5 = 0/3\)) and machines of different sizes, worker 1 will be matched with machine 1 in order to maximize output ($13 > $11).\(^7\) This illustrates the scale-of-resources effect in the absence of comparative advantage. It follows that a sufficient condition for the assignment of the more productive worker to the larger machine is the comparative advantage of worker 1 on machine 1 (assuming the existence of an equilibrium rental price, \(r\)). For instance, the following set of values should result in the matching of worker 1 and machine 1 (since $15 > $11):

<table>
<thead>
<tr>
<th>Machine</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker 1</td>
<td>$12</td>
<td>$5</td>
</tr>
<tr>
<td>Worker 2</td>
<td>$6</td>
<td>$3</td>
</tr>
</tbody>
</table>
In the case where the more productive worker has a comparative advantage with the smaller machine, the assignment is indeterminate. Suppose the following matrix:

<table>
<thead>
<tr>
<th>Machine</th>
<th>Worker</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$9</td>
<td>$5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$6</td>
<td>$3</td>
<td></td>
</tr>
</tbody>
</table>

Despite comparative advantage of worker 1 at machine 2 (9 < 3), he will be matched with machine 1 (since $12 > $11). On the other hand, if the matrix of output is as follows:

<table>
<thead>
<tr>
<th>Machine</th>
<th>Worker</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$7</td>
<td>$5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>$6</td>
<td>$3</td>
<td></td>
</tr>
</tbody>
</table>

worker 1 will be assigned to the smaller machine (since $10 < $11).

The point of the foregoing discussion is that if, as seems probable, more able or highly schooled workers have a comparative advantage at more capital-intensive jobs, then that is a sufficient (but not necessary) condition for them to be assigned to those jobs. It follows that earnings will be more unequally distributed the more unequally capital is distributed among workers. For instance, in each of the examples above where worker 1 is matched with machine 1, the ratio of outputs (and thus earnings) of the workers is greater than if both were matched with identical machines. We should observe, then, a positive relationship between the inequality in earnings and the inequality in capital among workers, even after accounting for difference in human capital.

The relationship between a labor market's level of capital intensity and its dispersion in earnings is indeterminate a priori. Sattinger (1980, Ch. 4) utilizes an aggregate production-function framework and derives an ‘inequality multiplier’ which is determined by output elasticities with respect to changes in inputs of capital and productive abilities. Within this framework, the effect of capital on earnings dispersion is dependent on the value of these elasticities and the functional form of the production function. It is unclear whether capital intensity directly affects earnings inequality independent of its relationship with the dispersion in capital among workers (jobs). Thus the existence of an independent effect of capital intensity on earnings inequality is an empirical question.

Sattinger does not explicitly examine the relationship between a labor market's level of earnings and the distribution of capital. However, given grades of labor will obviously be more productive the greater the amount of capital they complement (and vice versa). Thus we should observe a positive relationship between capital dispersion and the level of earnings in an area, assuming that labor-supply elasticities are not infinite. The relationship between capital dispersion and the earnings level is shown below to be a priori indeterminate, depending on the covariance between capital intensity and its ‘return’ among individuals within a labor market.

### SPECIFICATION

In order to examine empirically the relationship between the distribution of capital and the distribution of earnings, cross-sectional microdata from 48 Standard Metropolitan Statistical Areas (SMSAs) are utilized. A human capital earnings function developed by Chiswick and Mincer (1972) and Chiswick (1974) is used as our starting point. Treating capital per worker, $K/L$, as a productivity-augmenting attribute, the human capital model is modified to

$$\ln Y_i = a + r_S S_i + r_t t_i + r'' t_i^2 + \gamma (\ln WW_i) + \beta_i (K/L)_i + u_i,$$

where $Y_i = \text{annual earnings of individual } i$, $S_i = \text{years of schooling of individual } i$, $r_S = \text{average rate of return to schooling to individual } i$, $t_i = \text{years of experience of individual } i$, proxied by age $i - S_i - 5$, $r'_t$ and $r''_t = \text{parameters mapping the log earnings - experience profile}$, $WW_i = \text{weeks worked by individual } i$, $\gamma = \text{elasticity of annual earnings with respect to weeks worked, assumed constant across individuals}$, $K/L_i = \text{capital-to-labor ratio for worker } i$ (its measurement is discussed below), $\beta_i = \text{percentage increase in earnings associated with additional capital for worker } i$, and $u_i = \text{random error term with zero mean and constant variance}$. In order to estimate an earnings level equation the mean value of the earnings function is taken, assuming...
that \( r, r', r'' \) and \( \beta \) are random variables which need not be constant across individuals.\(^{10}\)

\[
\ln Y_k = a_0 + a_1 S_k + a_2 \sigma(S)_k + a_3 \tilde{S}_k + a_4 \tilde{S}^2_k + a_5 \sigma(t)_k + a_6 (\ln WW)_k + a_7 (K/L)_k + U_k.
\]

The level of earnings in SMSA\(_k\), measured by the mean of the log of earnings (log of the geometric mean), is thus estimated as a function of the means of schooling, experience, experience squared, log of weeks worked and capital per worker, and of the standard deviations of schooling, experience and capital per worker. The signs on \( \sigma(S) \), \( \sigma(t) \) and \( \sigma(K/L) \) will be determined by the covariance between \( r \) and \( S \), between the average slope of the earnings profile and \( t \), and between \( \beta \) and \( K/L \) respectively. Thus we predict \( a_1, a_2, a_6, a_7 > 0 \), \( a_3 < 0 \), while the signs of \( a_2, a_5 \) and \( a_8 \) are indeterminate.

While the direction of the effect of capital dispersion on the level of earnings is an empirical question, a negative relationship seems likely. Greater capital dispersion, holding constant capital intensity, will be associated with a lower earnings level if \( \beta \) is lower for individuals working with greater amounts of capital. Inter-SMSA mobility, by increasing a labor market's labor-supply elasticity, will lessen the wage returns from capital intensity. Because most migration (and some training) costs do not increase proportionately with wage levels, one observes greater mobility among those who are higher skilled and matched with more capital. Thus \( \text{Cov}(\beta, K/L) \) will be negative, implying \( a_3 < 0 \).

The simple human capital model of earnings inequality begins by taking the variance of both sides of the semi-log earnings function.\(^{11}\) Earnings inequality, as measured by the variance of the log of earnings, is then a function of the levels, variances and covariances of schooling, experience and weeks worked, each weighted by the appropriate earnings-function parameter. In this article variables measuring the dispersion in capital among jobs and the level of capital intensity are added to a modified version of the human capital model. The following regression model is estimated (where \( k \) represents SMSA).

\[
\sigma^2(\ln Y)_k = a_0 + a_1 S_k + a_2 \hat{\sigma}^2(S)_k + a_3 \tilde{S}_k + a_4 \tilde{S}^2_k + a_5 \sigma^2(t)_k + a_6 \text{Cov}(S,t)_k + a_7 \hat{\sigma}^2(\ln WW)_k + a_8 \hat{\sigma}^2(K/L)_k + U_k.
\]

The human capital model predicts that earnings inequality will be positively related to the level of schooling; the dispersion in schooling, experience and weeks worked; and to the covariance between schooling and experience, all being weighted by appropriate earnings function parameters (see Hirsch, 1978a). As discussed earlier, Sattinger's work regarding comparative advantage and the scale-of-resources effect implies that earnings inequality will be greater the larger the dispersion in capital among workers. The relationship with mean capital intensity is indeterminate.

Tinbergen (1975, p. 39), Sattinger and others have argued that earnings function parameters (e.g. rates of return) should not be used to weight the human capital variables. If the earnings function is viewed as a reduced-form 'price' equation relating earnings to supply-and-demand variables, then no prices (rates of return) should be used as explanatory variables.\(^{12}\) Thus, in addition to estimating the foregoing equation, which accounts for inter-SMSA differences in earnings structure, the following model not accounting for parameter differences is also estimated:

\[
\sigma^2(\ln Y)_k = a_0 + a_1 S_k + a_2 \hat{\sigma}^2(S)_k + a_3 \tilde{S}_k + a_4 \tilde{S}^2_k + a_5 \sigma^2(t)_k + a_6 \text{Cov}(S,t)_k + a_7 \hat{\sigma}^2(\ln WW)_k + a_8 \hat{\sigma}^2(K/L)_k + U_k.
\]

**EMPIRICAL ANALYSIS**

All variables in the study, except the capital variables \( K/L \) and \( \sigma^2(K/L) \), are derived from data in the \( \dagger \) file of the 1970 U.S. Census Public Use Sample. Individual data on 62,411 white, nonfarm, nonstudent males between the ages of 16 and 64 yr, with earnings in 1969, residing in 48 medium-to-large-size SMSAs, are used. Sample size within each of the 48 SMSAs is large, ranging from 349 to 4753. The values of the earnings function parameters \( r, r^* \) and \( \gamma \) are obtained by separate regressions within each SMSA of the log of individual earnings on years of schooling, years of experience and the log of weeks worked.\(^{13}\)

The capital-to-labor variables are constructed utilizing data from Kendrick (1976) on capital stocks per worker by industry and 1970 U.S. Census data on male employment shares by industry.\(^{14}\) Kendrick presents figures for 1966 and 1974 in constant 1958 dollars. Here the midpoint of these figures is used.
Mean capital intensity in each SMSA is calculated by:

\[
(K/L)_k = \frac{1}{28} \sum_{j=1}^{28} EMP_{jk} KLIND_j,
\]

where \(EMP_{jk}\) = share of male employment in industry \(j\) in SMSA \(k\), and \(KLIND_j\) = average capital per worker in U.S. industry \(j\) in thousands of dollars (20 manufacturing and 8 nonmanufacturing industries).\(^{15}\) Thus the variable \((K/L)_k\) measures differences across SMSAs in average capital intensity resulting from differences in industry mix and \emph{not} from intra-industry differences across SMSAs in capital usage.

The variance in capital per worker is used as a measure of the dispersion in capital among workers in the inequality equations. That is,

\[
s^2(K/L)_k = \sum_{j=1}^{28} EMP_{jk} (KLIND_j - (K/L)_k)^2,
\]

while the standard deviation of \(K/L\) is used in the earnings-level equations.

It is again worth noting that the capital measures employed here do not measure precisely the distribution of capital among workers in a labor market. Rather, they measure differences across SMSAs in its distribution of capital due entirely to differences in industry mix. They do not capture intra-industry differences across SMSAs in capital usage nor the dispersion in capital usage among different jobs within an industry. In addition, it was not possible with these data to separate capital equipment from capital structures. Despite the shortcomings of the capital measures, we are confident that they reflect approximately the level of capital intensity and the dispersion in capital among workers.\(^{16}\)

The empirical results generally support the hypotheses outlined earlier. The level of earnings, as measured by the geometric mean, is found to be positively related to the level of capital intensity, \(K/L\), and negatively to the dispersion in capital, \(\sigma(K/L)\). The following results are obtained for equation (2) (\(t\) ratios in parentheses):

\[
\ln Y = -0.011t^2 + 0.310\sigma(t) - 0.017\ln WW
\]

\[
(1.50) \quad (1.63) \quad (-0.11)
\]

\[
+ 0.0185K/L - 0.0270\sigma(K/L)
\]

\[
(3.06) \quad (-6.00)
\]

\[R^2 = 0.672 \quad n = 48.\]

These results indicate that both capital variables are highly significant determinants of a labor market’s levels of earnings. The lack of significance of \(t\) and \(t^2\) probably results from high multicollinearity, while that of \(\ln WW\) results from the very low inter-SMSA variability of average weeks worked. As expected, both the level and dispersion of schooling are highly significant determinants of earnings.

While these results are striking, it is possible that the capital variables are, in part, capturing the effects of other omitted variables. In order to examine this possibility we attempt to control for location in the South, city size and the level of unionism. Addition of a South–nonSouth dummy variable had an extremely small and insignificant effect, regardless of specification (these results not shown). As in other studies, city size (as measured by SMSA sample size divided by 1000) was found to be a positive and highly significant determinant of earnings level.\(^{17}\) This is believed to reflect systematic differences by city size in cost of living, nonpecuniary amenities and labor quality. The following results were obtained:

\[
\ln Y = 2.508 + 0.099S + 0.085\sigma(S) + 0.347t
\]

\[
(2.75) \quad (1.96) \quad (1.12)
\]

\[
- 0.008t^2 + 0.233\sigma(t) - 0.010\ln WW
\]

\[
(-1.19) \quad (1.31) \quad (-0.07)
\]

\[
+ 0.0168K/L - 0.0223\sigma(K/L) + 0.033\text{SIZE}
\]

\[
(2.99) \quad (-4.98) \quad (2.79)
\]

\[R^2 = 0.728 \quad n = 48.\]

As seen here, both capital variables remain highly significant with little change in magnitude. The estimated rate of return to schooling, however, falls from 17 to 10%, a value more in line with estimated internal rates of return, but still higher than regression estimates from individual 1970 U.S. Census data, which run at about 7%.

Because unionism, capital intensity and industrial mix are clearly related (though the relationship between them is not well understood, either theoretically or empirically), it is possible that the capital measures may, in part, be capturing the effects of
unionism. Unfortunately, unionism data by SMSA are not available from the census. A recent study by Freeman and Medoff (1979) does, however, provide union membership data for 37 of our 48 SMSAs. We assign the remaining SMSAs a value equal to the geographically closest SMSA for which data are available. Shown below are the partial results of a regression where UNION, an estimate of the proportion of the private sector labor force who are union members, is added to the regression equation just given:

\[
0.0128K/L - 0.0184u(K/L) + 0.148\text{UNION.}
\]

A modest reduction in the capital coefficients may indicate that at least some of the effect of the capital variables on earnings is due to unionism, though these relationships cannot be measured precisely here. The estimated union wage effect is about 15%, but as is well known, OLS estimates are likely to be biased. Other coefficient estimates were not affected; similar results were obtained using the smaller sample for which union membership data were directly available.

The empirical results also generally support the belief that earnings inequality increases with the dispersion in capital among workers. However, no consistent relationship between the level of capital and earnings dispersion is found. Prior to estimating the earnings inequality model just outlined, the following human capital model (without the capital-intensity and capital-dispersion variables) was estimated:

\[
\sigma^2(\ln Y) = 0.091 + 0.014\bar{S} + 2.584[\sigma^2(S)]
\]

Addition of the variables measuring capital intensity and dispersion, \((K/L)\) and \([u^2(K/L)]\), produces the following results:

\[
\sigma^2(\ln Y) = 0.192 + 0.011\bar{S} + 2.032[\sigma^2(S)] + 2.165[\bar{r}^2\sigma^2(t)] + 3.648[2\bar{r}\text{Cov}(S,t)] + 1.430[\gamma^2\sigma^2(\ln WW)] - 0.0068K/L + 0.089u^2(K/L)/1000
\]

Addition of the capital variables adds moderate explanatory power to the model, but does not significantly change the other coefficients from the human capital model.

As predicted from Sattinger's theory of comparative advantage among workers and a scale-of-resources effect in job assignment, a positive relationship exists between the dispersion in earnings and the dispersion in capital among workers. This finding supports the view that the structure of demand, as measured by the capital distribution resulting from an area's industry mix, is directly related to the distribution of earnings. The demand structure not only affects earnings indirectly via its effect on rates of return to investment paths, and thus on the pattern of human capital investment, but also directly by affecting the capital structure and thus the distribution of productivities among jobs.

The relationship between the level of capital intensity and earnings inequality is indeterminate a priori. While a negative coefficient on \((K/L)\) was found in specification (2), both its magnitude and sign were extremely sensitive to specification. The empirical results do not allow any conclusions to be drawn regarding the partial effect of capital intensity on earnings dispersion.

As previously noted, Tinbergen and Sattinger have argued that the inclusion of earnings-function parameters on the right-hand side of what is essentially a reduced-form price (earnings) equation is not strictly proper. Thus the inequality model was also estimated with the earnings-function parameters excluded from the right-hand side. The following results were obtained:
\[
\sigma^2(\ln Y) = -0.219 + 0.0315 S + 0.027\sigma^2(S) \\
(-0.68) (2.08) (3.85) \\
+ 0.00075\sigma^2(t) + 0.012\text{Cov}(S,t) \\
(0.65) (2.64) \\
+ 1.482\sigma^2(\ln WW) - 0.0023K/L \\
(3.39) (-0.58) \\
+ 0.056\sigma^2(K/L)/1000 \\
(1.26) \\
R^2 = 0.667 \quad n = 48.
\]

We continue to find that the dispersion in capital among workers is positively related to earnings dispersion, though the relationship is not significant. Sattinger (1980, Ch. 8, 9) has obtained a similar qualitative result using 1960 state data and U.S. time-series data.

Despite the similarity between these results and those found by Sattinger regarding the relationship between the dispersion in capital and earnings inequality, both may suffer from omitted variable bias. When a South–nonSouth dummy variable is added to equation (8), the coefficient on \(\sigma^2(K/L)\) falls by about half and becomes insignificant. It is not entirely clear what the regional variable measures. Addition of the unionism variable had virtually no effect on earnings inequality or the capital measures after controlling for region.21

CONCLUSION

Several caveats are in order regarding the results of this study. As previously mentioned, in order to measure the hypothesized effects of physical capital on earnings in a cross-sectional study some immobility of labor across SMSAs must exist, since mobility will tend to equalize the returns to all workers with similar amounts of human capital. For instance, a change in the distribution of capital in a single labor market should alter the earnings structure such that in the long run the distribution of earnings changes among all workers, rather than just within the affected labor market. Thus the use of individual data from a national cross-section may be inappropriate. Even if one could accurately measure capital per worker, it would probably have no measurable effect on individual earnings since otherwise similar workers would have equal earnings.22 Such an equation would fail to measure the effect of capital on the structure of earnings among workers with different characteristics. Empirical studies using time-series or cross-country data would avoid serious problems due to factor mobility, but would have difficulty holding constant other important determinants of the earnings distribution. Moreover, such studies would probably suffer from serious multicollinearity, structural differences and limited degrees of freedom. For these reasons, we believe the SMSA is the preferred unit of analysis.

An additional problem not treated in this article is simultaneity between the distribution of earnings and capital. While the empirical work has treated the distribution of capital, determined by the industry structure, as exogenous, it is clear that this distribution is determined simultaneously with earnings. Unfortunately, neither the magnitude nor direction of this bias is known. It is hoped that future work can treat capital and earnings determination within a simultaneous framework. However, convincing evidence on the relationship between capital and earnings may have to await the development of better capital data. Particularly useful would be capital data by SMSA, as well as data for nonmanufacturing industries, as detailed as those available for manufacturing industries.

While the empirical results in this article are far from conclusive, they do lend support to the view that industry or job mix in a labor market and the distribution of physical capital among workers directly affect earnings structure and the distribution of earnings. A labor market's level of earnings is found to increase with capital intensity and decrease with capital dispersion among workers, after accounting in detail for the distribution of human capital. It also appears that earnings inequality is greater the more dispersed the distribution of capital, ceteris paribus. These findings lend support to hypotheses proposed by Sattinger wherein comparative advantage among workers and a scale-of-resources effect among firms affect the job-assignment process. It is hoped that future theoretical and empirical research can provide a better understanding of the relationship between physical capital and the rewards to human capital.

Acknowledgements — Michael Sattinger made a number of helpful suggestions. John Hoftyzer provided assistance during the initial stages of the article.
NOTES

1. For a survey and analysis of these studies, see Hamermesh and Grant (1979). Also, a recent study by Horowitz and Sherman (1980), using the condition of ship equipment as a measure of productivity, finds some complementarity between high-quality physical capital and high-quality human capital.

2. The monopoly-wage hypothesis is examined by Weiss (1966) and Levinson (1967). The evidence that greater concentration leads to higher earnings, after accounting for worker characteristics, is quite weak. For an exception, see Dalton and Ford (1977).

3. Much of this neglect is due to the absence of appropriate data. In addition, if one is attempting simply to “account” for earnings differentials among persons in a single labor market (a city, county, etc.), workers with similar characteristics will have similar earnings if there is perfect information and mobility (we ignore nonpecuniary differences in jobs). Thus demand factors, while determining the structure of employment, will not help explain earnings differentials. This emphasis on the supply-side explanation for earnings differentials is not completely satisfactory if, for instance, labor-supply elasticities are not infinite within the component labor markets of one’s sample, or if one is attempting to explain the pattern of human capital investment and employment in a labor market.

4. Sattinger (1980) provides a complete statement of his theoretical and empirical work. For earlier analyses, see Sattinger (1975, 1978, 1979). Sattinger builds his theory around the general supply-and-demand framework associated with Tinbergen. Tinbergen (1975) and Sattinger provide detailed references to earlier work.

5. Also see Hanushek (1973) and Hirsch (1978a, b).

6. Sattinger notes that “the capital–skill complementarity hypothesis deals with intertemporal differences in factor use, whereas the scale of resources effect concerns interindustry differences at a point in time. An immediate consequence is that the capital–skill complementarity hypothesis cannot be tested using cross-section data by industry, because the capital costs will be the same for all firms with similar risk structures” (p. 91). Cross-sectional tests of the CSC hypothesis can be made, however, using SMSA or state data since relative input prices can vary even if the price of capital is constant across all areas. In this article the capital variables reflect only inter-SMSA differences in industry mix (discussed later). Thus we believe our empirical results reflect the scale-of-resources effect at work and not CSC.

7. Of course, there must exist an equilibrium differential rental price, \( r \), between the large and small machines. Otherwise, all jobs would have large machines. In this example the differential rental price must be between \$3 and \$5. That is: \( \$6 - \$3 = \$3 \leq r \leq \$5 = \$10 - \$5 \). In the four examples provided in the text, values of \( r \) of, say, \$4, \$5, \$3.50 and \$2.50 respectively would result in the assignments presented.

8. In the first three examples \( 1/6 > 1/10, \frac{1}{15} > \frac{1}{20} \), and \( \frac{1}{5} \geq \frac{1}{7} \).

9. As developed by Mincer and Chiswick, \( r' \) and \( r'' \) reflect the rate of return to postsecondary training, the initial investment ratio at labor market entry and the length of the positive net investment span.

10. For any two variables, \( x \) and \( y \), with a nonzero correlation, \( \sigma \), \( \sigma(x,y) = \sigma(x)\sigma(y) + \text{Cov}(x,y) = \sigma(x)\sigma(y) + \rho(x,y)\sigma(x)\sigma(y) \). Thus mean earnings is a function of the standard deviations of schooling, experience and capital per worker as well as their mean values. We omit the standard deviation of experience squared.

11. See Chiswick (1974), Chiswick and Mincer (1972) and Hirsch (1978a). The variable \( r' \) is normally deleted from the earnings function. The parameter \( r'' \) represents the average slope of the log earnings–experience profile.

12. Lucas (1977) provides related arguments in a critique of the human capital approach, while Marin and Psacharopoulos (1976) examine critically the assumption of independence between schooling and rates of return.

13. See Hirsch (1978a) for details on these results.


15. Excluded are agriculture, government and real estate. All other industries are included. While Kendrick’s data within industries reflects the capital–labor ratio for all workers, our analysis of earnings is restricted to white males. If capital–labor ratios differ markedly by sex or race within given industries, interpretation of the capital coefficients becomes more difficult.

16. Rather than using industry-specific capital per worker data for the entire U.S., such data by SMSA would be preferable. However, no such data are readily available. The Annual Survey of Manufactures does provide figures for new capital expenditures by SMSA. These data were available for 46 of our 48 SMSAs for all years since 1958. From these data mean capital-to-labor-ratio figures were constructed using alternative assumptions concerning depreciation. However, these measures are of dubious quality for our purposes. They include data only in manufacturing, which comprise about a quarter of total employment. Moreover, with no benchmark figures available on the initial capital stock (in 1958), we must assume that new investments are proportional to previous...
investments and the existing stock of capital (data on the book value of fixed assets are available for states but not SMSAs). This is unrealistic; indeed, we found no evidence of any correlation between new investments and our measure of capital intensity \((K/L)\). The problem of assuming a fixed relationship between new investments and the existing capital stock could be avoided by depreciating capital completely over the 1958–1970 period (i.e., assuming pre-1958 capital to be exhausted). This assumption is certainly unrealistic. Thus we use a capital-to-labor measure which reflects only differences in capital intensity due to differences in industry mix across labor markets.

17. For a recent study, see Quinn and McCormick (1981).
18. Parsley (1980) provides a review of the literature on union wage effects.
19. The positive relationship between inequality and the covariance between schooling and experience (age) results because secular increases in schooling (a more negative covariance) imply a smaller earnings differential between young and old than would otherwise exist. The other relationships require little explanation.
20. Additional empirical work was performed that attempted to relate the rate of return to schooling and other earnings-function parameters to the model’s explanatory variables. No significant relationships were found. Therefore the assumption of independence between the earnings-function parameters and schooling, experience and weeks worked may not be inappropriate. Thus the author concludes that equation (8) is the preferred specification of the inequality model.
21. For a recent study finding inequality within SMSAs to decrease with the level of unionism, see Hyclak (1979). To date, the most complete treatment of the effect of unions on wage dispersion is Freeman (1980).
22. One could easily include in a micro-earnings function a variable measuring capital intensity for each worker’s industry. However, in long-run equilibrium no relationship should exist between them. Moreover, measurement error due to the mixing of grouped with individual data would bias the capital coefficient towards zero.

REFERENCES