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LABOR MARKET COMPETITION AMONG YOUTHS, WHITE WOMEN AND OTHERS

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ABSTRACT

This paper examines labor market effects of increased labor force participation of youths and women. Using 1969 cross-section data for manufacturing, substitution elasticities for pairs of inputs from age-race-sex aggregates of labor and capital are estimated. Findings include strong substitution between youths and white females, and complementarity between many of the remaining inputs. Then, allowing either rigid or flexible youth wages, a ten percent increase in white female participation is simulated. Findings are respectively: either a large decrease in youth employment and moderate wage decreases of other labor, or moderate decreases in wages of youths and white women.

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I. Introduction

The two most important phenomena in the labor market in the past fifteen years have been the influx of large numbers of young workers and the growth in participation of adult women. The former is the result of the baby boom of the 1950s; the latter stems from changes in attitudes, reductions in discrimination, and lowered prices of substitutes for women's time at home. Each phenomenon alone could have a substantial impact on the labor market. In conjunction, their effects are compounded, with each group possibly affecting the employment opportunities facing the other.

A number of observers have argued that the youth unemployment problem of the 1970s has been exacerbated by competition for jobs from the growing number of adult women workers. One has noted that, "The job prospects of these youth are adversely affected, if indirectly, by the large supply of women still interested in joining the labor force. . . ." Another has pointed out that even in the 1980s "Competition for jobs will be intense and the three major groups of competitors will consist of young white males, young black males, and women of all working ages. . . ." Yet another has stated, "The growth in labor force participation by adult women probably diminished the recovery's impact on the unemployment rates of all groups--especially those of teenagers and non-white women."[1] Implicit in all these remarks are two statements about how labor markets work: (1) Youth and adult women are close substitutes in production, so that an influx of the latter shifts the demand curve for youth sharply to the left; and (2) Wage rates of youth are downward rigid, so that this shift is reflected in increased unemployment rather than reduced wage rates. Because some research, e.g.,

Freeman and Medoff (1978), finds indirect evidence that contradicts this view, in this study we examine the direct evidence on the extent to which women and youth are in fact substitutes in production. The latter issue is ignored, though some recent evidence suggests it may not be so important a problem as many observers seem to think.[2]

While there have been numerous studies of substitution among workers of different groups, very few of these have considered substitution between age groups, and none has examined substitution among women and youth (see Hamermesh and Grant, 1979).[3] Only Freeman (1979) includes women workers as a separate category, and, because men ages 20 through 34 are aggregated, his estimates tell us little about the issue of substitution between women and youth.

To fill this gap in our knowledge and provide some substantive basis for accepting or rejecting the contentions cited above, we estimate substitution possibilities among a set of age-race-sex groups in the labor force. The estimates are based on cross-section data from SMSAs in 1969, and they allow us to consider how substitutable adult women are for young women or young men. The estimates are used, along with assumptions about the extent of wage rigidity and elasticities of labor supply, to simulate the direct and indirect effects of the growth of the female labor force on job opportunities for youth, assuming rigid wages for young workers, and on the wage rates of adult males, assuming these wages are flexible.

II. Estimating Equations, Methods and Data

Our estimates are based upon the translog approximation to a production surface (see Christensen et. al., 1973). We estimate the production function using output shares, implicitly assuming that the production function is

characterized by constant returns to scale, and firms are price-takers in factor markets. The production function is used instead of the cost function because, at least for older workers, factor quantities are more properly viewed as exogenous than are factor prices. (See Hamermesh and Grant, 1979, for a discussion of exogeneity assumptions appropriate for estimating production models defined over labor-force subaggregates.)

Let the N-factor production function, $Q = F(X_1,\ldots,X_N)$, be approximated by the translog form:

$$\ln Q = \ln \alpha_0 + \Sigma_i \alpha_i \ln X_i + \frac{1}{2} \Sigma_i \Sigma_j \gamma_{ij} \ln X_i \ln X_j , \qquad (1)$$

where the α_i and γ_{ij} are technology coefficients, Q is output and the X_i are inputs. With the assumption of competitive input markets, $\partial Q / \partial X_i = P_i$, the N factor share equations for estimating the production technology are derived from the N output elasticity equations:

$$\partial \ln Q / \partial \ln X_i = P_i X_i / Q = S_i, \quad i=1,\ldots,N ,$$

where P_i is the price and S_i is the output share of factor i. The factor share equations derived from (1) are:

$$S_i = \alpha_i + \Sigma_j \gamma_{ij} X_j , \quad i=1,\ldots,N . \qquad (2)$$

While most work analyzing production relations has focused on partial elasticities of substitution and price elasticities (see Allen, 1938), those concepts are inappropriate if we are interested in considering the effects of exogenous changes in factor quantities on factor prices. We therefore concentrate on the Hicks partial elasticities of complementarity, defined as $C_{ij} = F F_{ij} / F_i F_j$ where the F_i and F_{ij} are respectively first and second partial derivatives of the production function F.[4] For the translog share equations

(2) these are calculated simply as:

$$C_{ij} = (\gamma_{ij} + S_i S_j)/S_i S_j \ , \tag{3a}$$

and

$$C_{ii} = (\gamma_{ii} + S_i^2 - S_i)/S_i^2 \tag{3b}$$

They measure the ceteris paribus effect on relative factor prices of changes in relative factor quantities, holding output price and other input quantities fixed. Factors i and j are quantity complements (substitutes), so that increases in inputs of j increase (decrease) i's price, as $C_{ij} > 0$ (<0). Associated with the C_{ij} are the factor price elasticities, $\theta_{ij} = S_j C_{ij}$, which show the change in the price of factor i given a one-percent change in the quantity of factor j, holding output price constant.

In the production-function tableau of (2) one cannot derive unbiased estimates of the γ_{ij} parameters, and thus of the C_{ij}, unless one assumes input supply is exogenous. Obversely, in the more commonly used cost-function tableau, one must assume all input prices are exogenous. Since wage flexibility seems, as noted above, to be a pervasive characteristic of the U.S. labor market, and since the evidence suggests labor supply is quite inelastic for most groups of workers, we can be fairly confident that the use of the production function approach is more appropriate than would be the estimation of a cost function.[5] Nonetheless, in our study, as in every study that has estimated production technologies, a general equilibrium approach that specified supply relationships as part of the model would improve the results (at the cost of substantial complexity).

The data are constructed for 1969.[6] Employment data for manufacturing are taken from the one-in-a-thousand sample of the County Group Public Use

Samples of Basic Records From the 1970 Census. Capital and output data are gathered from issues of the Census of Manufactures and the Annual Survey of Manufactures. The County Group Public Use Samples identify all SMSAs over 250,000 in population in 1970. The production model is estimated over the 67 SMSAs for which all the data could be constructed for the factor inputs youths 14-24 (Y); adult blacks (OB); white women (OFW); white men (OMW); and capital (K).[7]

The assumptions of symmetry, $\gamma_{ij} = \gamma_{ji}$, and homogeneity, $\Sigma\alpha_i = 1$, $\Sigma_i \gamma_{ij} = \Sigma_j \gamma_{ij} = \Sigma\Sigma_{ij} \gamma_{ij} = 0$, are imposed upon the model in (2). The system of share equations (2) is then estimated using the iterative Zellner method, a maximum-likelihood technique, over the cross-section data for manufacturing in 1969. In addition to being the first to examine substitution between youth and adult women, our estimates are among the few that use cross-section data to estimate parameters from flexible functional forms describing production relations.

III. Estimates of Elasticities of Complementarity and of Factor Prices

Before discussing the elasticity estimates based on the parameters estimated in the cross section for manufacturing in 1969, it is worthwhile considering whether the complete model in (2) is needed to describe production relations among the five factors, or whether instead some types of separability can be imposed. Most interesting would be if we found that the labor subgroups are jointly separable from capital. Though time-series studies using broad occupational categories (blue-collar and white-collar labor) do not find this (see Berndt and Christensen, 1974; and Denny and Fuss, 1977), it may be implied by cross-section data covering the small demographic subgroups used in this study that are of major interest for labor-market

policy. If so, we can conclude that estimates of the potential impact of such policies can be simulated without using capital stock data that are often difficult to construct.

Unfortunately, the imposition of various restrictions implied by weak separability of various sets of inputs from the others is generally inconsistent with the data.[8] In Table 1 we present the χ^2 statistics testing for weak separability in six cases which implicitly test popular notions about the extent to which various groups are similar. The only pair of inputs for which the hypothesis of a consistent aggregate is not rejected is youths and adult white women. Youths and adult blacks cannot be treated as an aggregate, nor can adult blacks and adult white males. White adult males are also not separable from other demographic groups, nor are adult white women. Finally, and corroborating the results of the several time-series studies that have tested for separability of (blue- and white-collar) labor from capital, the hypothesis that they are separable is decisively rejected. This implies that studies that do not include measures of the capital stock are likely producing unreliable estimates of the parameters describing substitution between the labor subaggregates.[9]

Table 2 presents the estimated C_{ij}. It is difficult to decide what are the appropriate measures of variance to attach to these parameter estimates (and to the θ_{ij} in Table 3). Accordingly, the first number in parentheses is the t-statistic on the estimated γ_{ij} underlying the calculation of C_{ij} or C_{ii} in (3). The second is based on a Taylor-series approximation that implicitly treats the S_i and S_j in (3) as stochastic (see Anderson, 1979).

The most striking finding in Table 2 is clearly that youths and adult white women are strongly substitutable in manufacturing. The estimated γ_{ij} upon which the C_{ij} is based is highly significant; even if we assume that

Table 1

TESTS FOR WEAK SEPARABILITY[a]

	Factor Inputs	χ^2	df
a.	(Y, OFW), OB, OMW, K	1.29	3
b.	(Y,OB), OFW, OMW, K	35.16*	3
c.	(OB, OMW), Y, OFW, K	36.80*	3
d.	(Y, OB, OFW), OMW, K	20.03*	4
e.	(Y, OB, OMW), OFW, K	38.08*	4
f.	(Y, OB, OFW, OMW), K	28.90*	3

[a]Parentheses surround the inputs whose aggregation is tested.

*Denotes significance at the .01 level.

Table 2

ELASTICITIES OF FACTOR COMPLEMENTARITY[a]

	With Respect to Quantity of:				
Price of:	Y	OB	OFW	OMW	K
Y	-.639 (12.37) (.09)	.592 (.46) (.64)	-2.35 (4.78) (1.15)	.128 (2.89) (.25)	.236 (3.09) (.79)
OB		-11.2 (12.87) (.94)	.312 (1.29) (.50)	-.145 (4.36) (.27)	.905 (.39) (3.83)
OFW			-2.99 (18.08) (1.76)	.056 (4.83) (.15)	.568 (3.08) (3.99)
OMW				-3.49 (9.51) (2.44)	.261 (5.80) (4.05)
K					-.374 (5.45) (2.88)

[a]The first number in parentheses below each elasticity here and in Table 3 is the absolute t-statistic on the γ_{ij} coefficient upon which the elasticty is based. The second is the absolute t-statistic computed using a Taylor-series approximation to the elasticity.

the shares are stochastic and approximate (3a) by a Taylor series, we still find that the estimated C_{ij} exceeds its standard error. The casual empiricism cited in Section I of this paper appears to have at least some foundation on the demand side of the labor market. We also find that older blacks and adult white males are substitutes. This result follows unsurprisingly from the observation that older blacks in manufacturing are mainly adult men who are likely to be close substitutes for adult white men. All the other pairs of labor categories are seen to be complements, though in no case is the complementarity relationship very strong.

Table 3 shows the elasticities of factor prices computed from the average fitted factor shares and the partial elasticities of complementarity. Since these follow from the results in Table 2, substantial additional comment is not required. It is worth noting, though, that the largest cross elasticity between any labor pair is that between the substitutes Y and OFW.

As the results in Tables 2 and 3 show, each labor group is complementary with inputs of physical capital. This finding is inconsistent with Freeman's (1979) time-series results on adult women and adult men. It parallels, though, that for white-collar workers in the many time-series studies that use an occupational classification, but may be inconsistent with their results that blue-collar workers are substitutes for capital.[10] It suggests that, for purposes of evaluating labor-market policies, most of which are directed at workers categorized by demographic group, we may infer that labor subaggregates and capital are complements. This implies generally that policies that increase employment in a particular labor subgroup will raise the rate of return to capital.[11]

Table 3

ELASTICITIES OF FACTOR PRICES

	With Respect to Quantity of:				
Price of:	Y	OB	OFW	OMW	K
Y	-.0300	.0226	-.1532	.0476	.1130
	(12.37)	(.46)	(4.78)	(2.89)	(3.09)
	(.09)	(.28)	(1.34)	(.24)	(.84)
OB	.0278	-.4282	.0203	-.0536	.4337
	(.46)	(12.87)	(1.29)	(4.36)	(.39)
	(.30)	(.92)	(.50)	(.29)	(3.93)
OFW	-.1105	.0119	-.1943	.0209	.2721
	(4.78)	(1.29)	(18.08)	(4.83)	(3.08)
	(1.62)	(.45)	(1.39)	(.16)	(5.26)
OMW	.0060	-.0055	.0037	-.1292	.1250
	(2.89)	(4.36)	(4.83)	(9.51)	(5.80)
	(.24)	(.35)	(.16)	(2.25)	(3.62)
K	.0111	.0346	.0369	.0966	-.1792
	(3.09)	(.39)	(3.08)	(5.80)	(5.45)
	(.71)	(2.28)	(2.91)	(3.04)	(2.88)

IV. The Effect of an Exogenous Increase in White Female Participation

In this section we examine the impact of a ten percent increase in the number of white women in the labor force, using the five-factor production model involving youths, adult blacks, white women, white men and capital.[12] The simulation is designed to gauge the effects of the tremendous increase in female labor force participation that has occurred since the early 1960s. Whether employment displacement occurred, or whether the effect has been to reduce the relative wage rates of youth, depends on whether in fact relative wage rates of youth are rigid. In our simulation we calculate the impact of the increase in adult white female employment under the two extreme assumptions of completely flexible and completely rigid wages in the youth labor market.[13]

Let P_i be the price of factor i, i=1,. . . , N, and assume that all P_i are flexible except that of young workers, whose wage is fixed at P_1^*.[14] Firms determine their demands for factor inputs from the usual marginal productivity conditions:

$$P_1^* = F_1(X_1, X_2^*, \ldots, X_N^*) , \tag{4}$$

$$P_i = F_i(X_1, X_2^*, \ldots, X_N^*), \; i=2, \ldots, N , \tag{5}$$

where X_i^* is employment of the i'th factor, which is exogenous to the economy under the assumption of inelastic labor supply, and F_i is the partial derivative of F.

Differentiating the N equations in (4) and (5), we have:

$$-F_{11}dX_1 - \sum_{j=2}^{N} F_{1j}dX_j^* = 0 ;$$

$$dP_i - F_{i1}dX_1 - \sum_{j=2}^{N} F_{ij}dX_j^* = 0, \; i=2, \ldots, N .$$

Solving this system yields:

$$dX_1/dX_j^* = -F_{1j}/F_{11},\ j=2, \ldots ,N, \quad (6)$$

$$dP_i/dX_j^* = (-F_{i1}F_{1j} + F_{ij}F_{11})/F_{11},\ i, j=2, \ldots ,N, \quad (7)$$

Multiplying both sides of (6) by X_j/X_1; noting that $F_{ij} = P_iP_jC_{ij}/Q$ and that $X_i = QS_i/P_i$ under the assumption of constant returns to scale, we have:

$$d\ln X_1/d\ln X_j^* = -S_jC_{1j}/S_1C_{11},\ j=2, \ldots , N. \quad (8)$$

Similarly, multiplying both sides of (7) by X_j^*/P_i, and making the same substitutions for F_{ij} and X_i, we have:

$$d\ln P_i/d\ln X_j^* = S_j(-C_{i1}C_{1j} + C_{ij}C_{11})/C_{11};i,j=2, \ldots ,N. \quad (9)$$

Equations (8) and (9) allow us to use the estimates in Table 2 to calculate the effect of an increase in adult white female employment on the employment of youths and on the wage rates of workers in other demographic groups, under the assumption that youths' wage rates are rigid. Equation (8) states simply that the effect on youth employment is larger and more negative the greater is the extent of q-substitutability of white women and youths, the larger is the share of white women in output, and the smaller is the share of youths. Equation (9) states that the effect on other factor prices depends both on their partial elasticities of complementarity with white women and on the degree to which they are q-complements or substitutes with youths and that youths are q-substitutes with white women. (The first term in parentheses enters because P_i^* is assumed fixed.) If all wages are flexible, the calculations reduce to:

$$d\ln P_i/d\ln X_j^* = S_jC_{ij} = \theta_{ij},\ i, j=1, \ldots , N, \quad (10)$$

the factor-price elasticities listed in Table 3.

The simulated effects of a ten percent increase in the labor force of adult white women are shown in column (1) of Table 4, under the assumption that the wages of young workers are rigid. As they show, the ease with which our estimates in Table 2 imply employers can substitute white women for youths gives rise to an unbelievably large decrease in the employment of youths in this simulation. Moreover, even though white women and adult blacks, and white women and white men, are complements, the simulated effect of the increase in the white female labor force is to decrease the wage rates of adult blacks and white men. These effects occur because the first term in the numerator in (9) outweighs the second due to the relative ease with which employers can substitute white women for youths. The rise in adult white female employment induces a direct increase in the wage rates of its complements, adult blacks and white men, but this is more than offset by the induced decline in their wages as employers substitute white women for youths.

If one takes the view that wages of youth are not rigid in the long run, the appropriate estimates of the effect of the increased female participation are those shown in column (2) of the Table. These are moderate decreases in the wage rates of white women and youths, and slight increases in the wage rates of the other inputs. These estimates are likely to be closer approximations to reality under the flexible-wage assumption than are those in column (1) under the fixed-wage assumption. This is because the translog estimates on which they are based are for a production function, that implicitly assumes that factor quantities are all exogenous, and thus implicitly is based on a model of flexible wages.

Regardless of whether one believes that wages of young workers are rigid or flexible, we have shown that, because youths and white women are substitutes in production, the flow of white women into the labor market has

Table 4

SIMULATION RESULTS

Percent Change in:	(1)[a]	(2)[b]
Youth Employment	-51.1	
Wage Rate of: Youths		-1.5
Adult White Women		-1.9
Adult Blacks	-1.2	.2
Adult White Males	-.3	.04
Price of Capital	.2	.4

(1) assumes rigid wages for youth;

(2) assumes all wages are flexible.

[a]Based on equations (8) and (9).

[b]Based on equation (10).

caused some displacement in the earnings of young workers. Under the fixed-wage assumption this displacement would have taken the form of reduced employment; under the flexible-wage assumption, it would have manifested itself as a reduction in wage rates, and thus a steeper cross-section age-earnings profile than would have otherwise been observed. Part, perhaps 10 percent, of the sharp relative decline in earnings of young workers that occurred in the late 1960s and 1970s (see Freeman, 1979, and Welch, 1979) is thus attributable to the increase in the adult female labor force. The baby boom of the 1950s is not the only reason for the relative decline in earnings in the youth labor force.

VI. Conclusions

Our estimates and those of Grant (1979) are the first that present tests for the separability of labor from capital using a disaggregation of the labor force based on a classification other than by occupation. The results are clear and somewhat depressing: Studies that seek to estimate the extent of substitution in production among demographic groups must include measures of the capital stock. Given the difficulties of constructing such measures even for the economy as a whole over time, and the near impossibility of building up a capital measure for nonmanufacturing industries in a cross section, our ability to derive accurate estimates of substitution parameters describing the demand for labor is limited. Indeed, because of the inappropriateness of assuming separability, even unbiased estimates of the own-price demand elasticity for small groups cannot be produced using data on the group alone.

Our most important finding is the extent to which white women and youths are substitutes in production. We have shown, at least in the

cross-section data for 1969 that we have used, and assuming the production-function approach is the more appropriate one for this disaggregation of the work force, that market forces change the relative wages received by these two groups of workers in a direction opposite that of the change in their relative quantities. We have also demonstrated that each type of labor in our age-race-sex disaggregation is complementary with capital, a finding that is partly consistent with the time-series results for blue-collar and white-collar labor. It is inconsistent with past results that are based on the disaggregation of the labor force by age and that use the inappropriate (for this disaggregation) cost-function specification.

Our estimates of white female-youth substitution imply strongly that the growth of the white female labor force has hurt the earnings prospects of young workers. Whether this effect has worked through a decrease in employment or a reduction in wages cannot be determined here. However, that it has occurred is the logical conclusion from our finding that these two groups are easily substituted in production, and the observation that there has been a sharp increase in adult female labor force participation in the past fifteen years. Competition from adult women has very likely had a negative impact on the labor market for youths.

FOOTNOTES

[1]These statements are respectively by Eli Ginzberg, "Dimensions of Youth Unemployment," April 5, 1979, unpublished; Alice Yohalem, Hearings before the Joint Economic Committee of Congress, 95:2, June 7, 1978, p. 255; and Alice Rivlin, Hearings before the House Budget Committee, February 21, 1978, p. 53.

[2]Freeman (1979) and Welch (1979) show that there has been substantial adjustment in relative wages of youths over the past fifteen years, and Morse (1980) indicates that, except for black males, teenage wage rates did adjust well between 1960 and 1970. However, Johnson (1980) presents arguments why one might, in the face of this evidence, believe the youth labor market is not entirely free of wage rigidity. Consistent with this view, King (1979) presents tentative evidence of some effect of increased female participation on youth unemployment.

[3]The studies looking at substitution by age are Anderson (1977), Freeman (1979), Grant (1979), Johnson-Blakemore (1979), and Welch-Cunningham (1978).

[4]Sato and Koizumi (1973) lay out the relationships among the substitution and complementary elasticities.

[5]For adult males, and increasingly too for adult females, the evidence is fairly clear that supply elasticities are nearly zero (see Borjas and Heckman, 1978). For other groups this assumption is less tenable.

[6]For a description of the construction of the data see Grant (1979).

[7]Even this fairly fine disaggregation of the work force may involve some inadmissable aggregations. For example, aggregation of youths 14-19 and 20-24 may be incorrect. Nonetheless, the broader categorization is all that the data source allows; in any event, finer disaggregations simply did not give estimates of the C_{ij} that are consistent with theory.

[8]See Denny and Fuss (1977) for the methods of testing for weak separability in the context of the translog approximation.

[9]Berndt (1980) demonstrates that when labor-capital separability is inappropriately implicitly assumed, the resulting cross-price elasticities of demand for factors are overestimated and the own-price elasticities of demand are underestimated.

[10]Those studies, however, only show that blue-collar labor and capital are p-substitutes, a result which follows automatically once one finds that white-collar labor and capital are p-complements. Further, because most previous studies, including Grant (1979) and Anderson (1977), present elasticities of substitution, their finding that each labor type is a p-substitute for capital is not necessarily in conflict with our finding on their q-complementarity.

[11]In an attempt to extend our work beyond manufacturing we estimated the capital stock in the entire private nonfarm economy in each SMSA by prorating the manufacturing capital stock by the ratio of hours worked. The capital stock measure was entered into equations (1). The results were disappointing: The significance of the estimated γ_{ij} dropped sharply. It would appear that data limitations make it impossible to derive useful cross-section estimates of labor-labor substitution parameters outside manufacturing, since, as we have shown for manufacturing, a capital measure must be included where none is available.

[12]Between May 1967 and May 1979 the share of the labor force accounted for by white women 25+ grew from .243 to .268, roughly a ten percent increase. Data by age, race, sex and industry cannot be obtained for each year, but we can note that, as a percent of full-time employees in manufacturing, women increased from 23.9 to 25.7 percent between 1967 and 1977. (Computed from Current Population Reports, P-60, Nos. 60 and 118.)

[13]Though we wish to simulate employment effects, our estimates are based on manhours of inputs. Assuming, as is standard in the literature, that the exogenous change produces no long-run change in the relative prices of persons and hours, our estimates are appropriate for simulating the long-run effect of the influx of women.

[14]This discussion is modelled after that in Johnson (1980).

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