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ABSTRACT

This paper examines the extent to which rapid increases in female labor supply contributed to rising wage inequality and to declining real wages of less skilled males during the 1980s. We find that while the male wage declines are concentrated in the 1980s, female labor supply growth slowed in the 1980s relative to the 1970s. Women also increased the relative supply of skill in the economy in the 1980s. We find these findings to be inconsistent with a simple story in which supply shifts among women have played a major role. Instead, they further support the view that demand shifts, rather than supply shifts, have been the underlying cause of declining opportunities for less skilled males and rapid inequality growth in the 1980s.

We also use state and SMSA-level data to estimate cross-substitution effects between men and women of different skill types. We find weak evidence that women may be substitutes for high school dropout men and that college educated women may have contributed to wage inequality growth by being better substitutes for high school dropout men than high school graduate men. We end with some suggestive evidence that unmeasured demand shifts which favored skilled female workers over less skilled male workers may be biasing our results towards finding substitution between these two groups.

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I. Introduction

Two of the most important phenomena in the U.S. labor market during the past several decades have been rising labor force participation of married women and dramatic increases in earnings inequality. A substantial literature now documents the sharp declines in real wages of less skilled men during the 1980s -- both in an absolute sense and relative to more skilled workers.[1] While most of this literature emphasizes relative demand shifts rather than supply shifts, a question still remains as to what extent the growing number of women in the labor force have contributed to these changes. In this paper, we seek to answer two distinct yet related questions. First, have women reduced real wages of men by substituting for their labor? Second, have women contributed to rising inequality between skilled and less skilled male workers? Previous work which have examined the substitution possibilities between women and other groups have found women to be strong substitutes for youth (Grant and Hamermesh (1979)) and adult black males (Borjas (1986)). With regards to inequality, Topel (1994) recently reported that increasing numbers of highly skilled female workers could possibly account for the entire decline in the *relative* wage of less skilled males since the early 1970s.

Our approach is to build a body of evidence using different variations in the data. Using the decennial Census, we first examine aggregate changes in female labor supply and male wages over the period 1940 to 1990. We also disaggregate the data by skill level and examine how women's contributions to labor of different skill type have varied across the decades. Our main finding is that the aggregate evidence is inconsistent with a simple story where supply shifts among women have played a major role in recent changes in the male

[1]The most often cited works include Bound and Johnson (1992), Juhn, Murphy, and Pierce (1993), Katz and Murphy (1992), Levy and Murnane (1992) and Murphy and Welch (1991). See also Freeman and Katz (1994).

wage structure. First, comparing across the decades we find that female labor supply growth actually slowed down in the 1980s relative to the 1970s. In the absence of other factors, this implies that we should have observed the largest wage declines and the largest increases in wage inequality during the 1970s. Since the dramatic changes in the wage structure occurred in the 1980s and not in the 1970s, this suggests that other factors, such as demand shifts away from less skilled male workers, were important during the 1980s.

The evidence when we disaggregate by skill also point in the direction of demand shifts. We find that over the 1980s women actually made greater contributions to labor in the higher skill categories than in the lower skill categories. This is a distinct break from past trend where women have typically added more to the lower skill categories. To the extent that women substitute for men *within* skill levels, this suggests that the entry of more skilled women into the labor force may have tempered, rather than further contributed to, male wage inequality growth during the 1980s. These findings based on aggregate changes confirm the earlier findings in the wage inequality literature that emphasize the importance of relative demand shifts in favor of skilled workers over less skilled workers.[2]

While demand shifts appear to be of central importance, it is still possible that the rapid entry of women into the labor force further exacerbated wage declines for certain categories of men. To investigate this question we estimate cross-price elasticities between men and women using state and SMSA-level data. Our cross-state regressions offer weak evidence that women may be substitutes in production for high school dropout men. They also indicate that college educated women may be better substitutes for high school dropout men than high school graduate men, thereby widening inequality in the bottom half of the male wage distribution. Despite the fact that we rely mostly on cross sectional variation in

[2]For example, Katz and Murphy (1992), Murphy and Welch (1992), Bound and Johnson (1989), and Berman, Bound, and Griliches (1994).

the data, these results are similar to Topel (1994) which used regional aggregates and relied more heavily on time series variation. These findings must be qualified, however, to the extent that we imperfectly capture demand shifts away from low-skilled male workers towards high-skilled female workers in our estimation. We conclude with some indirect evidence that unmeasured demand shifts may be biasing our results towards finding substitution between these two groups.

The paper is organized as follows. Section II lays out a simple framework in which we specify our null and alternative hypotheses. Section III describes the data. Section IV examines long run changes in male wages and female employment. This section concludes by comparing female labor supply growth across different skill types. Section V presents our main findings from the cross-state analysis. Section VI concludes.

II. A Labor Demand Framework

Following Katz and Murphy (1992), LaLonde and Topel (1989) and Topel (1994), we lay out a simple aggregate demand framework to facilitate the discussion of the main hypotheses to be examined in this paper. We begin by specifying an aggregate production function with J factors defined by gender and education groups. Relative wages between different groups are determined by the interaction of relative factor supplies and factor demands implied by the aggregate production function. Labor market equilibrium can be described as

$$X_t \equiv D(W_t,\ Z_t) \qquad (1)$$

where X_t is a Jx1 vector of observed factor quantities, D is a Jx1 vector of factor demands, W_t is a Jx1 vector of observed wages, and Z_t is a Nx1 vector of demand shifters. Taking logs, totally differentiating and rearranging terms yields the following,

(2) $$\dot{W} = E^{-1} \cdot [\dot{X} - \dot{D}]$$

where E^{-1} is the JxJ matrix of elasticities of factor price and the term inside brackets represents log changes in net factor supplies. For women to have negatively impacted male wages and significantly contributed to inequality growth in the 1980s, women and men must be substitutes in production (the appropriate factor price elasticities are negative and large in magnitude) and the net supply of women must have increased substantially during the 1980s. In section IV we report the observed aggregate changes in wages, $\dot{W}$, and factor quantities, $\dot{X}$, and examine to what extent these changes are consistent with the hypothesis that women and men are substitutes in production and demand shifts, $\dot{D}$, were relatively unimportant. In Section V we estimate the matrix of factor price elasticities directly using state and SMSA-level data. We also estimate the corresponding matrix of elasticities of complementarity by regressing changes in relative wages (wages relative to male high school graduate wage) on relative factor quantities. The coefficients on female quantity changes tell us the impact of women on male wage inequality.

III. The Data

Our calculations are based on the 1/100 sample of the 1940-1990 Public Use Micro Samples (PUMS). Our wage measures are based on a select sample of individuals with strong labor force attachment. Specifically, we choose male and female wage and salary workers in the non-agricultural sector who had 1-40 years of potential labor market experience, who worked full-time, who worked at least 40 weeks and earned at least 1/2 the legal federal minimum weekly wage. Our wage measure is the weekly wage calculated as annual earnings divided by weeks worked. Annual earnings were deflated using the PCE deflator from the national product and income accounts.

We use two alternative measures of labor quantities. One measure, which we call our unweighted measure, is constructed by counting the number of men and women with 1-40 years of experience who were working during the survey week. A second measure, which we call our weighted measure, is based on a sample of individuals who worked at least one week the previous year and we construct labor quantities by summing over total annual hours worked.[3] Following Katz and Murphy (1992), for each year we divided the data into 80 groups defined by sex, education and experience categories.[4] For each demographic group we calculate average employment share over the entire period, 1940-1990. We use these average shares as fixed weights to calculate average wages at more aggregate levels and also to calculate a fixed-weight wage index for each year. For much of our analysis we examine relative wages for different demographic and skill groups by dividing the group's average wage by the fixed-weight wage index for that year. We also multiply the group's labor share by the group's relative wage averaged over all years to convert labor quantities into efficiency units. While we report cross-state regression results based on annual hours weighted efficiency units of labor, we have not found our results to be sensitive to the choice of the labor quantity measure.

IV. Male Wages and Female Employment Growth 1940-1990

In this section we examine the long run changes in male wages and female employment over the period, 1940-1990. Table 1 presents log changes in average weekly

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[3]Usual hours worked last year which would be more appropriate for calculating total annual hours is unavailable until the 1980 Census. We use hours worked during the survey week to maintain consistency.

[4]We use five education categories, <8, 8-11, 12, 13-15, 16+ years of schooling, and eight five-year experience categories.

wage by gender and education group. Overall, real wages grew rapidly during the 1950s and the 1960s, were constant during the 1970s and fell considerably during the 1980s. Male and female wages moved closely together up to 1980 and diverged sharply with males losing considerably more than women. The following panel showing real wage changes for men in different education category tells a more dramatic story of wage losses with high school dropout and high school graduate men losing 12.5 and 14.1 percents in real wages during the 1980s. While less educated women have also lost during the 1980s (note that high school graduate women lost 2.2 percent in real wages during the 1980s), the wage declines for women have not been nearly as dramatic.

Table 2 examines the long run trends in female employment growth. Panel A presents changes in employment to population ratios for women with 1-40 years of potential experience. Female employment growth was particularly rapid during the 1970s with the employment to population ratio rising by 11 percentage points from .474 to .585. In the 1980s, however, the pace of female employment growth actually slowed down somewhat to 9.4 percentage points. In percentage terms, female employment to population ratios increased at a rate of approximately 20 percent per decade until the 1980s when it grew approximately 15 percent. Panels B and C illustrate which women have entered the labor force most intensively. During the 1980s in particular, increases in female employment rates have occurred almost exclusively among high school and college graduate women. Panel C isolates married women and disaggregates by the husband's relative earning power. Wives of men in the top wage categories have exhibited particularly strong entry patterns with employment rates growing approximately 14 percentage points over the 1980s.

Table 3 shows how rising employment rates translated into increases in the female share of the labor force. Panel A of Table 3 reports the ratio of female workers to total number of workers while panel B reports the ratio of female hours worked to total hours worked. Changes in the female share of the labor force exhibit the same basic time pattern as the changes in employment rates in that female labor supply growth accelerates somewhat in the 1970s and slows down in the 1980s. There are some important differences between the weighted and unweighted numbers, however. Based on the unweighted numbers, female share of the labor force increases 9.1 percentage points from .288 in 1940 to .379 in 1970. When we weight by annual hours the increase in female share is much smaller, rising less than 5 percentage points from .258 to .305. This suggests that a sizable fraction of newly entering cohorts of women over this period may have been part-time and part-year workers who worked significantly less than their male counterparts. On the other hand, the growth in female labor supply since 1970 is somewhat larger when workers are weighted by their annual hours, suggesting that part-time work may have become less important over time for women.[5]

Panels C and D report female shares of the labor force by education category. These panels show the rapid changes in the educational composition of the female work force. For example, women with less than a high school degree accounted for approximately 10 percent of total hours worked in 1969. By 1989, these women accounted for 4.3 percent of total hours worked. On the other hand, college graduate women accounted for 3.3 percent of the nation's labor supply in 1969. By 1989, their share had more than tripled to 10.1 percent. This rapid increase in the labor supply share of college graduate women reflects both the rapid rise in the fraction of the population going to college and rising participation rates among college-educated women.

We conclude from examining the long run changes in male wages and female labor supply that while wage declines among less skilled men were concentrated in the 1980s, the

[5]Using March CPS data, Levenson (1995) shows that the fraction of women employed part-time was constant over the 1970s and declined over the 1980s.

pace of female labor supply growth was somewhat slower than in the previous decades. If the aggregate change in female labor supply was not exceptional in the 1980s, what was different about the 1980s? We argue below that the most notable change regarding female labor supply during the 1980s was its changing composition rather than its growing number. We now turn to a more systematic examination of how the skill composition of working women has changed over time.

Similar to Borjas, Freeman and Katz (1991) and more recently Jaeger (1995) who examine immigrants' contribution to relative wage changes, we ask in this section how working women have altered the relative supply of skill in the economy. In a more general framework, women may substitute for men of different skill type (for example, high skilled women may substitute for low skilled men). However, in this section we have in mind a simpler framework where women substitute for men *within* skill levels. Building on this assumption, then, we may ask whether women have increased or decreased the relative supply of skilled workers in the economy thereby reducing or increasing wage inequality between skilled and less skilled workers. In order to answer this question, we examine the ratio of all workers including women to male workers in each skill category. The percentage change in this ratio over time tells us how women's contributions to the labor supply of different skill types have changed over time. Finally, we can compare across skill categories to examine whether women have increased or decreased the relative supply of skilled workers. We use three alternative definitions of skill: relative wages, education and three-digit occupation. In our first method, we first determine wage percentile cutoffs by pooling the men in our wage sample over all years. We then allocate men and women to different wage percentile categories based on their observed wages. One concern with this method is that it may be confounding changes in wage discrimination against women with real changes in skill level. We therefore also predict the number of men and women in different wage categories based on the distribution of observable characteristics such as education and occupation.

We predict the ratio of all workers to male workers of percentile category p at time t using the following equation:

(3)
$$\frac{\hat{N}_{pt}}{\hat{N}^{m}_{pt}} = \frac{\sum_{j} \alpha_{pj} N_{jt}}{\sum_{j} \alpha_{pj} N^{m}_{jt}}$$

where $\alpha_{pj} = N^{m}_{pj}/N^{m}_{j}$ (the conditional wage distribution of men with characteristic j). In other words, we predict changes in labor quantities of different skill types using changes in the distribution of the characteristic j. To calculate the average conditional wage distribution, α_{pj}, we used the pooled wage sample of men over all the years 1940-1990. To calculate changes in the distribution of j across years, we used the entire sample of men and women who worked during the survey week.

Figure 1 shows the ratio of total to male labor supply by skill type when we allocate men and women to skill categories based on their wages. There are two points we wish to make regarding Figure 1. First, in every period, women alter the skill distribution of the economy by adding significantly more labor to the bottom skill categories than the top skill categories. For example, while women more than tripled the effective labor supply of workers in the bottom wage category in 1980, they made virtually no difference to the effective supply of workers in the top wage category. This is a statement about the levels (i.e. how women alter the skill distribution at a point in time). However, we are mainly interested in the *changes*, or more specifically, how women's contributions by skill level have changed over time. When we focus on the differences between the lines in Figure 1, we find that women added more to the bottom skill categories in every period until 1980.

Over the 1980s, however, women's contributions to the very bottom skill categories actually declined while their contributions to the middle and top skill categories increased.

Figure 2 shows our results based on education while Figures 3-5 present our results based on three-digit occupations.[6] The flatter lines in Figure 2 indicate that the distribution of female workers are much closer to that of male workers when we compare across education categories than when we compare across wage categories. In terms of changes, Figure 2 shows that women have had an almost neutral effect on changes in the skill composition of the work force until the 1980s. Once again, the 1980s appear to be distinct in that women added significantly more labor to the top skill categories than the bottom skill categories. In percentage terms, we estimate the incremental contribution of women to the labor supply of the top quintile group to be approximately 8 percent over the 1980s. Their contribution to the bottom quintile appears to be about 3 percent. Based on these numbers, women increased the relative supply of the most highly skilled workers in the economy to that of the least skilled workers by 5 extra percentage points. Our findings regarding changes over the 1980s are qualitatively similar but more dramatic in number when we use occupation as a measure of skill. Figure 5 shows that the growth of female labor supply by skill type has been distinctly non-neutral in the 1980s. Based on occupational changes, we estimate that women's contribution to the increase in the relative supply of skilled workers in the economy (again measured as the ratio of workers in the top quintile to workers in the bottom quintile) was in the order of 11 percentage points. Our results based on all three measures of skill clearly indicate that women increased the relative supply of skill in the

[6]We present changes over 1940-70, 1970-80 and 1980-90 in three separate figures reflecting our ability to match occupations across the different Census years. We are unable to match occupations at the three-digit level across the 1970 and the 1980 Censuses and therefore present results based on 1969-71 and 1979-81 March CPS surveys in Figure 4.

economy in the 1980s.[7] This is a break from past trend where women have typically added more labor to the bottom than the top skill categories. A plausible interpretation of this difference is that the pattern of female labor supply growth in the 1980s largely reflects the differential response of skilled and less skilled women to relative demand shifts favoring more skilled workers in general. However, to the extent that we regard changes in female labor supply as exogenous changes and to the extent that we maintain the assumption that women substitute for men within skill levels, our findings here suggest that women may have actually reduced, rather than increased, the wage gap between skilled and less skilled male workers in the 1980s.

V. Estimates of Factor Price Elasticities using State Data

In this section we use cross-state variation in female labor supply growth and male wage changes to estimate elasticities of factor price between male and female workers. We also estimate elasticities of complementarity, defining high school graduate males as the base group, to assess women's contribution to rising wage inequality in the 1980s. After laying out our framework and describing the data we present our main results in Tables 4 and 5 below.

We begin by specifying an economy consisting of I sectors (defined by industry-occupation cells) and J factors. Assuming a constant returns to scale production technology, we can write the cost function of sector i as

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[7]We suspect that we have somewhat understated the skill upgrading of female workers relative to male workers in the 1980s by ignoring increases in actual labor market experience and the increasing market orientation of women's education in recent years. For example, O'Neill and Polachek (1993) and Blau and Kahn (1994) report that rising relative experience levels among women account for a significant portion of the wage convergence between men and women in the 1980s.

(4) $$C^i(\hat{w}^i, y_i) = A^i(\hat{w}^i)y_i\ , \qquad \hat{w}^i = (W_1/\tau_1^i\ , \ldots, W_J/\tau_J^i)\ , \quad i = 1,\ldots,I$$

$\hat{w}^i$ is a J-dimensional wage vector normalized by sector-specific and factor non-neutral shocks (τ_j^i's). y_i is sector i's output and A^i is the unit cost function of sector i which is homogeneous of degree 1 with respect to $\hat{w}^i$.

Using Shepherd's Lemma, sector i's compensated factor demand for skill group j can be written as

(5) $$X_j^i\ (=\frac{\partial C^i}{\partial W_j}) = A_j^i(\hat{w}^i)\ \frac{y_i}{\tau_j^i}\ , \quad j = 1,\ldots,J$$

where A^i_j is the partial derivative of $A^i(.)$ with respect to the jth element of $\hat{w}^i$. By taking logs and totally differentiating (5), we can write

(6) $$\dot{X}_j^i = \sum_{k=1}^{J} \epsilon_{jk}^i\ (\dot{W}_k - \dot{\tau}_k^i) + \dot{y}_i - \dot{\tau}_j^i$$

where ϵ^i_{jk} is the compensated demand elasticity of factor j with respect to the price of factor k in sector i. The second term, $\dot{y}_i$, represents factor-neutral product market shocks that increase factor demands proportionately within each sector. With profit maximization, we can write $\dot{y}_i$ as a cost share weighted average of input changes as in the following.

(7) $$\dot{y}_i = \sum_{j=1}^{J} \omega_{ij}\dot{X}_j^i\ , \qquad where\ \ \omega_{ij} = \frac{W_jX_j^i}{\sum_{j=1}^{J} W_jX_j^i}$$

Aggregating over all sectors yields

(8) $$\dot{X}_j \; (\equiv \sum_{i=1}^{I} S_{ji}\dot{X}_j^i) = \sum_{k=1}^{J}\left[\sum_{i=1}^{I} S_{ji}\epsilon_{jk}^{i}\right]\dot{W}_k + \sum_{i=1}^{I} S_{ji}(\sum_{j=1}^{J} \omega_{ij}\dot{X}_j^i) + \eta_j$$

where S_{ji} is sector i's share of factor j employment and η_j is the weighted average of sector specific demand shocks for factor j. The first term in (8) corresponds to the change in demand for factor j due to relative wage changes, the second term represents the component due to product demand shocks, and the final term corresponds to the component due to factor specific demand shocks which may or may not vary across sectors.

Assuming that the production function of a given sector does not vary across states, we can arrive at state-level factor demand equations comparable to equation (8) such as

(9) $$\dot{X}_{sj} = \sum_{k=1}^{J}\left[\sum_{i=1}^{I} S_{ji}^{s}\epsilon_{jk}^{i}\right]\dot{W}_{sk} + \sum_{i=1}^{I} S_{ji}^{s}(\sum_{j=1}^{J} \omega_{ij}^{s}\dot{X}_{sj}^{i}) + \eta_{sj}$$

where s subscripts states. By stacking these equations and inverting, we can write

(10) $$\dot{W}_s = E^{-1}\cdot(\dot{X}_s - \dot{D}_s) + E^{-1}\,\eta_s = E^{-1}\,(\dot{X}_s - \dot{D}_s) + \xi_s$$

$\dot{W}_s$ is a Jx1 vector of wage changes, $\dot{X}_s$ is a Jx1 vector of factor employment changes, $\dot{D}_s$ is a Jx1 vector of factor-neutral product demand shifts and ξ_s is a Jx1 vector of factor non-neutral demand shocks in state s. E^{-1} is a J-dimensional square matrix of elasticities of factor price. Our strategy is to estimate (10) using state-level variation in wages and labor supply.[8]

We also derive an equation for elasticities of complementarity by measuring wages and net supplies of skill groups relative to male high school graduates.

[8]Capital is ignored in our factor demands. This may bias our estimates (Berndt, 1980; Grant and Hamermesh, 1979), but we maintain the separability assumption due to lack of data on capital stock at state and industry level.

(11) $$\dot{W}_s^R = C(\dot{X}_s - \dot{D}_s)^R + \psi_s$$

Superscript R indicates that wages and supplies are measured relative to male high school graduate wages and supplies. C is now the J-1 dimensional square matrix of partial elasticities of complementarity.

For our cross-state analysis, we focus on the latter period 1970-1990. To reduce the number of parameters to be estimated we use 6 labor aggregates defined by gender and education (those with < 12 years of schooling, those with 12-15 years of schooling, and those with 16+ years of schooling). Our dependent variables are weekly wages of men in different education category normalized by the state-level fixed-weight wage index at time t. Factor supplies are measured as shares of total annual hours worked (in efficiency units) in state s at time t.

Our demand shift measures are state-level counterparts to the between-sector demand shift measures employed by Katz and Murphy (1992) and are comparable to those used by Bartik (1991), Blanchard and Katz (1992), and Bound and Holzer (1993). We estimate relative demand shifts due to product demand, $\dot{D}_{js}$, for each of our 6 labor inputs by the following formula,

$$\dot{D}_{jst} = \sum_{i=1}^{I} \left[\frac{\hat{N}_{ist} / \hat{N}_{st}}{N_{it} / N_t} - \frac{N_{ist-1} / N_{st-1}}{N_{it-1} / N_{t-1}} \right] \frac{N_{ij}}{N_j}$$

where N_{ij}/N_j is sector i's share of group j's employment in efficiency units and the term inside the brackets is the change in employment share of sector i in state s (normalized by the aggregate change). Intuitively, we predict a positive demand shift for the skill group j in state s if it is predominantly located in sectors which are growing faster than the national average. One concern is that regional differences in sectoral employment changes may reflect exogenous supply changes (such as the influx of low skilled immigrants into the West region). We therefore obtain predicted sectoral employment shares in state s at time t, $\hat{N}_{ist}/\hat{N}_{st}$, by using initial sectoral employment in the state and aggregate changes according to the following formula.

$$\frac{\hat{N}_{ist}}{\hat{N}_{st}} = \frac{N_{ist-1}\,\dfrac{N_{it}}{N_{it-1}}}{\sum_{i=1}^{I} N_{ist-1}\,\dfrac{N_{it}}{N_{it-1}}}$$

Since we lack direct measures of factor specific demand shocks, η_s, its effects remain in our error term. All variables in the regressions are specified as (decade) log changes thereby controlling for state-specific fixed effects. We run weighted least squares where each observation is weighted by the number of wage observations in the state averaged over all years. We use 48 states excluding Washington D.C., Hawaii and Alaska. We explore an alternative cross-sectional variation using SMSA-level data and also report the results in Tables 4 and 5.[9]

We estimate factor price elasticities and elasticities of complementarity by first pooling the 1970-80 and the 1980-90 changes. We also estimate the elasticities using only the 1970-80 changes since a larger part of observed employment changes in the 1980s may reflect demand shifts rather than supply shifts. The parameters estimated from the 1970-80 changes are qualitatively similar to those from the pooled regression but are less precisely estimated. We therefore discuss below the results from the pooled regression and report the

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[9]We limit the number of SMSA's to 51 largest SMSA's that we are able to match across all Census years. The estimation using the 1970-80 changes, reported in the appendix, uses 122 SMSA's. We thank David Jaeger for providing us with the code to match SMSA's across the 1980 and the 1990 Censuses.

1970s results in the appendix.

Table 4 reports factor price elasticities of male wages with respect to each of the 6 labor quantities. In columns (1) and (2) we regress wage changes on factor supply changes without correcting for demand changes. In columns (3) and (4) we use our demand shift measures and regress on *net* supply changes. Turning first to our estimates based on state-level data reported in columns (1) and (3), we find negative and significant own effects for all 3 skill groups which build our confidence in these results. One puzzling finding is that high school graduate men are strong complements in production for high school dropout men. Our state-level data offer weak evidence that women may be substitutes for high school dropout men. For example, the coefficient on college graduate women is marginally significant (at the 10 percent significance level) in the high school dropout equation when net supply measures are used as regressors. The hypothesis that the effect of all three types of women is jointly zero in the high school dropout male equation can be rejected at the 10 percent level, although not at the 5 percent level. There is somewhat stronger evidence that high school graduate women may be complements in production to college graduate men although this result disappears when we focus on only the 1970-80 changes.

In the SMSA-level regressions reported in columns (2) and (4), the own effects are negative and significant for high school dropout men but insignificant for high school and college graduate men. Our failure to find significant own effects in the high school graduate and the college graduate equations may reflect our inability to match SMSA's cleanly across all Census years due to changing definitions of county groups. Also, labor mobility between adjacent SMSA and non-SMSA areas may weaken the link between price and quantity changes observed between SMSA's. It is worth noting, however, that in the high school dropout equation where we do estimate strong own effects, we do not find substitution effects between women and high school dropout men.

We also estimate (partial) elasticities of complementarity using male high school graduates as the base group and we report these results in Table 5. Based on the state-level regressions reported in column (1) we find that college graduate women have a significant negative effect (-.07) on the wage ratio between high school dropout and high school graduate men implying that increasing numbers of college educated women will increase wage inequality between the bottom two male skill groups. Again, while we find significant own effects in the high school dropout equation we do not find substitution between women and men based on SMSA-level data.

Given that the labor share of female college graduates relative to high school graduate males increased approximately 67 percent from .18 in 1979 to .30 in 1989 the state-level regression result implies that increasing labor supply of highly skilled women contributed approximately 3.5 log points (=log(.30/.18) x .07) to the wage inequality between high school dropout and high school graduate men in the 1980s. Since the relative wage of high school dropouts to high school graduates (those with 12-15 years of schooling) declined roughly 2.4 log points, increase in the supply of college educated women more than accounts for the entire rise in wage inequality in the bottom half of the distribution. These results are comparable to those reported in Topel (1994) in that taken literally they imply that had high skilled women not increased their labor supply, high school dropout men would have experienced an increase in their relative wage, mainly due to the rapid decline in their own supply.

There are at least two caveats to the above observation. First, the 67 percent increase cited above is based on actual observed female employment changes as opposed to changes *net of demand changes*. Our findings based on aggregate changes already suggested that demand shifts were important in the 1980s. More specifically, with regards to women, a number of previous studies have suggested that demand shifted in favor of women in the

1980s. For example, as reported by Katz and Murphy (1992) (a finding we confirm in this paper with Census data), female wages increased relative to male wages during the 1980s even as the relative supply of women increased, suggesting demand must have shifted in favor of women. This simultaneous rise in the price and quantity of female labor remains even after one takes into account changes in the skill composition of the female labor force such as the rise in their actual labor market experience (Blau and Kahn (1994)). Demand shift measures based on changes in industrial composition of the labor force also suggest that labor demand has shifted in favor of women over men (Katz and Murphy (1992)). These findings suggest to us that using our cross-sectional estimates together with the actual observed aggregate changes in female labor supply most likely results in an upper bound estimate of women's contribution to declining male wages and rising inequality in the 1980s.

The second caveat is that our cross sectional estimates may be biased for similar reasons. While our demand measures account for between-sector demand shifts, we have not accounted for factor specific demand changes which may have occurred within sectors. To the extent that we imperfectly capture demand shifts away from low-skilled male workers toward high-skilled female workers in our estimation this will bias our results toward finding "substitution" between these two groups. We explore this possibility in columns (3) and (4) of Table 5. In columns (3) and (4), we include factor supply changes and our demand shift measures as separate regressors. If our demand shift measures understate true demand shifts by constant proportions, this method will yield consistent estimates under standard assumptions. When we include our demand measures as separate regressors in the high school dropout equation, the significant own price effect remains while the negative and significant effect of college educated women disappears. Instead, the results in column (3) suggest that college educated women may actually lower the wage of college graduate men relative to high school graduate men.

VI. Conclusion

In this paper we have examined to what extent rapid increases in female labor supply contributed to rising wage inequality and to declining real wages of less skilled males during the 1980s. Based on aggregate changes we find: 1) female labor supply growth slowed in the 1980s relative to the 1970s and 2) women increased the relative supply of skill in the economy in the 1980s. These findings are inconsistent with a simple story in which supply shifts among women have played a major role. Instead, they further support the view that relative demand shifts, rather than supply shifts, have been the underlying cause of declining opportunities for less skilled males and rapid inequality growth in the 1980s.

Recently, Topel (1994) has suggested that cross-substitution effects may exist between men and women of different skill level. More specifically, the entry of skilled women in the 1980s may have worked to the disadvantage of less skilled men. In a more general framework, we estimate these cross-substitution effects using state and SMSA-level data. Our state-level regressions offer weak evidence that women may be substitutes in production for high school dropout men and that college graduate women may have contributed to wage inequality in the 1980s by being better substitutes in a relative sense for high school dropout than high school graduate men. These effects, however, turn out to be insignificant when we allow our demand shift measures to play a larger role.

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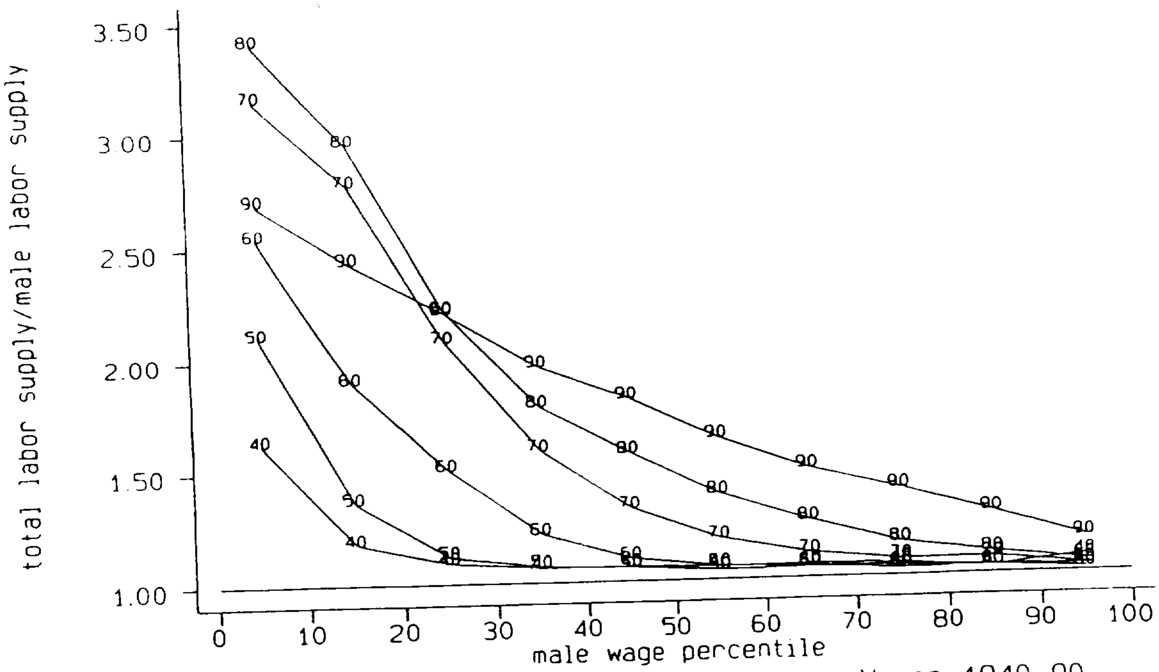

Fig. 1 Female Contribution to Labor Based on Wages 1940-90

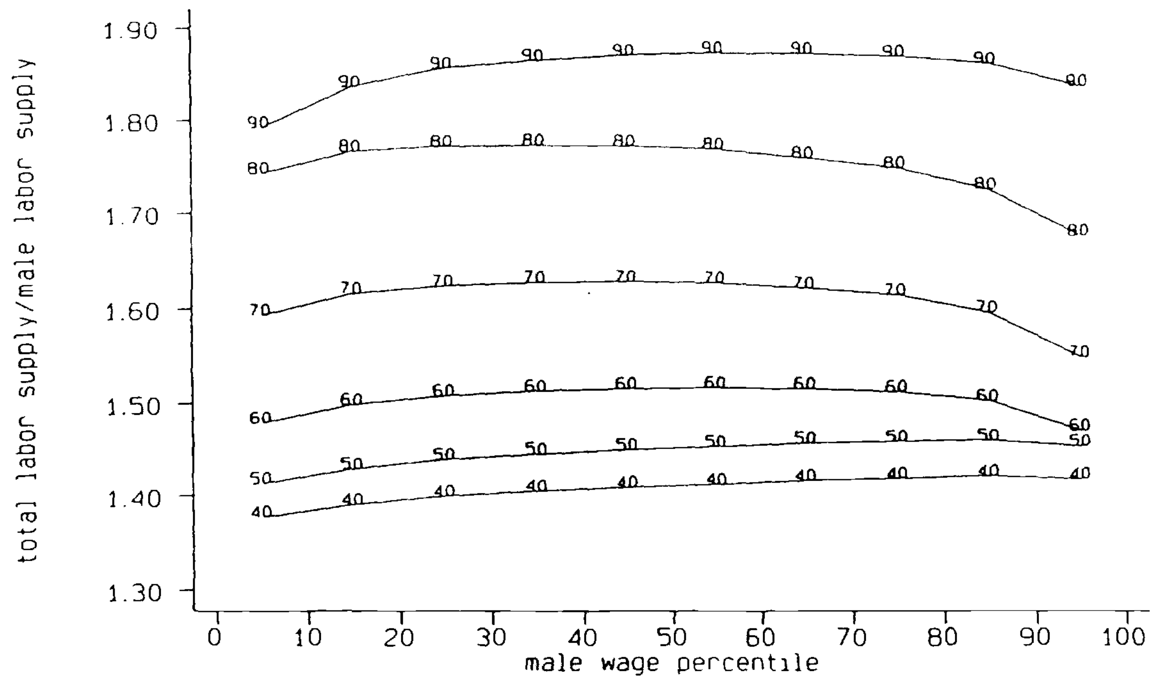

Fig. 2 Female Contribution to Labor Based on Education 1940-90

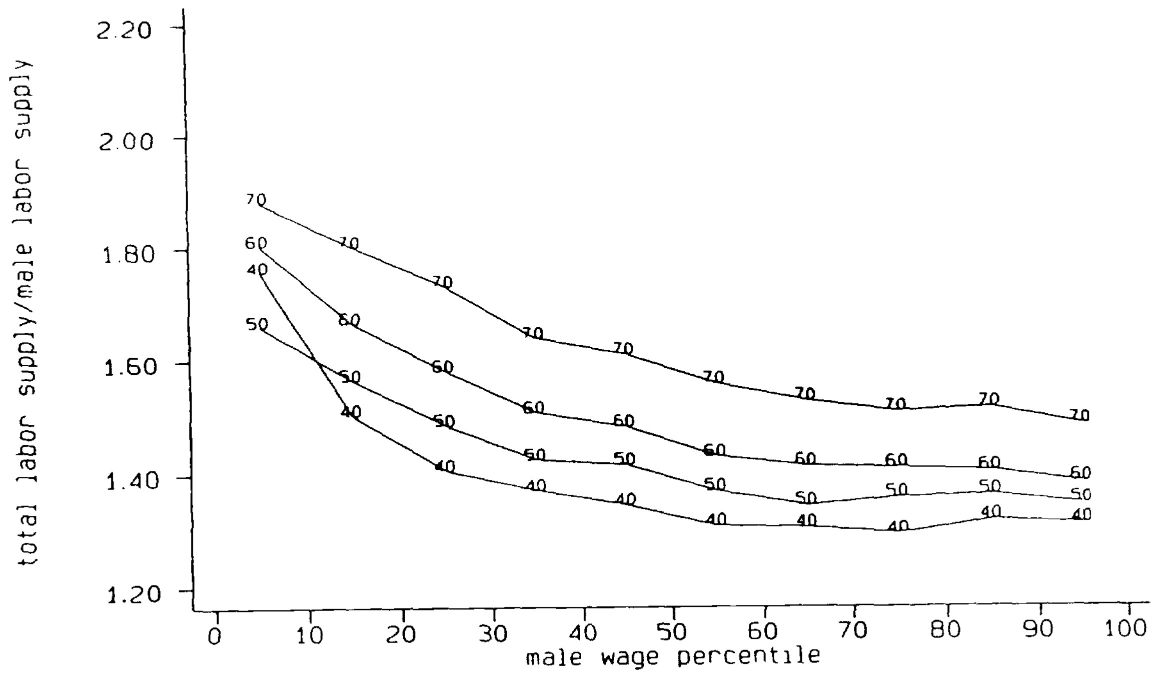

Fig. 3 Female Contribution to Labor Based on Occupation 1940-70

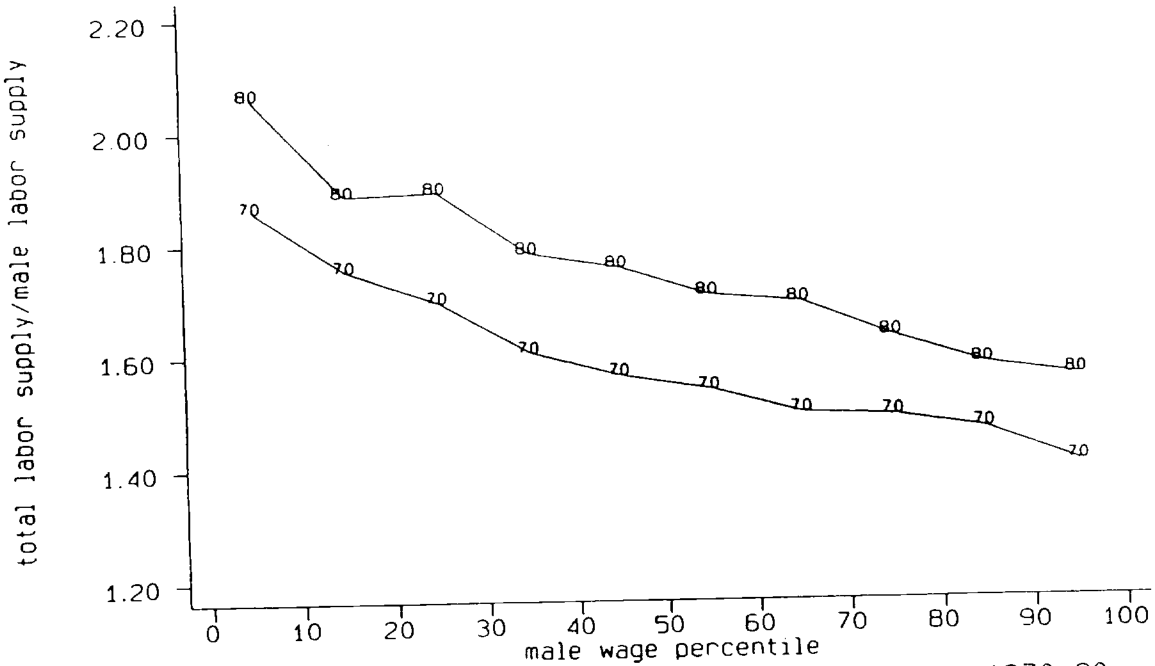

Fig. 4 Female Contribution to Labor Based on Occupation 1970-80

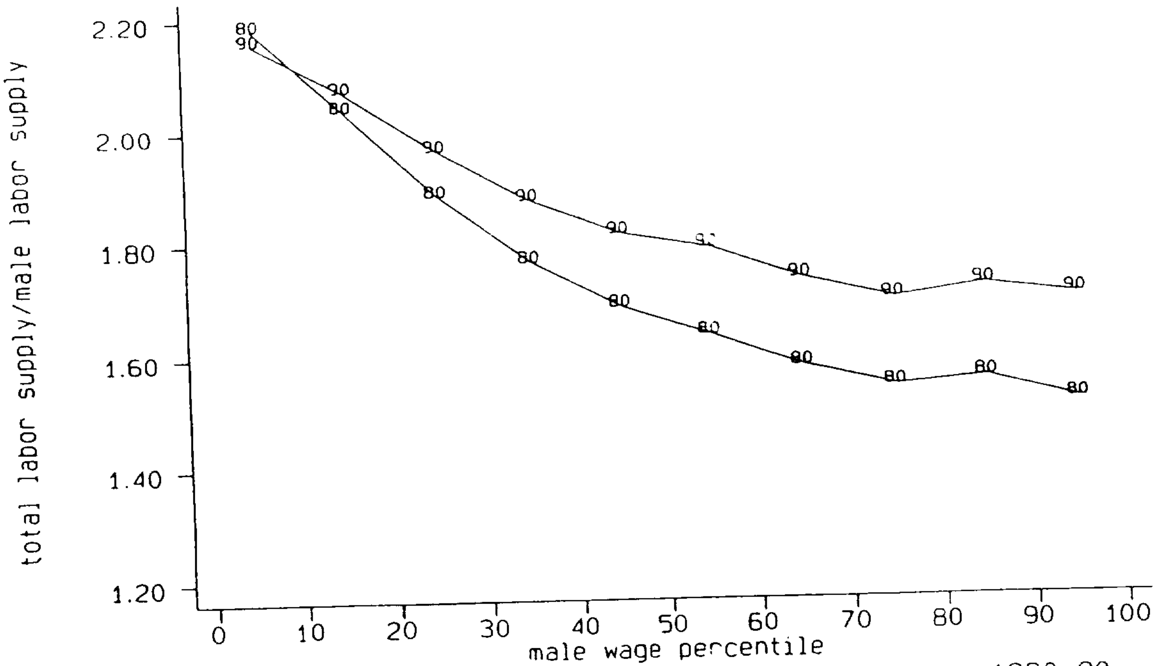

Fig. 5 Female Contribution to Labor Based on Occupation 1980-90

Table 1

Change in Log Average Weekly Wage
(Multiplied by 100)

	Year				
	1939-49	1949-59	1959-69	1969-79	1979-89
All	13.1	24.7	20.6	1.1	-5.8
Men	13.2	25.6	21.1	1.1	-8.5
Women	12.9	22.2	19.3	0.9	1.5
Men:					
<8	20.9	22.0	19.5	6.1	-11.0
8-11	16.6	23.3	17.6	1.8	-12.5
12	12.0	24.9	19.7	3.0	-14.1
13-15	13.2	26.1	20.8	-0.9	-7.3
16+	7.1	30.7	27.6	-2.6	2.5
Women:					
<8	20.0	24.5	23.6	5.8	-5.0
8-11	17.5	20.0	17.4	4.2	-5.3
12	15.8	19.7	16.4	1.7	-2.2
13-15	12.8	20.2	19.1	1.5	4.5
16+	1.4	30.6	25.2	-5.8	13.1

Notes: The numbers are calculated from the 1940-1990 PUMS files. The sample includes men and women with 1-40 years of potential labor market experience who were in the non-agricultural sector, who worked full-time and at least 40 weeks, who were not self-employed, and who earned at least 1/2 the legal minimum weekly wage.

Table 2

Female Employment Population Ratios

A. All Women

1940	1950	1960	1970	1980	1990
.263	.324	.392	.474	.585	.679

B. Education

	1940	1950	1960	1970	1980	1990
<8	.205	.265	.327	.362	.377	.397
8-11	.232	.291	.364	.418	.446	.470
12	.346	.365	.408	.495	.595	.667
13-15	.340	.381	.434	.512	.654	.743
16+	.455	.477	.546	.601	.723	.804

C. Employment of Married Women

Male Wage Quintile	1940	1960	1970	1980	1990
1-20	.149	.326	.437	.511	.598
21-40	.153	.320	.440	.555	.678
41-60	.144	.293	.409	.550	.688
61-80	.138	.262	.376	.522	.666
81-100	.122	.194	.306	.471	.610

Notes: The numbers are calculated from the 1940-1990 PUMS files. The sample includes women with 1-40 years of potential labor market experience who were not in school or military service. Employment rates reported in panels A and B are fractions of women who were working during the survey week. The employment rates reported in panel C are based on a sample of married women and numbers are reported by husband's wage quintile. Employment rates are calculated by dividing number of weeks worked last year by 52.

Table 3

Female Share of the Labor Force

A. All Women - Unweighted

1940	1950	1960	1970	1980	1990
.288	.308	.335	.379	.428	.461

B. All Women - Hours Weighted

1939	1959	1969	1979	1989
.258	.266	.305	.364	.408

C. Women by Education - Unweighted

	1940	1950	1960	1970	1980	1990
<8	.053	.047	.035	.020	.013	.004
8-11	.114	.104	.110	.094	.062	.052
12	.079	.102	.123	.170	.192	.145
13-15	.024	.031	.038	.052	.087	.152
16+	.019	.024	.030	.043	.075	.109

D. Women by Education - Hours Weighted

	1939	1959	1969	1979	1989
<8	.046	.026	.016	.010	.003
8-11	.101	.085	.073	.049	.040
12	.075	.102	.140	.165	.127
13-15	.020	.030	.042	.075	.137
16+	.015	.023	.033	.064	.101

Notes: The numbers are calculated from the 1940-1990 PUMS files. Panels A and C report the number of women working during the survey week divided by the total number of workers during the survey week. Panels B and D report annual hours worked by women as a share of total annual hours worked. Annual hours for 1949 are not reported due to the unreliability of the weeks worked data.

Table 4

Estimated Elasticities of Factor Price

	(1)	(2)	(3)	(4)
<u>Wage of Men <12</u>				
Labor Quantities				
<12 Men	-.14*(.04)	-.14*(.04)	-.14*(.05)	-.14*(.04)
12-15 Men	.30*(.09)	.22*(.08)	.32*(.09)	.22*(.08)
16+ Men	.03 (.08)	-.03 (.06)	.03 (.08)	-.03 (.06)
<12 Women	-.06 (.04)	-.04 (.04)	-.07 (.04)	-.05 (.04)
12-15 Women	-.08 (.09)	-.04 (.08)	-.09 (.09)	-.04 (.08)
16+ Women	-.05 (.03)	.04 (.04)	-.06*(.03)	.04 (.04)
Year Dummy=89	-.11*(.02)	-.07*(.02)	-.12*(.02)	-.06*(.02)
State U Rate	-.01*(.00)		-.01*(.00)	
<u>Wage of Men 12-15</u>				
Labor Quantities				
<12 Men	.01 (.02)	.00 (.02)	.01 (.02)	.00 (.02)
12-15 Men	-.07*(.04)	-.01 (.03)	-.07 (.04)	-.01 (.02)
16+ Men	.03 (.03)	.04 (.03)	.04 (.03)	.04 (.03)
<12 Women	-.01 (.02)	-.01 (.02)	-.02 (.02)	-.01 (.02)
12-15 Women	.02 (.04)	-.03 (.03)	.02 (.04)	-.03 (.03)
16+ Women	.02 (.01)	.01 (.02)	.01 (.02)	.01 (.02)
Year Dummy=89	-.07*(.01)	-.06*(.01)	-.07*(.01)	-.06*(.01)
State U Rate	-.00 (.00)		-.00 (.00)	
<u>Wage of Men 16+</u>				
Labor Quantities				
<12 Men	.02 (.04)	.01 (.03)	.02 (.04)	.01 (.03)
12-15 Men	-.10 (.08)	-.08 (.06)	-.07 (.08)	-.09 (.06)
16+ Men	-.14*(.07)	-.00 (.04)	-.16*(.07)	-.01 (.04)
<12 Women	.02 (.04)	.03 (.03)	.02 (.04)	.01 (.03)
12-15 Women	.19*(.08)	.12*(.06)	.16*(.08)	.13*(.06)
16+ Women	.01 (.03)	-.05*(.03)	.03 (.03)	-.06*(.03)
Year Dummy=89	.09*(.02)	.08*(.01)	.09*(.02)	.08*(.01)
State U Rate	-.00 (.00)		.00 (.00)	
Demand Shifts Included	No	No	Yes	Yes
Units of Obs.	State	SMSA	State	SMSA
No. of Obs.	96	102	96	102

Notes: (*) denotes significance at the 5% level and (·) denotes significance at the 10% level.
Homogeneity restriction is imposed on all equations.

Table 5

Estimated Partial Elasticities of Complementarity

	(1)	(2)	(3)	(4)
<u>Wage of Men < 12</u>				
Labor Quantities				
<12 Men	$-.15^{*}$(.05)	$-.15^{*}$(.04)	$-.15^{*}$(.05)	$-.15^{*}$(.04)
16+ Men	.00 (.04)	-.02 (.03)	-.00 (.04)	-.01 (.04)
<12 Women	-.05 (.05)	-.04 (.04)	-.03 (.05)	-.04 (.04)
12-15 Women	-.11 (.10)	-.03 (.08)	-.07 (.10)	-.01 (.09)
16+ Women	$-.07^{*}$(.03)	.02 (.04)	-.03 (.04)	.00 (.04)
Year Dummy=89	$-.05^{*}$(.02)	.00 (.02)	.03 (.04)	.00 (.02)
State U Rate	$-.01^{+}$(.00)		-.00 (.00)	
<u>Wage of Men 16+</u>				
Labor Quantities				
<12 Men	.00 (.04)	-.02 (.03)	-.00 (.04)	-.01 (.04)
16+ Men	$-.19^{*}$(.09)	-.04 (.06)	-.09 (.09)	-.02 (.06)
<12 Women	.04 (.04)	.04 (.04)	.02 (.04)	.04 (.04)
12-15 Women	.13 (.10)	$.15^{+}$(.08)	.11 (.11)	.09 (.09)
16+ Women	.01 (.04)	-.07 (.04)	$-.15^{*}$(.05)	-.06 (.05)
Year Dummy=89	$.16^{*}$(.02)	$.15^{*}$(.02)	.04 (.04)	$.13^{*}$(.02)
State U Rate	.00 (.00)		-.00 (.00)	
Demand Shifts as Separate Regressors	No	No	Yes	Yes
Units of Obs.	State	SMSA	State	SMSA
No. of Obs.	48	122	48	122

Notes: (*) denotes significance at the 5% level and (+) denotes significance at the 10% level.

Symmetry restriction is imposed on all equations.

(1), (2): Regressors are log changes in relative net supplies.

(3), (4): Regressors are log changes in relative supplies and relative demand changes.

Appendix

Estimated Elasticities of Factor Price
1970-80 Changes Only

	(1)	(2)	(3)	(4)
<u>Wage of Men <12</u>				
Labor Quantities				
<12 Men	-.24*(.09)	-.13*(.04)	-.25*(.09)	-.13*(.04)
12-15 Men	.40*(.11)	.21*(.06)	.39*(.11)	.21*(.06)
16+ Men	.01 (.10)	-.01 (.04)	.01 (.09)	-.01 (.04)
<12 Women	.03 (.07)	-.04 (.03)	.02 (.07)	-.04 (.03)
12-15 Women	-.12 (.12)	-.04 (.06)	-.10 (.12)	-.04 (.06)
16+ Women	-.07*(.04)	-.00 (.03)	-.07*(.03)	-.00 (.03)
State U Rate	.00 (.00)		.00 (.00)	
<u>Wage of Men 12-15</u>				
Labor Quantities				
<12 Men	.02 (.05)	-.03 (.02)	.04 (.05)	-.03 (.02)
12-15 Men	-.09 (.06)	-.03 (.03)	-.10 (.06)	-.03 (.03)
16+ Men	.01 (.05)	.01 (.02)	.04 (.05)	.01 (.02)
<12 Women	.01 (.04)	.02 (.02)	-.01 (.04)	.02 (.02)
12-15 Women	.03 (.06)	.04 (.03)	.02 (.07)	.04 (.03)
16+ Women	.02 (.02)	-.00 (.01)	.01 (.02)	-.00 (.01)
State U Rate	-.00 (.00)		-.00 (.00)	
<u>Wage of Men 16+</u>				
Labor Quantities				
<12 Men	.05 (.09)	.10*(.04)	.06 (.09)	.10*(.04)
12-15 Men	-.09 (.11)	-.11*(.05)	-.07 (.11)	-.10*(.05)
16+ Men	-.07 (.10)	-.01 (.04)	-.07 (.09)	-.01 (.04)
<12 Women	.01 (.07)	-.00 (.03)	-.00 (.07)	-.02 (.03)
12-15 Women	.05 (.12)	.03 (.05)	.03 (.12)	.03 (.05)
16+ Women	.05 (.04)	-.00 (.02)	.05 (.03)	-.00 (.02)
State U Rate	-.01 (.01)		.01 (.01)	
Demand Shifts Included	No	No	Yes	Yes
Units of Obs.	State	SMSA	State	SMSA
No. of Obs.	48	122	48	122

Notes: (*) denotes significance at the 5% level and (·) denotes significance at the 10% level.
Homogeneity restriction is imposed on all equations.

Appendix

Estimated Partial Elasticities of Complementarity
1970-80 Changes Only

	(1)	(2)	(3)	(4)
Wage of Men < 12				
Labor Quantities				
<12 Men	-.28*(.12)	-.10*(.05)	-.32*(.10)	-.09*(.05)
16+ Men	.00 (.08)	.07^{+} (.04)	-.03 (.07)	.05 (.04)
<12 Women	-.02 (.09)	-.06 (.04)	.09 (.07)	-.06 (.04)
12-15 Women	-.14 (.15)	-.09 (.07)	-.06 (.13)	-.07 (.07)
16+ Women	-.09*(.04)	-.02 (.03)	-.03 (.05)	-.02 (.03)
State U Rate	-.00 (.01)		.01 (.01)	
Wage of Men 16+				
Labor Quantities				
<12 Men	.00 (.08)	.07^{+}(.04)	-.03 (.07)	.05 (.04)
16+ Men	-.11*(.12)	-.02 (.05)	.06 (.11)	-.00 (.05)
<12 Women	.02 (.07)	.01 (.05)	-.03 (.06)	.02 (.04)
12-15 Women	.01 (.16)	-.02 (.07)	-.03 (.13)	-.03 (.07)
16+ Women	.04 (.04)	.00 (.03)	-.15*(.05)	.02 (.03)
State U Rate	-.01 (.01)		-.01 (.01)	
Demand Shifts as separate regressors	No	No	Yes	Yes
Units of Obs.	State	SMSA	State	SMSA
No. of Obs.	48	122	48	122

Notes: $^{(*)}$ denotes significance at the 5% level and $^{(+)}$ denotes significance at the 10% level.

Symmetry restriction is imposed on all equations.

(1), (2): Regressors are log changes in relative net supplies.

(3), (4): Regressors are log changes in relative supplies and relative demand changes.