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The fortunes of one's birth: Relative cohort size and the youth labor market in the United States

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Abstract. Using two different measures of relative cohort size – one indicating the size and placement of an individual's own birth cohort, and the other, the ratio of young to prime age adults in the United States in that year – it has been possible to isolate strong effects of the population age structure on wages in the United States over the past thirty-three years. These effects have been strong enough that virtually all of the observed change in the experience premium, and a substantial proportion of the changes in the college wage premium, can be explained by the relative cohort size variables alone. Even changes in the amount of within-group variance in wages appear to be largely a function of changing age structure, and absolute wage levels have been strongly affected by these demographic changes, suggesting that population growth can have positive effects on the economy.

JEL classification: J21, J23, J31

Key words: Wages, cohort size, youth labor market

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1. Introduction

To what extent have the major dislocations observed in the United States youth labor market over the last 35 years – especially declining relative and absolute wages – been a function of changes in the age structure of the population? Studies such as Katz and Murphy (1992), Bound and Johnson (1992), Levy and Murnane (1992), and Murphy and Welch (1992) all conclude that shifts in labor supply due to the baby boom and bust cannot account for the changes observed, at least since 1980: they appeal to shifts in the composition of labor demand. But to what extent have shifts in *demand* been a function of changing age structure in the population? The large number of studies which have attempted to measure the effects of age structure on wages have assumed that these would be related only to the excess supply of labor created by large cohort size. They have ignored any potential aggregate demand effects related to population growth and change.

The idea of strong aggregate demand effects of population change is not new. Simon Kuznets (1958, 1961) identified cycles in economic activity which induced new population growth, in the form of international migration, and were in turn reinforced by the induced investment created by that population influx. Others (for example, Lösch 1937; Abramovitz 1961; Hall 1963; Kelley 1965, 1968, 1969; Ben-Porath 1997) even suggested that the initial cycles in economic activity observed by Kuznets were generated by changes in population age structure. Richard Easterlin's (1968) work on long swings in economic activity elaborated on and extended Kuznets' work, and demonstrated the substitutability between growth through international migration and indigenous fertility rates. And recent work such as Mankiw and Weil (1989), McMillan and Baesel (1990), and Fair and Dominguez (1991) suggests continued significant effects.

The work presented in this paper is based on the hypothesis that changes in domestic consumption – and in the induced investment generated by that consumption – have resulted from the sharp changes which have occurred in various age groups in the population in the postwar period. The passage of the baby boom, and then the baby bust, into the labor market and household formation stages was not a smooth and gradual process: it was characterized by a number of 'spikes' when growth surged and then fell dramatically – sometimes by over 15% in just a five-year period. For example following its 1945–47 run-up from 85.9 to 113.3, the General Fertility Rate (GFR: the number of births per 1000 women aged 15–44 in a given year) then dropped back to about 106 for the next three years – and in 1961 it declined from 117.1 to 90.8 in just 5 years, and then seemed to be on another upswing when in 1968–1970 it rose 6.6% – and then dropped 16% in the next 3 years.

In a market as finely tuned to changes in 'underlying fundamentals' as the U.S. economy, such sharp fluctuations are likely to have caused strong ripple effects through investment and consumption multipliers, as these fluctuations passed through key age groups. The condition of the U.S. economy twenty years after any of the dates mentioned above suggests that is indeed the case. In addition, when the baby boomers were children in their parents' households they contributed to significant changes in consumption as a proportion of household income, as they grew from toddlers to teenagers – changes which contributed to the strong growth in the economy in the 1960s, but then fell off dramatically in the 1970s as the boom in children turned into a bust (Lazear and Michael 1988; Macunovich 1997).[1] These aggregate demand effects would have differentially affected the wages of segments of the labor market depending on those segments' proximity to their full employment rate of unemployment.

The objective of this paper is to demonstrate that two simple measures of relative cohort size, designed to capture both supply and demand effects of population change, appear to explain the bulk of between-group – and a significant proportion of within-group – variation in wages observed over the past thirty-five years. Because earlier studies of relative cohort size effects have focused on the wages of white males working full time, that is also the focus of the current analysis.[2]

2. The model

The theoretical model which underlies the analysis presented in this paper can be formalized as follows. Assume a constant elasticity of substitution (CES) production function

$$Q_S = f(\mathbf{L}, K, \Theta) \tag{1}$$

where $\mathbf{L}$ is a vector of employed population groups $L_{x,e}$, $x = 1, 2 \ldots 49+$; $e = <8$, 8–11, 12, 13–15, 16, 17+; and an aggregate demand function

$$Q_D = g(PCE, \mathbf{M}, \Delta, \mathbf{Z}). \tag{2}$$

$Q_D = Q_S$ in equilibrium, with $PCE = h(\mathbf{P}, Y)$ where $\mathbf{P}$ is a vector of population age groups P_a, $a = 0, 1, 2 \ldots 75+$; $\mathbf{M}$ is a vector of military enlisted groups $M_{x,e}$; and $\mathbf{P} = \mathbf{L} + \mathbf{U} + \mathbf{M} + \mathbf{N}$, with

$a =$	age
$e =$	completed years of education
$x =$	years of work experience
$K =$	non-labor inputs into production
$\mathbf{N} =$	vector of population not in the labor force or the military, by age
$PCE =$	personal consumption expenditures
$\Theta =$	technological change
$\mathbf{U} =$	vector of unemployed population, by age
$W =$	real wage
$\Delta =$	international trade
$Y =$	income
$\mathbf{Z} =$	a vector of all other components of Q_D.

Q_s is assumed to be increasing in all inputs, and holding all other inputs constant with i and j representing years of experience $(i \neq j)$

$$\begin{aligned} ln(W_{i,e}/W_{j,e}) = ln(\alpha_{i,e}/\alpha_{j,e}) - (1/\xi_{ij,e})\, ln(L_{i,e}/L_{j,e}) \\ - ((\Theta_{j,e} - \Theta_{i,e})/\xi_{ij,e})t, \end{aligned} \tag{3}$$

where $\alpha_{i,e}$ is the intensity of use of $L_{i,e}$ in producing Q_S, $\xi_{ij,e}$ is the (positive) elasticity of substitution between $L_{i,e}$ and $L_{j,e}$, $\Theta_{i,e}$ is the effect of technological change on $L_{i,e}$ and t is some function of time. It is assumed that $\xi_{ij,e}$ is a decreasing function of e as suggested, for example, by Freeman (1979) and Welch (1979), and that for $i < 10$ and $j \geq 10$, it is a decreasing function of $j - i$ up to $j \approx 35$, but increasing thereafter.

Also, it is assumed that $\delta Q_D/\delta P > 0$, $\delta Q_D/\delta Y > 0$, and $\delta Q_D/\delta M > 0$, but $\delta\Theta/\delta M < 0$ (because of diversion of funding from research to military expenditures caused by the military buildup), and $\delta\Theta/\delta\Delta > 0$ (with increasing specialization brought about by increasing globalization of trade). $\delta(W_{i,e}/W_{j,e})/\delta(M_{i,e}/M_{j,e}) > 0$ (because the proportional increase in young people in the military reduces their relative supply in the civilian labor force).

If, as suggested by the literature cited in the previous section, $\bigwedge_i = \delta(PCE/Y)/\delta(P_i/P) > 0$ when $i < 25$, and $\bigwedge_j \neq \bigwedge_k$ when $j \neq k$, then the passage of the baby boom through the younger ages would have caused marked changes in the year-to-year growth of Q_D. If $\mathbf{U} \leq \mathbf{U_N}$ (where $\mathbf{U}_N$ is the full employment rate of unemployment), then assuming an adequate supply of K (and/or an increase in Θ), $\delta(\delta Q_S/\delta L)/\delta(P_i/P) > 0$ and thus $\delta W/\delta(P_i/P) > 0$: population-induced increases in aggregate demand will tend to result in wage increases when the economy is at full employment. And, at any given level of P_i/P, for $i < 25$, it is assumed that younger cohorts will tend to be closer to full employment when $\delta(P_i/P) > 0$ (on the leading edge of a population boom), than when $\delta(P_i/P) < 0$ (on the lagging edge of a population boom, after the largest cohorts have entered the labor market and swelled the ranks of the unemployed). Thus, in addition to its effect on the *general* wage level, changing population age structure will tend to have a differential positive aggregate demand effect, on the relative wages of the young: the effect is more likely to be translated into wage increases for the young on the leading than on the lagging edge of the boom in labor market entrants. The same type of differential effect could be expected with regard to skill level: higher skill groups who always tend to be closer to their $\mathbf{U}_N$ would not experience as great a differential on the two sides of a boom, as lower skilled groups, because of this full employment effect.

3. Rethinking relative cohort size measures

It is fairly typical in analyses of relative cohort size effects, to develop cohort size measures using labor force data. Many have used ratios of the numbers of workers in each education-experience cell relative to the total number with that level of education (as, for example, in Welch 1979; Freeman 1979; Berger 1984, 1985; and Murphy *et al.* 1988). Murphy and Welch (1992) take this to an extreme by calculating not simply the number of workers, but the number of *hours worked*, by members of each education-experience cell. This type of calculation ignores any potential endogeneity of hours and weeks worked, educational attainment, and even labor force participation rates, with respect to relative cohort size. The number of hours worked by a cohort with an excess supply of labor will not be a good measure of the pressure on wages created by that excess supply, and the proportion choosing to pursue a college education has been hypothesized to vary at least in part as a function of changing cohort size.

Endogeneity is a factor acknowledged by, for example, Mincer (1991) and Berger (1989), who used population totals by age group to develop their relative cohort size measures. Similarly, in a recent cross-national analysis of the youth labor market, Korenman and Neumark (1997) used lagged births (both absolute and relative to the current older adult population) to control for cohort size, acknowledging the potential endogeneity of current population measures as a result of migration. This is similar to work by Lillard and Macunovich 1988; Macunovich and Lillard 1989; and Macunovich, forthcoming.

But what is an appropriate series to use: lagged births – an absolute measure – or lagged birth rates – as, for example, the General Fertility Rate (GFR)? The two have followed nearly identical paths since the middle of the century; because of this, they have tended to be used interchangeably by some researchers. But the use of lagged births is suspect since it is, theoretically, an unbounded series: an estimated negative relationship between absolute cohort size and wages would imply an infinitely declining wage series. In addition, a lagged birth series does not give any indication of *relative* numbers – the ratio of younger to older members of the population, between whom substitutability in the labor market is assumed to be most difficult – and constructing a ratio using the current adult population leads back once again to problems of endogeneity.

This analysis makes use of the rate – the GFR – since the pattern of the lagged GFR very closely approximates that of a current population ratio of young to old – but the lagged GFR has the advantage of exogeneity. The national ratio of the population aged 20–22 to those aged 45–49, and the GFR lagged 20 years, are presented in the top panel of Fig. 1, and their first differences are presented in the bottom panel of that figure. Notable there is the contrast between strong positive values in the 1950s, 1960s and early 1970s, and strong negatives in the following twenty years. The years 1973, 1985, 1990 and 1998 are indicated by vertical lines in the bottom panel: there is a striking correlation between the pattern of the first difference of the lagged GFR, and the strength of the economy during this period – and for that matter, in earlier periods at least as far back as World War II.[3]

The GFR is used here in two different forms, the first representing supply effects and the second, demand effects of relative cohort size. In the first we assign to each individual the GFR associated with his year of birth (using the log of a five year moving average of that series), together with a change variable (logged GFR in $T+2$ minus logged GFR in $T-2$, where T is an individual's year of birth) to differentiate individuals born on the leading from those born on the lagging edge of any upswings.[4] This individual (cohort) measure will be referred to as *birth cohort size*, and remains constant for a cohort throughout its lifetime, as does its log difference, which is positive on the leading edge of any increase, and negative on the trailing edge.

It is assumed that those born on the lagging edge experience more adverse supply effects of cohort size, than those born on the leading edge, because throughout life they follow a supply glut caused by the passage through each career phase of the largest cohorts born at the peak of the boom: those born on the lagging edge will always be further away from their $\mathbf{U}_N$, than those born on the leading edge, *ceteris paribus*. Thus, the coefficient on an individual's birth cohort GFR will reflect a lifelong negative (supply) effect on his wage level – the 'fortunes of one's birth' (Easterlin 1987) – mitigated by a

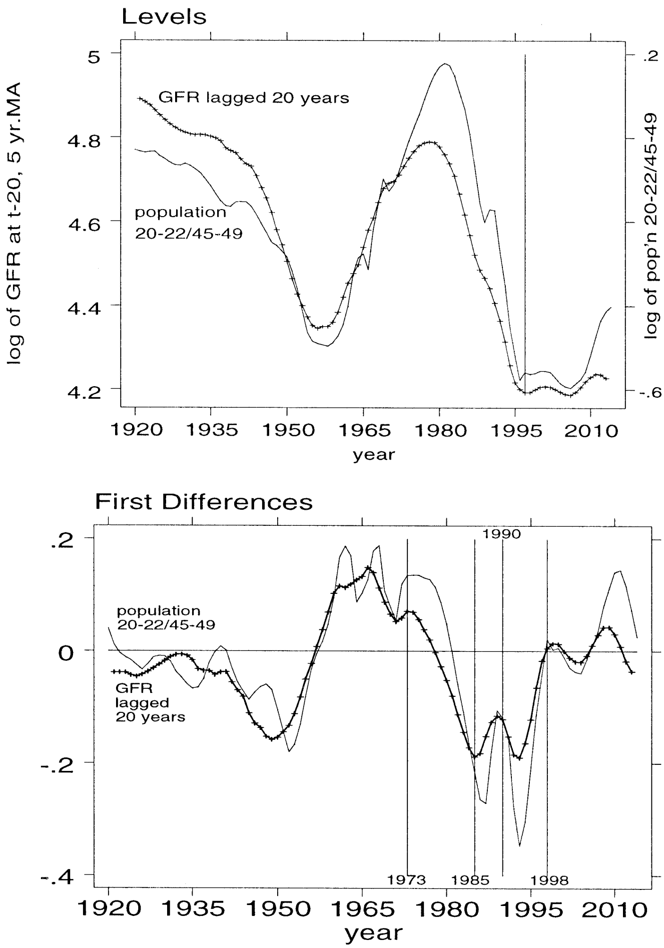


Fig. 1. General fertility rate (GFR), 5 year moving average, lagged 20 years, and current population ratio.

positive differential effect (leading versus lagging) of his first difference measure. An individual's entire wage profile will be shifted as a result of the effect of birth cohort size on his entry level wage. This assumption differs from that made by Welch (1979), who assumed that an initially steeper wage profile for large cohorts would cause the dissipation of their entry-level disadvantage by the end of a "learner" phase. The assumption here is that the shape of an individual's career profile after entry will be a function of the *size of succeeding entry-level cohorts* – the aggregate demand effect of current relative cohort size in the population. Welch's data set (1968–1976) observed only leading edge cohorts in the "learner" phase, cohorts whose initial career profile was buoyed up by the positive aggregate demand effects of the larger cohorts who followed them into the labor market.

This then brings us to the second of the two uses of the GFR mentioned above, the form intended to capture aggregate demand effects of relative cohort size in the current population. A birth cohort's own size relative to that of its parents will tell us little about its fortunes later in life, apart from the shift mentioned above. If there are aggregate demand effects of changes in the population age structure affecting a cohort's wage growth over time, they will be the result of more general measures of *current* population ratios. And here, once again, observed measures are plagued by problems of endogeneity, which can be overcome once again by using the GFR, this time lagged twenty years and constant for all individuals in a given year, rather than a given birth cohort.[5] Such a ratio – which will be referred to as *current cohort size* – is more likely to result in wage increases on an upswing than on a downswing in economic activity because of full employment effects, so that here again it will be necessary to include the first difference as well as the level of the variable. Both the level and the first difference are expected to have a positive effect on wages. The aggregate demand effect of current cohort size ($CCS_t = \beta_1 GFR_{t-20} + \beta_2 \Delta GFR_{t-20}$, where β_1 and β_2 are the estimated coefficients on the current cohort size variable and its first difference, respectively) is estimated as a net effect on the entry-level cohort after controlling for the negative supply effect of current cohort size on that entry-level cohort ($BCS_t = \beta_3 GFR_{t-20} + \beta_4 \Delta GFR_{t-20}$, where β_3 and β_4 are the estimated coefficients on the birth cohort size variable and its first difference, respectively).

If there were no interaction terms included in the model, the total estimated effect of cohort size in year t, on a cohort which had entered in year $t-i$ would be $BCS_{t-i} + CCS_t$. However, the supply effect of current cohort size in year t on a cohort with i years of experience will be poorly approximated using BCS_{t-i} as i becomes large. A correction term is required, $\xi BCS_t - BCS_{t-i}$, where ξ is Hicks' elasticity of complementarity between the entry cohort and the cohort with experience i. Since on average $GFR_{t-20} = \rho GFR_{t-20-i} + u_{t-20}$, where ρ is the serial correlation in GFR at lag i, and $\mathrm{E}|u_{t-20}| = 0$, the coefficient on the correction term if based on current cohort size GFR_{t-20} will be directly proportional to ξ and inversely proportional to ρ. The observed pattern of serial correlation in GFR, and an hypothesized pattern of elasticities of complementarity between each level of experience and the entry-level cohort, are presented in Fig. 2, together with the pattern of coefficients expected on an interaction term between the current cohort size and experience variables ($\xi + \rho$).

In summary, then, two cohort size measures are used in the analysis to represent the effects of relative cohort size on wages: *birth cohort size* with its first difference representing differential supply effects around the peak of a boom, and *current cohort size* with its first difference representing differential aggregate demand effects around the peak of a boom – and the lagged GFR is used to approximate both measures. The level of the birth cohort size measure is expected to exert a negative effect on wages, while its difference and the level and difference of the current cohort size measure are expected to have a positive effect. As an adjustment for differentials between supply effects on entry level and older cohorts, the current cohort size variables are interacted with experience. In our basic models there is no allowance for variation in effects by skill level, but we will later explore such variation by education level, and at different points in the income distribution.

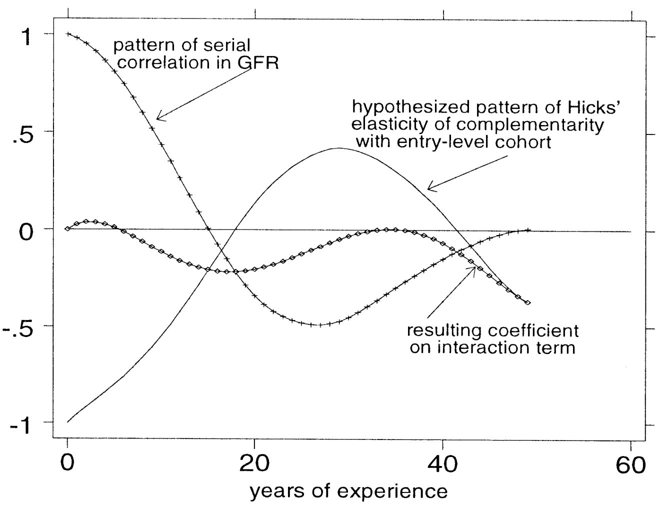


Fig. 2. Approximating the coefficient on an interaction term between current cohort size and experience.

4. Macroeconomic indicators

In order to control for potential forces other than relative cohort size, three macroeconomic variables will be included in some versions of the model (in their de-trended form), together with a time trend (year minus 63): the annual change in (logged) total real GDP; the (logged) per capita level of the current durable goods trade deficit (imports minus exports), together with interactions with indicator variables for those with less than ten years of experience, and low (<12 years) and high (16+ years) levels of education; and the (logged) ratio of 20–24 year olds in the military relative to the total active military each year.

The first of these will be included despite its hypothesized endogeneity, to test for its residual effect in the presence of the relative cohort size variables. The last is an overall indicator of military activity since it has risen historically only during periods of active combat, and it also serves – with an interaction term for those with less than ten years of experience – as a control for differential effects of the draft on the relative size of younger cohorts. The military measure is included along with its first difference (log at time $t + 2$ minus log at time $t - 2$) in order to control for effects of military buildups and cutbacks.

One might question the apparent absence of control variables for technological change and/or productivity changes. This is in part due to the fact that the literature does not appear to provide a generally agreed-upon measure in this area, but also because the military change measure and the trade measures are expected to act as proxies to some extent (as suggested in Sect. 2) – along with relative cohort size itself. We will see a strong negative effect on wages, of military build-ups when funds are diverted from productivity-enhancing activities, and also a strong differential effect of trade, with respect to levels of education and experience, probably reflecting the globalization of production which occurs as domestic production becomes increasingly enhanced technologically.

With regard to productivity, it is assumed that the excess supply of inexperienced labor which occurs when entering cohorts are relatively large – and the resultant drop in relative wages for the young – will lead producers to substitute labor for capital (which has been identified as a substitute for inexperienced and complement to experienced labor), thus lowering productivity measures within industries. In addition, the increasing female labor force participation which occurs in response to the falling relative wages of young men (Macunovich 1996; Fair and Macunovich 1996) will induce an increased shift toward lower-productivity service jobs, as women purchase market replacements for their services in the home.

5. Data and methodology

The theoretical model described in Sect. 2, and elaborated in Sects. 3 and 4, is implemented in the analysis in this paper using the following equations, each of which is estimated using weighted least squares (a methodology described in greater detail in the Appendix):

$$\text{Model 1}: \ln W_{exp,ed,S,t} = \alpha_0 + \alpha_1\, year_t + \underline{\text{EXP}} + \underline{\text{STATE}} + e_{exp,ed,S,t} \tag{4}$$

$$\text{Model 2}: \ln W_{exp,ed,S,t} = \beta_0 + \beta_1 \ln GFR_C + \beta_3\, year_t + \underline{\text{EXP}} + \underline{\text{STATE}} + \eta_{exp,ed,S,t} \tag{5}$$

$$\text{Model 3}: \ln W_{exp,ed,S,t} = \varsigma_0 + \varsigma_1 \ln GFR_C + \varsigma_2 \Delta \ln GFR_C + \varsigma_3\, year_t + \underline{\text{EXP}} + \underline{\text{STATE}} + \varepsilon_{exp,ed,S,t} \tag{6}$$

$$\text{Model 4}: \ln W_{exp,ed,S,t} = \lambda_0 + \lambda_1 \ln GFR_C + \lambda_2 \Delta \ln GFR_C + \lambda_{3,exp} \ln GFR_{t-20} + \lambda_4\, year_t + \underline{\text{EXP}} + \underline{\text{STATE}} + \mu_{exp,ed,S,t} \tag{7}$$

$$\text{Model 5}: \ln W_{exp,ed,S,t} = \phi_0 + \phi_1 \ln GFR_C + \phi_2 \Delta \ln GFR_C + \phi_{3,exp} \ln GFR_{t-20} + \phi_{4,exp} \Delta \ln GFR_{t-20} + \phi_5\, year_t + \underline{\text{EXP}} + \underline{\text{STATE}} + u_{0,exp,ed,S,t} \tag{8}$$

$$\text{Model 6}: \ln W_{exp,ed,S,t} = \phi_{10} + \phi_{11} \ln GFR_C + \phi_{12} \Delta \ln GFR_C + \phi_{13,exp} \ln GFR_{t-20} + \phi_{14,exp} \Delta \ln GFR_{t-20} + \mathbf{X}_\gamma + \phi_{15}\, year_t + \underline{\text{EXP}} + \underline{\text{STATE}} + u_{1,exp,ed,S,t} \tag{9}$$

$$\text{Model 7}: \ln W_{exp,ed,S,t} = \phi_{20} + \phi_{21} \ln GFR_C + \phi_{22} \Delta \ln GFR_C + \phi_{23,exp} \ln GFR_{t-20} + \phi_{24,exp} \Delta \ln GFR_{t-20} + \mathbf{X}_\gamma + \underline{\text{EDUC}} + \phi_{25}\, year_t + \underline{\text{EXP}} + \underline{\text{STATE}} + u_{2,exp,ed,S,t} \tag{10}$$

where

$\mathbf{X}_\gamma$ =	$\gamma_1 \Delta\, ln\, GDP_t + ln\, Milit_t(\gamma_2 + \gamma_{2'}\, exp\_10) + \gamma_3 \Delta\, ln\, Milit_t + ln\, Trade_t(\gamma_4 + \gamma_{4'}\, exp\_10 + \gamma_{4''}\, educ\_hi + \gamma_{4'''}\, educ\_low)$
$\underline{\text{EXP}}$ =	a polynomial in years of potential work experience
$\underline{\text{EDUC}}$ =	a vector of five education dummy variables (<8, 8–11, 13–15, 16 and 17+ years)
$\underline{\text{STATE}}$ =	a vector of twenty state-group dummy variables

and

C =	1901, 1902 ... 1979 is the cohort year of birth associated with a given cell
t =	1963, 1964 ... 1995 is the year in which a given cell's wage is observed
ed =	years of education, and takes the values <8, 8–11, 12, 13–15, 16, and 17+ years
exp =	0, 1, 2 ... 49+ years of potential work experience
S =	1, 2 ... 21 is the Census-defined state grouping associated with a given cell
Δ	represents the first difference of a variable (calculated as its value in $t+2$ minus its value in $t-2$)
$ln\, W_{exp,ed,S,t}$	is the real (weighted) average of the logged hourly wage of all individuals with *exp* years of potential work experience, *ed* completed years of education, residing in State grouping S in year t (using March CPS weights and CPI-X)
$ln\, GFR_C$	is *birth cohort size*: the log of the General Fertility Rate in a cohort's year of birth (calculated as the weighted average of the logged GFR in the year of birth of each individual in a given cell, using the March CPS weight and a 5-year moving average of the GFR) – held constant for a given cohort through time[6]
$ln\, GFR_{t-20}$	is *current cohort size*: the *de-trended* log of the General Fertility Rate 20 years prior to time t (using a 5-year moving average of the GFR) – varies by year, but the same for all cells in a given year (and variation by year of experience in the effect of this current cohort size measure is achieved by interacting it with the experience polynomial)
$ln\, GDP_t$	is the *de-trended* annual change in the log of real Gross Domestic Product in year t
$ln\, Milit_t$	is the *de-trended* logged ratio of 20–24 year olds in the military relative to all other age groups in the active military in year t
$ln\, Trade_t$	is the *de-trended* logged ratio of real per capita durable goods imports to real per capita durable goods exports (in chained 1992 dollars) in year t
exp_10	is a dummy variable set equal to one for cells in which potential work experience is less than 10 years
$educ\_low$	is a dummy variable set equal to one for cells in which completed education is less than 12 years
$educ\_hi$	is a dummy variable set equal to one for cells in which completed education is greater than 15 years

de-trended indicates the use of only the residuals of a variable, after regression on a constant and a time trend (over the period 1963–1995).

Models 1–6 are estimated without controls for education, because of the potential endogeneity of that variable in a relative cohort size model of wages: to the extent that relative cohort size affects wages, and especially the college wage premium, it is a factor in changing levels of educational attainment. Experience is represented using a fifth-degree polynomial, which was found to be most stable in the presence of additional explanatory variables, as explained in the Appendix.

After estimating and evaluating models 1–7, the education and experience constraints will be lifted in two unconstrained models. The first is a version of model (7), presented in column 9 of Table 3, in which experience is represented using a series of seventeen dummy variables: one each for the years 0–9 and five year groupings thereafter, to 45+. The second is a version of model (6), presented in Table 4, in which full sets of interaction terms are included to distinguish effects among four different education groups: <12, 12, 13–15 and 16+ years of education.

The attempt throughout the analysis has been to ensure that the results will be comparable to those from other studies of cohort size effects in the labor market. As a result, the data set was developed to reproduce (and update through 1996) that used in Murphy and Welch (1992), and is referred to as the 'Welch' data set. Also, in addition to the birth- and current- cohort size measures described earlier, a relative cohort size (RCS) variable was constructed which is similar to those used in Murphy and Welch and, for example, in Welch (1979), and Berger (1984, 1985). The data were developed using the annual files from the March Current Population Survey (CPS) for the years 1964–1996, and the wage sample, as in Murphy and Welch, was restricted to white civilian men aged 15+ who worked full time at least 40 weeks during the year, excluding men with self employment income and men whose wages were imputed. Any observations with zero or negative March supplement weights were dropped, and in all cases these weights were used when calculating averages and totals using individual observations. Only non-farm wage and salary earnings were used in the hourly wage calculations. The employment sample used to calculate the 'Welch' relative cohort size measure in this data set, as in their data, is based on annual hours worked by all civilian men regardless of race, self-employment status or time worked.

As in Murphy and Welch, experience was calculated as age-minus-16 years for those having completed ten or fewer grades, and age-minus-grades-minus-6 for those with eleven or more years of schooling. Experience was set to zero if calculated as negative, and "topcoded at values ranging from 42 to 49 depending on educational category such that the top level refers to men 64 years or older (Murphy and Welch 1992, 290)." Observations were categorized by completed years of education: <8, 8–11, 12, 13–15, 16 and 17+. Real hourly wages were calculated as weighted log averages within education-experience cells, separately for each of the thirty-three survey years and for each of twenty-one state groupings which can be identified continuously in the CPS over the 33-year period. This produced 207,900 cells ($6 \times 50 \times 33 \times 21$) of which approximately 62,375 were empty, leaving approximately 145,525 cells for analysis.

Finis Welch kindly provided the algorithms used in imputing hours and weeks worked for the years prior to 1976, which were used in calculating average hourly wages in the wage sample, and total hours worked in the employment sample. The numerator of a *'Welch' relative cohort size variable* was calculated as a five-year moving average of the total hours worked within each education-experience cell. The denominator for cells in each education group was the total hours worked at all levels of experience within that education group. For further detail on the data and methodology used in the analyses, together with tests of alternative formulations, please see the Appendix.

6. Results

Presentation of results begins with those estimated using a 'Welch' relative cohort size variable, and moves from there to a comparison with results obtained using the newly formulated birth and current cohort size variables. *Please note that unless otherwise specified, all coefficient estimates presented here have been standardized* (that is, calculated with all variables converted to mean zero, standard deviation one).

Table 1 presents regression results using the 'Welch' cohort size measure in place of the GFR-based measures, in models (5), (6) and (7). There it is estimated to have a *positive* effect on wages – but this effect is very small (0.015) when education controls are included, as in Model (7). Its effect is, of course much larger without this control because the Welch RCS is education-based (with each cell assigned a ratio based on its share of total hours worked in its education group). Because Welch (1979) and Berger (1984, 1985) identified differential effects of their cohort size measure by level of experience, columns 5i, 6i and 7i in Table 1 present results in which the Welch RCS is interacted with four experience dummies representing 0–4, 5–9, 10–14 and 15–19 years of experience. The effect of the variable remains consistently positive.

Understandably, similar results have led other researchers to conclude that relative cohort size contributed little toward the decline in young men's wages relative to those of older men over the last 30 years – and suggest that in fact cohort size acted to boost young men's absolute (and relative) wages, rather than depress them. The use of only this type of variable would leave us looking elsewhere for the real culprit in observed wage decline.

The picture changes, however, when we switch to the GFR-based relative cohort size measures. Table 2 begins with the simple Model (1) and then adds in each of the GFR-based measures and its first difference sequentially, in columns 2 through 5. Table 3 then goes on to present models (6) and (7). The effect of the basic birth cohort size measure is strongly and significantly negative in all formulations, consistent with its hypothesized aggregate supply effect, and remains so in the presence of its first difference and the current cohort size measure. All of the other effects of the GFR-based measures are estimated to be strongly and consistently positive, however, consistent with the asymmetry and aggregate demand hypotheses presented earlier.

However, the R-squareds in Tables 2 and 3 suggest that despite their significant *t*-statistics the cohort size variables don't add much explanatory power. This result is explored in Fig. 3, which compares the predicted and observed relative wage of young men with 1–5 years of work experience using

Table 1. Standardized regression results using the Welch-type relative cohort size (RCS) variable, in Models 5, 6 and 7.

Model:	***(5)***	***(6)***	***(7)***	***(5i)***	***(6i)***	***(7i)***
Welch-type cohort size	**0.089**	**0.091**	**0.015**	**0.039**	**0.041**	**0.012**
	(25.9)	*(26.3)*	*(5.8)*	*(10.7)*	*(11.4)*	*(4.3)*
Experience interactions with Welch-type cohort size:						
0–4 years				**0.386**	**0.373**	**0.003**
				(31.5)	*(30.7)*	*(0.4)*
5–9 years				**0.474**	**0.468**	**0.043**
				(38.9)	*(38.7)*	*(4.9)*
10–14 years				**0.340**	**0.335**	**0.045**
				(41.4)	*(41.0)*	*(7.6)*
15–19 years				**0.155**	**0.153**	**0.016**
				(31.9)	*(31.8)*	*(4.5)*
Time trend	**0.060**	**0.079**	**−0.032**	**0.053**	**0.074**	**−0.033**
	(22.6)	*(26.3)*	*(−13.7)*	*(20.1)*	*(24.5)*	*(−13.9)*
Experience	**3.823**	**3.879**	**4.345**	**5.848**	**6.002**	**5.073**
	(44.6)	*(44.8)*	*(63.1)*	*(44.7)*	*(45.2)*	*(47.2)*
Experience^2	**−10.78**	**−10.76**	**−13.21**	**−25.59**	**−25.91**	**−16.51**
	(−21.7)	*(−21.4)*	*(−33.1)*	*(−35.0)*	*(−35.0)*	*(−28.0)*
Experience^3	**14.216**	**13.945**	**19.652**	**41.872**	**42.191**	**24.999**
	(12.7)	(12.3)	*(21.6)*	*(26.7)*	*(26.6)*	*(19.7)*
Experience^4	**−8.485**	**−8.205**	**−14.25**	**−29.88**	**−30.08**	**−18.05**
	(−7.6)	*(−7.2)*	*(−15.5)*	*(−19.9)*	*(−19.9)*	*(−14.8)*
Experience^5	**1.484**	**1.400**	**3.856**	**7.541**	**7.605**	**4.853**
	(3.6)	*(3.3)*	*(11.2)*	*(14.2)*	*(14.2)*	*(11.1)*
GDP change		**−0.027**	**−0.018**		**−0.023**	**−0.018**
		(−9.0)	*(−8.2)*		*(−7.8)*	*(−8.1)*
Military:						
level		**−0.010**	**0.007**		**−0.005**	**0.008**
		(−3.0)	*(2.9)*		*(−1.4)*	*(3.1)*
change		**−0.101**	**−0.096**		**−0.098**	**−0.096**
		(−48.9)	*(−59.5)*		*(−47.9)*	*(−59.5)*
*level * experience < 10*		**0.049**	**0.027**		**0.049**	**0.027**
		(19.2)	*(14.2)*		*(19.8)*	*(14.0)*
Trade deficit:						
level		**0.028**	**0.017**		**0.024**	**0.017**
		(7.2)	*(5.4)*		*(6.1)*	*(5.3)*
*level * experience < 10*		**−0.031**	**−0.022**		**−0.030**	**−0.022**
		(−9.5)	*(−9.6)*		*(−9.5)*	*(−9.6)*
*level * education > 15*		**−0.002**	**0.004**		**−0.001**	**0.004**
		(−0.5)	*(1.5)*		*(−0.3)*	*(1.5)*
*level * education < 12*		**−0.002**	**−0.005**		**20.002**	**−0.005**
		(−0.6)	*(−2.5)*		*(−0.6)*	*(−2.5)*
Completed years of education:						
<8			**−0.245**			**−0.244**
			(115.7)			*(114.6)*
8–11			**−0.189**			**−0.187**
			(−90.2)			*(−89.0)*
13–15			**0.125**			**0.125**
			(62.2)			*(62.0)*
16			**0.309**			**0.308**
			(149.8)			*(148.9)*
17+			**0.316**			**0.316**
			(140.3)			*(140.1)*

Table 1. (Continued)

Model:	*(5)*	*(6)*	*(7)*	*(5i)*	*(6i)*	*(7i)*
Intercept	**2.251**	**2.228**	**1.830**	**2.503**	**2.459**	**1.783**
(not standardized)	*(125.5)*	*(124.6)*	*(130.1)*	*(111.0)*	*(109.2)*	*(98.3)*
Number of obs	**145525**	**141394**	**141394**	**145525**	**141394**	**141394**
F statistic	**1547.30**	**1280.69**	**3454.99**	**1409.35**	**1198.31**	**3149.23**
R-squared	**0.2573**	**0.2750**	**0.5547**	**0.2689**	**0.2863**	**0.5552**
Root MSE	**0.36308**	**0.35747**	**0.28014**	**0.36023**	**0.35466**	**0.28**

Notes: Dependent variable is ln(hourly wages) for white males working full time. t-statistics in parentheses. *All coefficients are standardized.* Each regression also included twenty state dummies not reported here. Regressions are based on models 5, 6 and 7, but substituting Welch RCS for GFR-based cohort variables, and interacting the Welch RCS with experience in columns 5i, 6i and 7i.

Table 2. Standardized regression results using GFR-based birth and current cohort size variables, in Models 1–5.

Model:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Birth cohort size:					
level		**−0.053**	**−0.054**	**−0.068**	**−0.060**
		(−20.1)	*(−21.1)*	*(−22.8)*	*(−16.7)*
first difference			**0.103**	**0.089**	**0.095**
			(38.8)	*(27.9)*	*(25.1)*
Current cohort size:					
level				**0.144**	**0.146**
				(8.3)	*(8.4)*
first difference					**0.047**
					(2.6)
Experience interactions with current cohort size:					
*level * experience*				**0.759**	**0.724**
				(4.9)	*(4.7)*
exp^2				**−5.088**	**−4.907**
				(−7.8)	*(−7.5)*
exp^3				**11.610**	**11.479**
				(8.8)	*(8.6)*
exp^4				**−10.99**	**−11.13**
				(−8.8)	*(−8.9)*
exp^5				**3.709**	**3.839**
				(8.4)	*(8.6)*
*1st diff * experience*					**−0.029**
					(−0.2)
exp^2					**−0.356**
					(−0.5)
exp^3					**1.741**
					(1.3)
exp^4					**−2.524**
					(−2.0)
exp^5					**1.145**
					(2.5)
Time trend	**0.060**	**0.061**	**0.061**	**0.103**	**0.113**
	(22.7)	*(22.8)*	*(23.3)*	*(40.9)*	*(40.5)*
Experience	**4.169**	**4.224**	**4.138**	**4.098**	**4.089**
	(49.4)	*(49.6)*	*(49.6)*	*(47.1)*	*(46.8)*

Table 2. (Continued)

Model:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Experience^2	**−12.52**	**−12.75**	**−12.85**	**−12.21**	**−12.16**
	(−25.6)	*(−25.9)*	*(−26.7)*	*(−24.5)*	*(−24.3)*
Experience^3	**17.618**	**17.783**	**18.514**	**16.910**	**16.770**
	(16.0)	*(16.1)*	*(17.0)*	*(15.1)*	*(14.9)*
Experience^4	**−11.79**	**−11.66**	**−12.40**	**−10.96**	**−10.78**
	(−10.7)	*(−10.6)*	*(−11.5)*	*(−9.8)*	*(−9.6)*
Experience^5	**2.734**	**2.629**	**2.840**	**2.411**	**2.329**
	(6.8)	*(6.5)*	*(7.1)*	*(5.9)*	*(5.6)*
Intercept	**1.844**	**2.488**	**2.527**	**2.639**	**2.535**
(not standardized)	*(213.2)*	*(74.5)*	*(77.0)*	*(71.6)*	*(57.3)*
Number of obs	**145525**	**145525**	**145525**	**145525**	**145525**
F statistic	**1579.96**	**1562.36**	**1566.21**	**1492.14**	**1281.31**
R-squared	**0.2526**	**0.2551**	**0.2648**	**0.2840**	**0.2852**
Root MSE	**0.36423**	**0.36362**	**0.36125**	**0.35649**	**0.35622**

Notes:
– Dependent variable is ln(hourly wages) for white males working full time. t-statistics in parentheses. *All coefficients reported in this Table and in Table 3 have been standardized.*
– Each regression in this table and in Table 3 also included twenty state dummies – results available on request.

Table 3. Standardized regression results using the GFR-based birth and current cohort size variables, in Models 5–7 with variations.

Model:	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Birth cohort size:					
level	**−0.060**	**−0.060**	**−0.050**	**−0.054**	**−0.053**
	(−16.7)	*(−16.3)*	*(−18.1)*	*(−23.6)*	*(−19.6)*
first difference	**0.095**	**0.082**	**0.038**	**0.036**	**0.038**
	(25.1)	*(19.9)*	*(12.9)*	*(14.5)*	*(12.8)*
Current cohort size:					
level	**0.146**	**0.137**	**0.148**	**0.143**	**0.086**
	(8.4)	*(7.7)*	*(10.2)*	*(9.9)*	*(15.6)*
first difference	**0.047**	**0.066**	**0.059**		**0.071**
	(2.6)	*(3.5)*	*(3.9)*		*(13.5)*
Experience interactions with current cohort size:					
*level * experience*	**0.724**	**0.665**	**0.261**	**0.250**	*
	(4.7)	*(4.2)*	*(2.1)*	*(2.0)*	
exp^2	**−4.907**	**−4.529**	**−2.306**	**−2.314**	*
	(−7.5)	*(−6.7)*	*(−4.3)*	*(−4.3)*	
exp^3	**11.479**	**10.349**	**5.415**	**5.454**	*
	(8.6)	*(7.5)*	*(4.9)*	*(4.9)*	
exp^4	**−11.13**	**−9.787**	**−5.033**	**−5.058**	*
	(−8.9)	*(−7.5)*	*(−4.8)*	*(−4.8)*	
exp^5	**3.839**	**3.290**	**1.634**	**1.638**	*
	(8.6)	*(7.1)*	*(4.3)*	*(4.3)*	
*1st diff * experience*	**−0.029**	**0.008**	**0.096**		*
	(−0.2)	*(0.1)*	*(0.7)*		
exp^2	**−0.356**	**−0.364**	**−0.515**		*
	(−0.5)	*(−0.5)*	*(−0.9)*		
exp^3	**1.741**	**1.561**	**1.351**		*
	(1.3)	*(1.1)*	*(1.2)*		

Table 3. (Continued)

Model:	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
exp^4	**−2.524**	**−2.243**	**−1.541**		*
	(−2.0)	*(−1.7)*	*(−1.4)*		
exp^5	**1.145**	**1.023**	**0.610**		*
	(2.5)	*(2.2)*	*(1.5)*		
Time trend	**0.113**	**0.127**	**0.019**	**−0.006**	**0.019**
	(40.5)	*(38.2)*	*(7.0)*	*(−2.8)*	*(7.0)*
Experience	**4.089**	**4.145**	**4.403**	**4.403**	*
	(46.8)	*(45.1)*	*(60.4)*	*(60.5)*	
Experience^2	**−12.16**	**−12.24**	**−13.46**	**−13.45**	*
	(−24.3)	*(−23.3)*	*(−32.4)*	*(−32.4)*	
Experience^3	**16.770**	**16.775**	**19.967**	**19.928**	*
	(14.9)	*(14.3)*	*(21.2)*	*(21.2)*	
Experience^4	**−10.78**	**−10.76**	**−14.42**	**−14.36**	*
	(−9.6)	*(−9.2)*	*(−15.1)*	*(−15.1)*	
Experience^5	**2.329**	**2.327**	**3.911**	**3.883**	*
	(5.6)	*(5.4)*	*(11.0)*	*(11.0)*	
GDP change		**−0.004**	**−0.003**	**0.015**	**−0.003**
		(−1.2)	*(−1.4)*	*(6.5)*	*(−1.4)*
Military					
level		**0.005**	**0.007**	**0.025**	**0.007**
		(1.4)	*(2.9)*	*(10.4)*	*(2.7)*
change		**−0.043**	**−0.044**	**−0.053**	**−0.043**
		(−19.0)	*(−25.0)*	*(−30.8)*	*(−24.9)*
*level * experience < 10*		**0.011**	**0.010**	**0.010**	**0.011**
		(4.0)	*(4.9)*	*(4.8)*	*(5.1)*
Trade deficit					
level		**0.047**	**0.051**	**−0.003**	**0.052**
		(9.1)	*(12.4)*	*(−0.9)*	*(12.5)*
*level * experience < 10*		**−0.007**	**−0.008**	**−0.009**	**−0.010**
		(−1.7)	*(−3.0)*	*(−3.8)*	*(−3.5)*
*level * education > 15*		**−0.003**	**0.003**	**0.002**	**0.003**
		(−1.0)	*(1.1)*	*(0.8)*	*(1.2)*
*level * education < 12*		**−0.003**	**−0.006**	**−0.003**	**−0.006**
		(−1.0)	*(−2.6)*	*(−1.6)*	*(−2.7)*
Completed years of education:					
<8			**−0.240**	**−0.240**	**−0.241**
			(−115.)	*(−115.)*	*(115.5)*
8–11			**−0.185**	**−0.185**	**−0.185**
			(−92.0)	*(−91.7)*	*(−92.2)*
13–15			**0.128**	**0.127**	**0.129**
			(66.9)	*(66.4)*	*(67.2)*
16			**0.312**	**0.311**	**0.311**
			(156.0)	*(155.1)*	*(155.4)*
17+			**0.313**	**0.313**	**0.314**
			(140.4)	*(139.9)*	*(140.3)*
Intercept	**2.535**	**2.522**	**2.324**	**2.383**	**3.201**
(not standardized)	*(57.3)*	*(55.0)*	*(68.4)*	*(84.8)*	*(95.7)*
Number of obs	**145525**	**141394**	**141394**	**141394**	**141394**
F statistic	**1281.31**	**1056.87**	**2890.22**	**3212.91**	**1696.29**
R-squared	**0.2852**	**0.2915**	**0.5689**	**0.5672**	**0.5682**
Root MSE	**0.35622**	**0.35339**	**0.27565**	**0.2762**	**0.27592**

Notes: Column 9 is an unrestricted version of column 7, in which experience was represented by a series of 17 dummy variables (0–9 years of experience, and 5 year groupings thereafter to 45+), rather than a polynomial. See text, and notes in Table 2. t-statistics in parentheses. Dependent variable: ln(hourly wages).

each of the models in Tables 2 and 3. The first panel in Fig. 3 compares the predicted values from models 1–3 with the observed pattern of the relative wage. Moving from model (1), which contains controls only for experience, state and a time trend, to model (2) – adding in the level of the birth cohort size variable – produces a modest effect, introducing a somewhat U-shaped pattern over time, but a dramatic effect is produced by adding the first difference of that variable, allowing for asymmetry in the effects of birth cohort size around the peak of a boom. Apart from the sharp peak in the relative wage which occurred in the late 1960s, these two variables alone appear to explain most of the decline in young men's relative wages.

Moving to the second panel, where we compare models (3), (4) and (5), we achieve little by adding the current cohort size variables; it's only in the third panel, when we add in the macro and education controls (as presented in columns 6 and 7 of Table 3), that we achieve some further improvement. The effect of the military buildup in Vietnam explains much of the sharp increase in the late 1960s, as the draft depleted the supply of younger males in the civilian economy and encouraged higher enrollments through educational deferments.

Once again the picture changes, however, if we look at predicted versus observed values of *absolute* wages during this period, as in Fig. 4. Here we can see the marked effect of the *current cohort size* variable, when it's added in the middle panel – and once again, in the third panel, the addition of the macro controls (especially the military variables) improves the explanatory power in the late 1960s.

These results in Tables 2 and 3 and Figs. 3 and 4 are consistent with the hypothesis: birth cohort size explains changes in the relative wage of younger males due to aggregate supply effects, once we allow for asymmetry in those effects, while current cohort size with its aggregate demand effect explains the secular trend in the absolute wage. Thus, although the cohort size variables don't do much to improve explanatory power with regard to cross-sectional differences in wages, they add a great deal in the time series variation.

Logically, however, it would seem that the birth cohort size variable should do less well in predicting the secular trend of wages relative to those of prime age males, as we look at men with progressively higher levels of work experience – and this is indeed the case, as we can see in Fig. 5. The birth cohort size variables on their own, in Models (2) and (3) in the panels on the left, produce progressively more distorted predictions for the relative wages of these older males. The addition of the current cohort size measures in the middle panels is sufficient to bring predicted values in line with observed for those with 6–9 and 10–14 years of experience – but still more is required for those with 40 or more years of experience. There we need to add in the education controls, since quite reasonably the birth cohort size variables cannot account for changing educational differentials between prime age and *older* males – only for the differentials between prime age and young males. For men with 40+ years of experience even the education controls are not sufficient to explain all of the sharp rise and then fall in the relative wage between 1985 and 1995 – but this spike may be an artifact of changing CPS topcodes, as demonstrated in Macunovich (1998).

As in Fig. 4 for entry-level workers, Fig. 6a and b present a comparison of observed and predicted absolute wages for men with more than five years of work experience. There we see a consistent pattern, with the birth cohort size

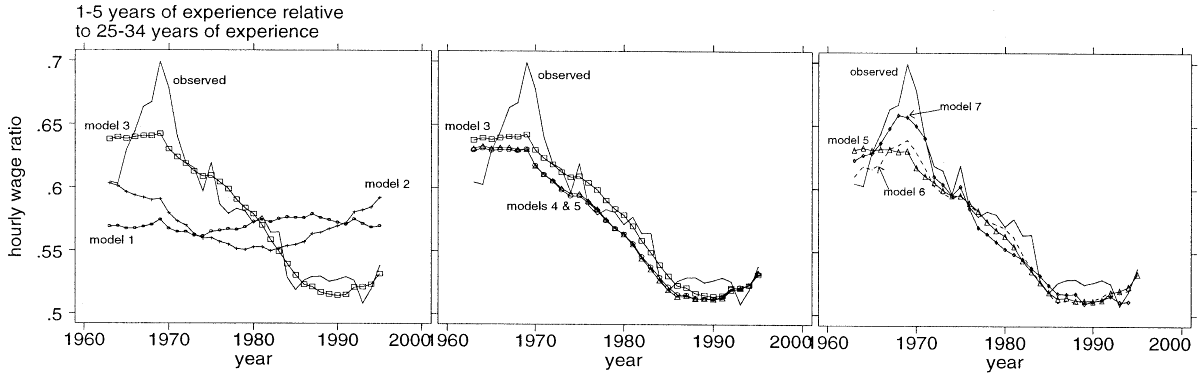


Fig. 3. Comparing observed and predicted values for the relative hourly wage of young men with 1–5 years of work experience, using Models 1–7.

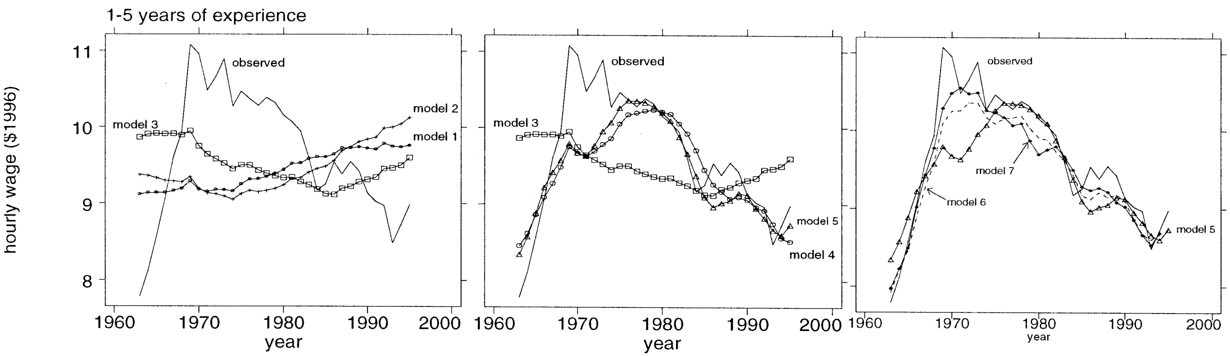


Fig. 4. Comparing observed and predicted values for the real hourly wage of young men with 1–5 years of work experience, using Models 1–7.

variable in the panels on the left explaining less of the trend in real wages with rising experience, and the current cohort size variable doing a respectable job of explaining the remainder of the trend in the middle panels. “Fine-tuning” to account for the Vietnam spike in the late 1960s and what appears to be a trade-induced bulge in the mid-1980s is achieved in the panels on the right, with the addition of the macro variables. It is significant that in columns 6–9 in Table 3, the GDP change variable is significant only in the absence of the first difference of the current cohort size variable (in column 8): changes in the GFR in $t - 20$ are highly correlated with the GDP change variable in year t.

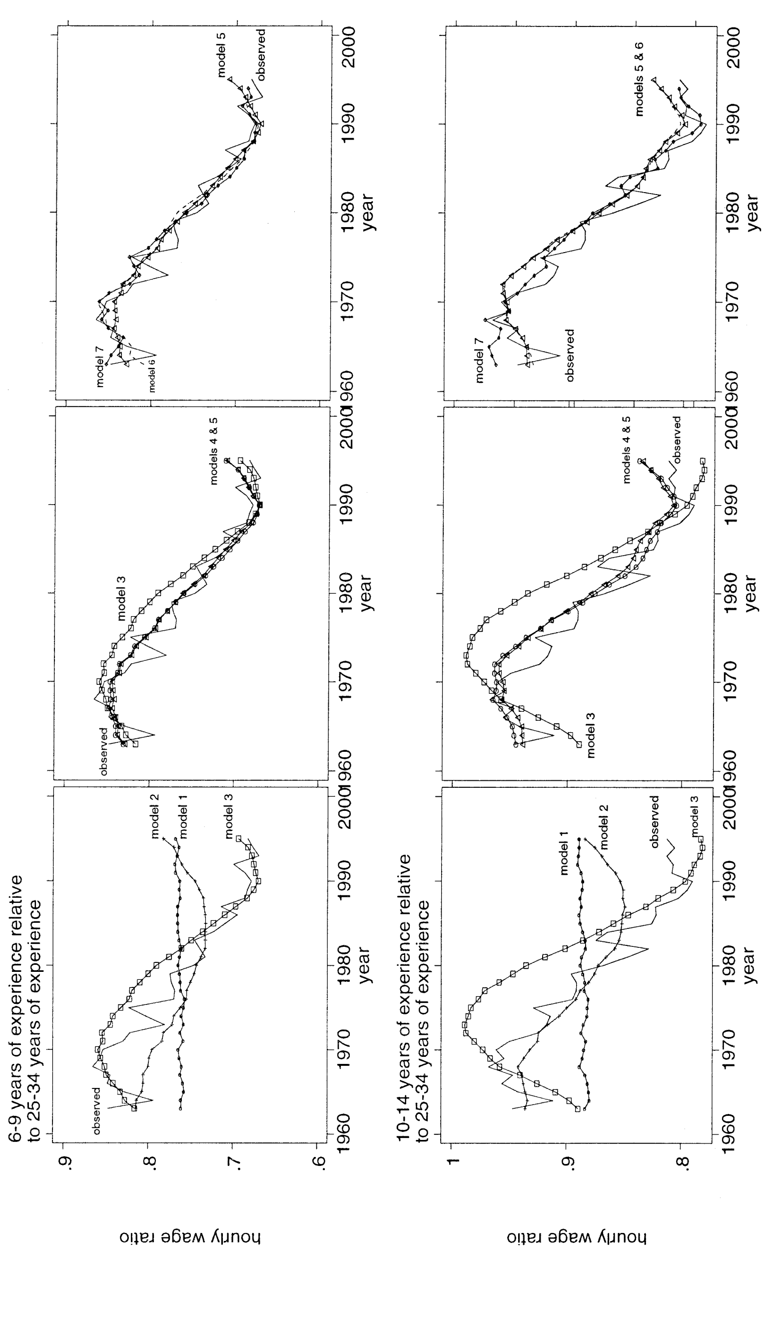
Because it has been demonstrated that cohort size effects vary by education level (Welch 1979; Freeman 1979), models (1), (4), (5) and (6) have also been estimated in an unrestricted form; that is, including full sets of interaction terms for those with <12, 13–15, and 16+ years of education. The results of this exercise, for model (6), are reported in Table 4, and comparisons of observed and predicted values using these four unrestricted models are presented in Fig. 7 (for the college wage premium) and 8 (for wages of young relative to older men by level of education).

In Table 4, the coefficient estimates in the first column on the left are the estimates for the omitted group (high school graduates), and the coefficients in the other three rows should be interpreted as deviations from the high school grad’s pattern, at the other education levels. These differentials show that the benefit of increased current cohort size for college graduates is only about one-third of that experienced by high school grads: this is consistent with the hypothesis that, being closer to their full employment level of unemployment at all times than high school grads, the differential effect of large versus small current cohort size is not as great for them, as for high school grads. It explains the declining skill premium in the 1970s, and then its rise in the 1980s.

7. Within-group variance of wages

Much has been made of the fact that the observed growth in inequality in the United States, at least since 1980, appears to have occurred more *within* than *between* groups defined by education and experience (see for example Karoly 1992). It has been suggested that this type of inequality is also related to skill differentials, differentials which occur within education levels, which are signaled by different positions in the income distribution. Is there any relationship between this type of wage change, and population age structure? This section of the paper examines that question using the calculated variance around the (weighted) mean log wage within each year-state-education-experience cell in the ‘Welch’ wage sample used previously.

Model (7) is used to attempt to explain such within-cell variance in the wage sample. The results, presented in the first column of Table 5, don’t look very impressive: the overall R^2 is only 0.0092 and large standard errors produce few significant coefficients. However, the (standardized) coefficients on the *birth cohort size* variables are significant, and these variables are estimated to have a large effect in increasing within cell variance, relative to any of the macro control variables (not reported here). This effect is counterbalanced by *current cohort size*, which is estimated to reduce such variation through its positive effect on economic activity. The second set of (standardized) estimated coefficients in Table 5 reports results of the same model fitted on the



6-9 years of experience relative
to 25-34 years of experience
10-14 years of experience relative
to 25-34 years of experience
hourly wage ratio
year
observed
model 1
model 2
model 3
models 4 & 5
model 5
model 6
model 7
models 5 & 6

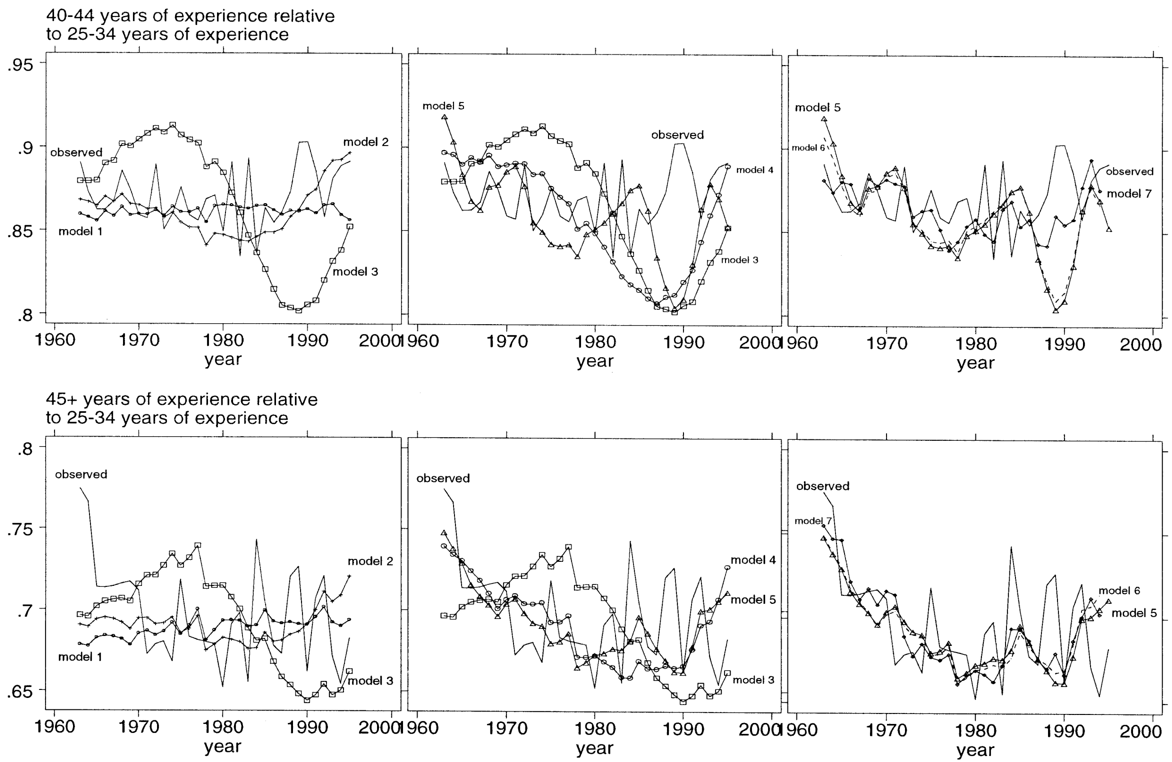
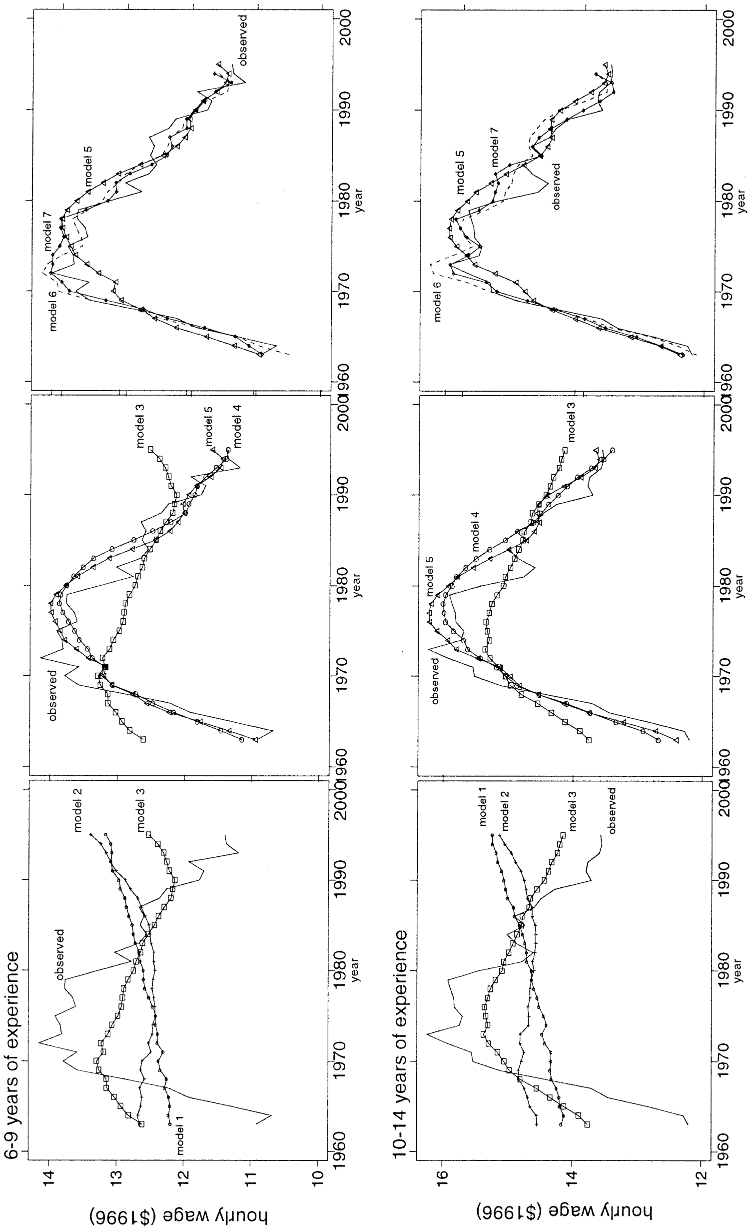


Fig. 5. Comparing observed and predicted values for the relative hourly wage of men with more than 5 years of work experience, using Models 1–7.


6-9 years of experience
10-14 years of experience
hourly wage ($1996)
year
observed
model 1
model 2
model 3
model 4
model 5
model 6
model 7

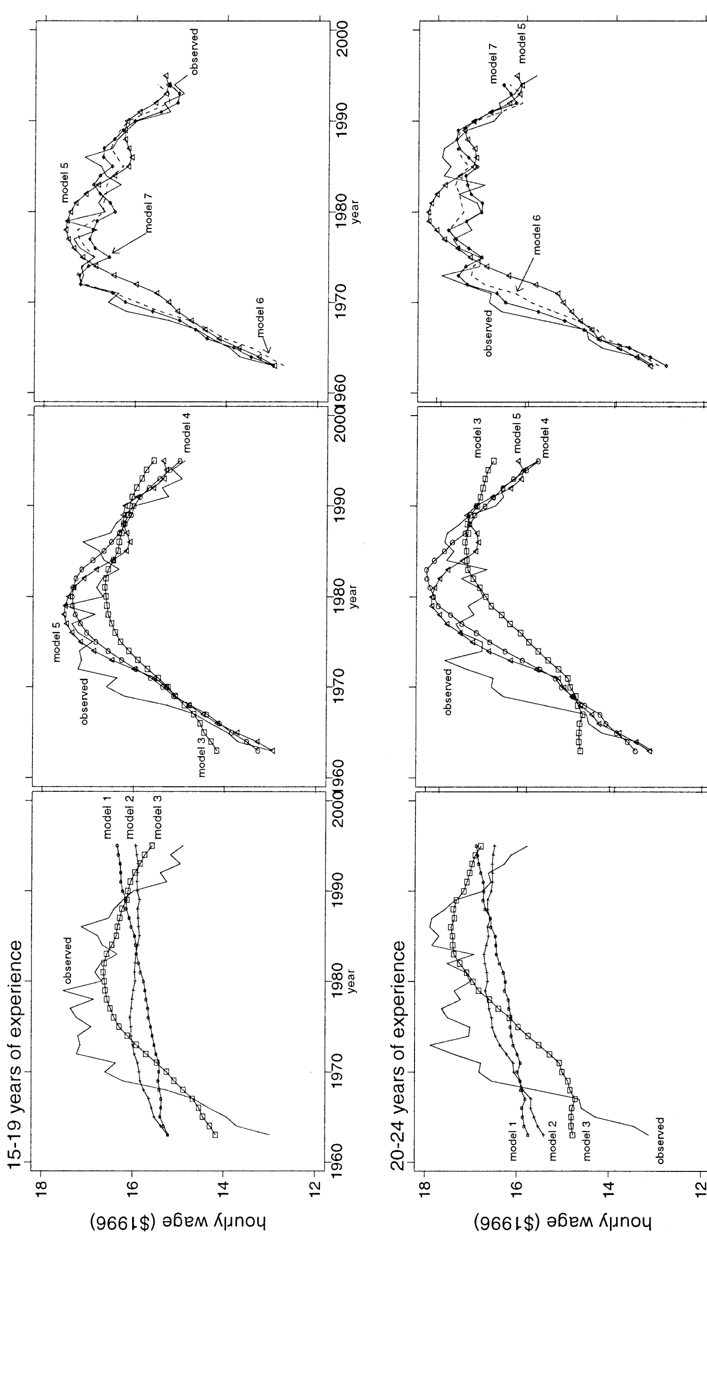
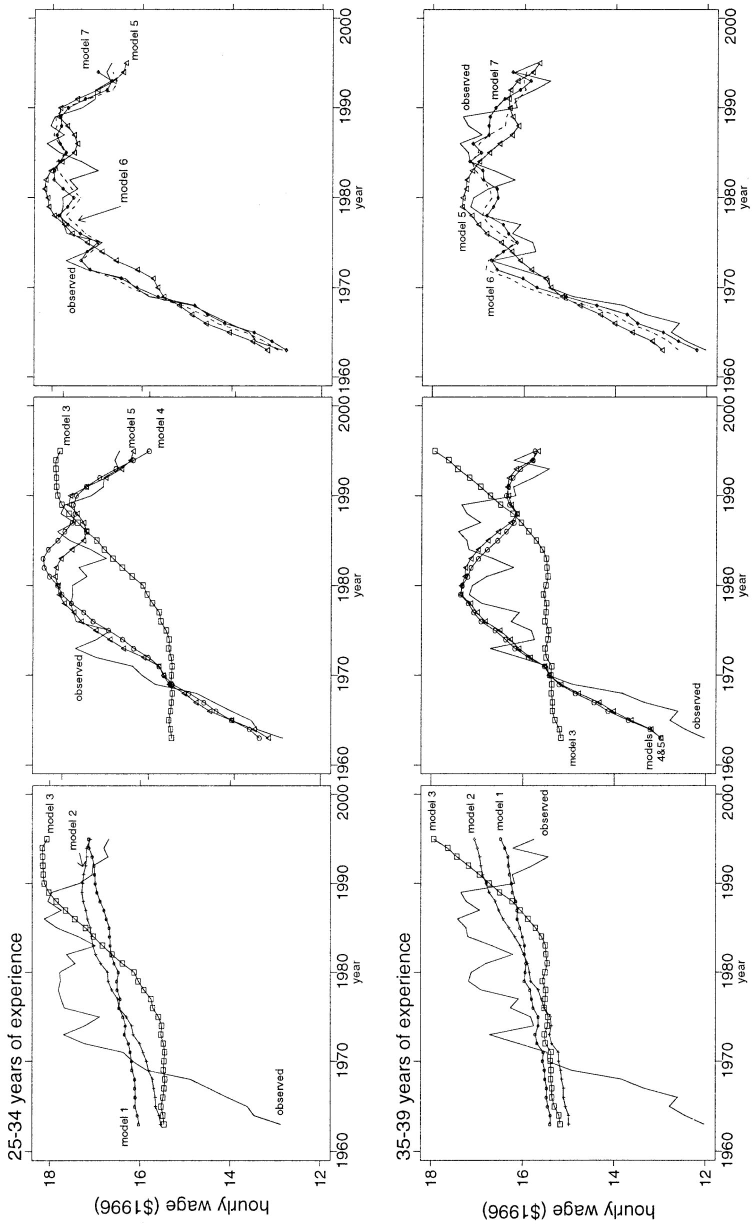


Fig. 6a. Comparing observed and predicted values for the real hourly wage of men with more than 5 years of experience, using models 1–7.


25-34 years of experience
35-39 years of experience
hourly wage ($1996)
year
observed
model 1
model 2
model 3
model 4
model 5
model 6
model 7
models 4&5
1960
1970
1980
1990
2000
12
14
16
18

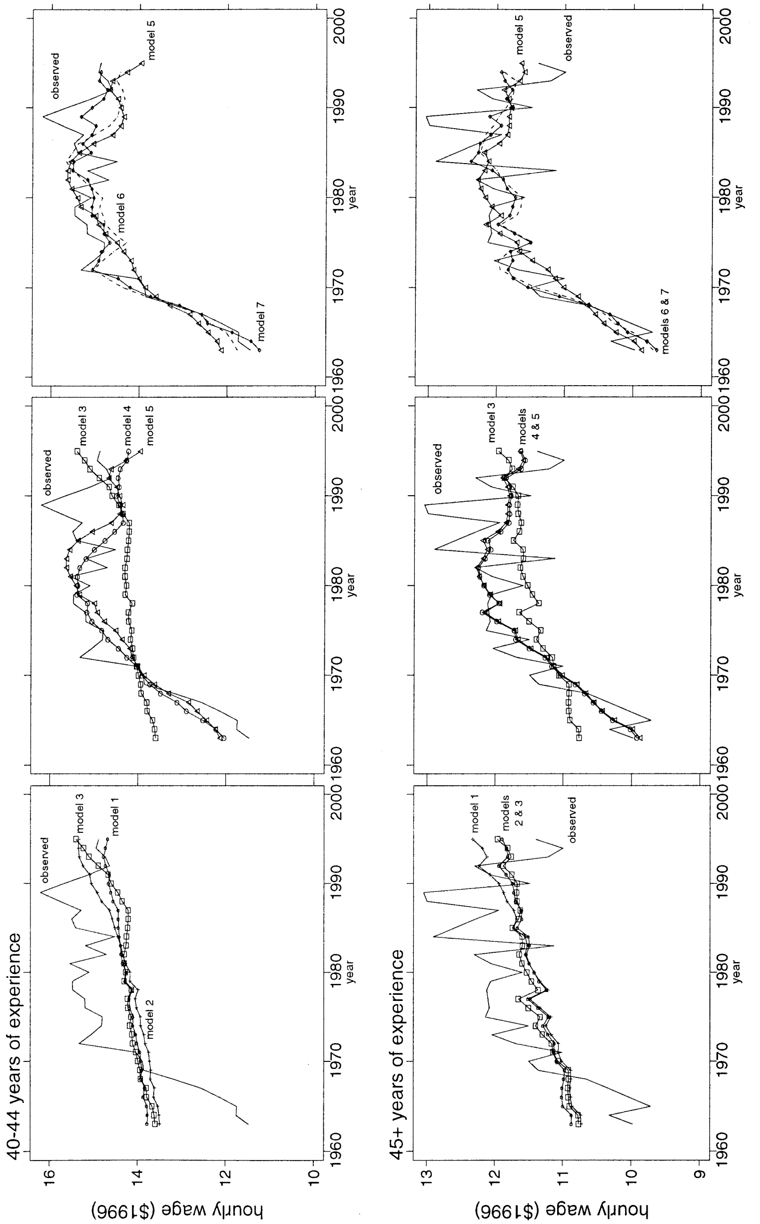


Fig. 6b. Comparing observed and predicted values for the real hourly wage of older men with 25 or more years of experience, using Models 1–7.

Table 4. Non-standardized regression results by education level, using Model 6 with a full set of interaction terms for each education group.

	Baseline effect		*Differential effect by education level (coefficient on interaction term)*					
	High school graduates		*Less than high school*		*Some college*		*College graduates*	
Birth cohort size:								
level	**−0.232**	*(−20.8)*	**−0.067**	*(−3.1)*	**0.037**	*(1.7)*	**0.043**	*(1.6)*
first difference	**0.149**	*(7.6)*	**−0.344**	*(−8.8)*	**0.012**	*(0.3)*	**0.015**	*(0.3)*
Current cohort size:								
level	**0.669**	*(9.6)*	**−0.208**	*(−1.0)*	**−0.053**	*(−0.5)*	**−0.438**	*(−3.6)*
first difference	**1.760**	*(7.5)*	**−2.300**	*(−3.5)*	**−0.643**	*(−1.6)*	**−1.265**	*(−3.3)*
Experience interactions with current cohort size:								
*level * experience*	**0.1119**	*(4.3)*	**0.1193**	*(1.8)*	**−0.1049**	*(−2.6)*	**−0.1043**	*(−2.2)*
exp^2	**−0.0206**	*(−6.3)*	**−0.0050**	*(−0.7)*	**0.0127**	*(2.3)*	**0.0113**	*(1.6)*
exp^3	**0.0011**	*(6.2)*	**−0.0002**	*(−0.5)*	**−0.0006**	*(−1.8)*	**−0.0003**	*(−0.7)*
exp^4	**−2.4e−5**	*(−5.6)*	**1.0e−5**	*(1.3)*	**1.2e−5**	*(1.4)*	**9.7e−7**	*(0.1)*
exp^5	**1.8e−7**	*(4.9)*	**−1.2e−7**	*(−1.9)*	**−8.9e−8**	*(−1.2)*	**2.3e−8**	*(0.2)*
*1st diff * experience*	**−0.0530**	*(−0.6)*	**0.7712**	*(3.6)*	**0.1108**	*(−0.7)*	**0.0512**	*(0.3)*
exp^2	**−0.0169**	*(−1.5)*	**−0.0794**	*(−3.3)*	**0.0301**	*(1.4)*	**0.0200**	*(0.8)*
exp^3	**0.0025**	*(2.4)*	**0.0033**	*(2.8)*	**−0.0019**	*(−1.5)*	**−0.0014**	*(−1.0)*
exp^4	**−4.1e−5**	*(−2.7)*	**−6.1e−5**	*(−2.3)*	**4.7e−5**	*(1.5)*	**3.3e−5**	*(0.8)*
exp^5	**3.7e−7**	*(2.8)*	**3.9e−7**	*(1.8)*	**−4.1e−7**	*(−1.5)*	**−2.5e−7**	*(−0.6)*
Time	**−0.000**	*(−0.6)*	**−0.003**	*(−8.1)*	**0.011**	*(1.7)*	**0.132**	*(14.7)*
Experience	**0.1507**	*(39.1)*	**0.0490**	*(5.1)*	**0.0117**	*(1.9)*	**−0.0488**	*(−6.9)*
Experience^2	**−0.0100**	*(−20.2)*	**−0.0039**	*(−3.7)*	**−0.0014**	*(−1.7)*	**0.0052**	*(5.4)*
Experience^3	**0.0003**	*(12.5)*	**0.0001**	*(2.6)*	**0.0001**	*(1.5)*	**−0.0003**	*(−4.6)*
Experience^4	**−5.0e−6**	*(−8.3)*	**−1.9e−6**	*(−1.8)*	**−1.6e−6**	*(−1.3)*	**6.5e−6**	*(4.2)*
Experience^5	**2.9e−8**	*(5.5)*	**9.6e−6**	*(1.1)*	**1.1e−8**	*(1.1)*	**−5.9e−8**	*(−4.0)*
GDP change	**−0.120**	*(−1.6)*	**0.210**	*(1.5)*	**−0.251**	*(−1.8)*	**−0.030**	*(−0.2)*
Military:								
level	**−0.023**	*(−2.3)*	**0.010**	*(0.5)*	**0.025**	*(1.2)*	**0.144**	*(6.2)*
change	**−0.058**	*(−12.4)*	**−0.027**	*(−3.3)*	**−0.011**	*(−1.2)*	**−0.045**	*(−4.6)*
*level * experience < 10*	**0.089**	*(5.1)*	**0.080**	*(2.0)*	**−0.057**	*(−1.7)*	**−0.127**	*(−3.6)*

Trade deficit:								
level	**0.128**	*(9.3)*	**−0.052**	*(−2.1)*	**0.000**	*(0.0)*	**0.033**	*(1.4)*
*level * experience < 10*	**−0.001**	*(−0.1)*	**−0.098**	*(−2.1)*	**−0.012**	*(−0.4)*	**−0.006**	*(−0.2)*
Intercept	**2.761**	*(53.7)*	**−0.118**	*(−1.2)*	**−0.032**	*(−0.3)*	**0.305**	*(2.5)*
Number of obs	**141394**							
F *(178, 141209)*	**817.99**							
R-squared	**0.5728**							
Root MSE	**0.27453**							

Notes:
– Dependent variable is ln(hourly wages) for white males working full time. t-statistics in parentheses. *Coefficients are not standardized.*
– Regression pooled all education levels (<12 years, 12 years, 13–15 years and 16+ years) and included full sets of interactions for each education level.
– Regression also included twenty state dummies – results available on request.

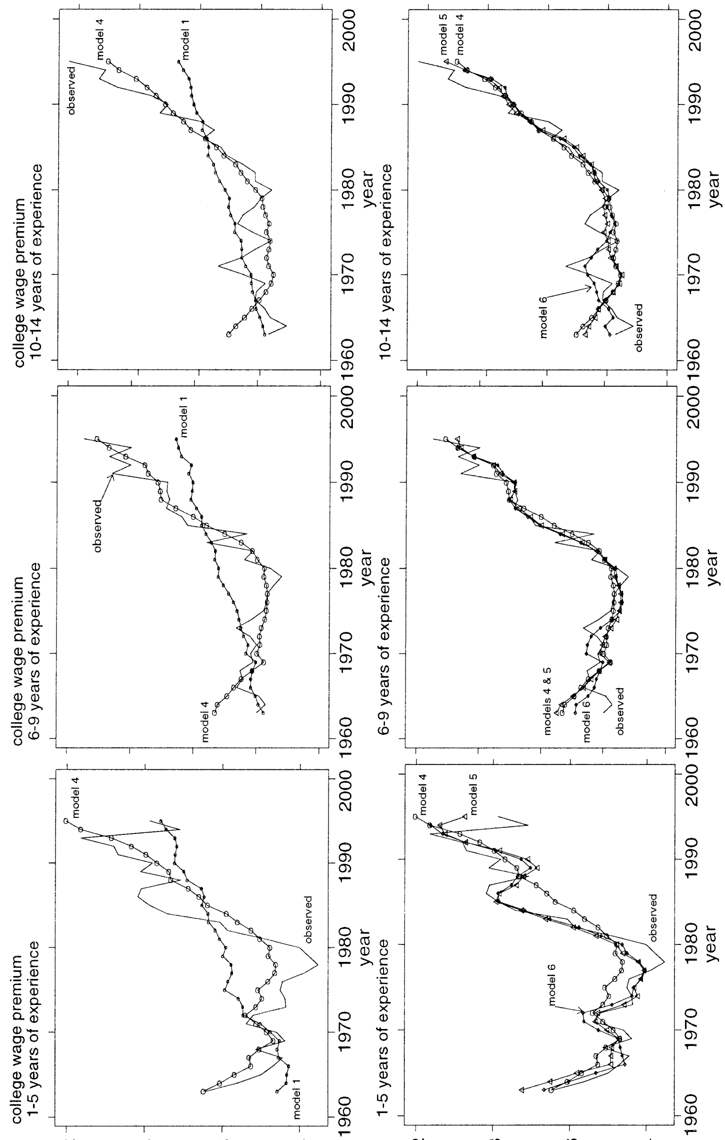


Fig. 7. Comparing observed and predicted values of the college wage premium, using Models 1 and 4–6, but allowing estimated coefficients to vary by education group as in Table 4.

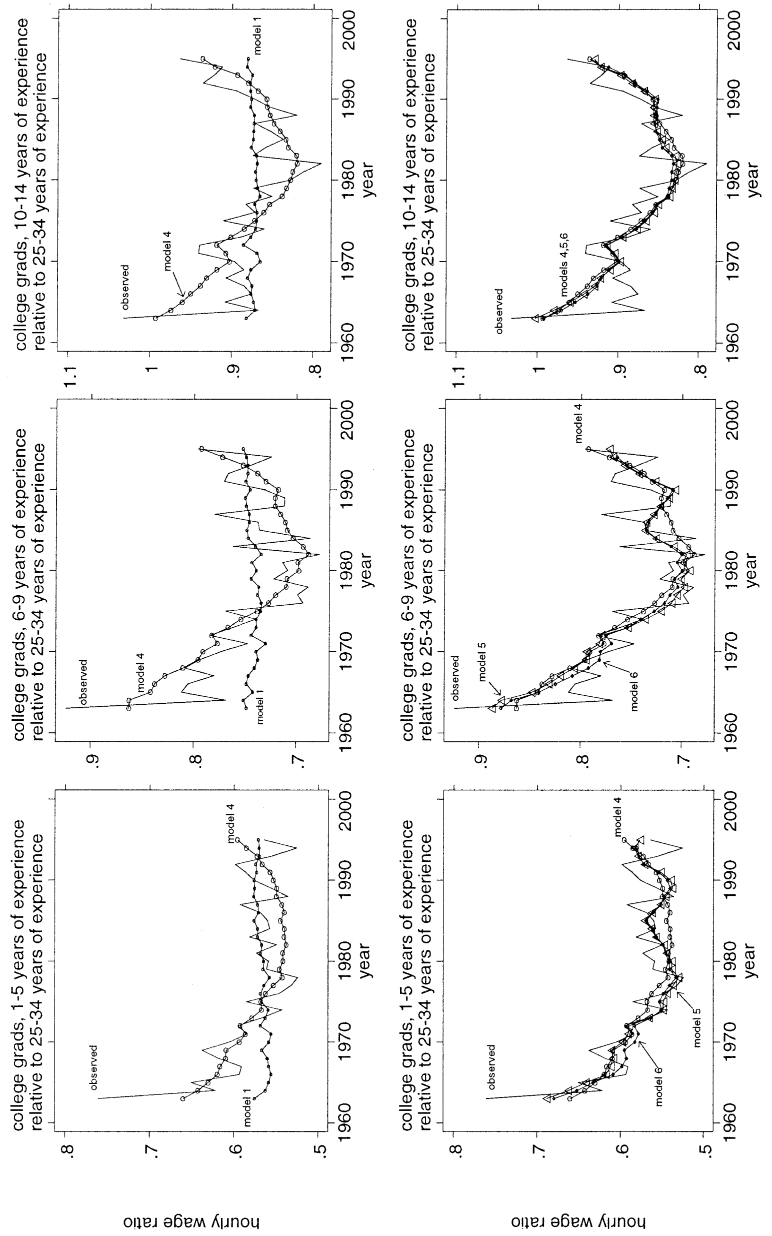
Welch data set when a uniform earnings topcode is imposed in all years, in an attempt to correct for changing CPS topcodes over time (see Macunovich 1998, for details). Here, the magnitude of the coefficients on the current and birth cohort size variables increases dramatically, as does the significance of these variables.

And here again it appears that the unexplained variance is largely cross-sectional. Figure 9 plots fitted and observed within-cell variance in the original Welch data set: it presents the *observed* time pattern of within-cell variance, together with the model's *predicted* value using all information on the historic pattern of the macroeconomic variables, and a *'simulated'* value obtained by holding all variables other than those measuring cohort size, constant at their 1980 levels. Figure 9 shows that the secular trend in within-cell variance for all experience groups is explained fairly well by the model, with cohort size once again explaining the bulk of the change. We see sharp increases in observed and predicted variance after 1975 for all groups.

Table 6 demonstrates that this does appear to be a full employment effect of changing current cohort size. The variance in the quality of jobs available, as signaled by hours and weeks worked each year, rises during this period. Table 6 examines the effect of relative cohort size on the proportion working full time, and average hours and weeks worked, in each cell of (the white portion of) Welch's fuller data set – that is, including all civilian white males who worked in the previous year, regardless of full time status. There we see the expected negative effect of birth cohort size on all three variables, together with a positive effect on within-cell variance of hours and weeks worked. Here again, there is an off-setting effect when current cohort size is large and increasing: proportions working full time and hours and weeks worked are all increased at such times, while within-cell variance of hours and weeks worked is reduced.

And here again, as in the previous cases, it can be shown that the unexplained variance is largely cross-sectional: plots of observed, simulated and predicted values for the proportion working full time, and hours and weeks worked, (see Macunovich 1998) show that the model explains a significant proportion of the time trends in these three variables.[7]

Another way of looking at this issue is through quantile regression, which permits the estimate of effects at different points in the income distribution.[8] Table 7 presents regression results for five different points in the income distribution – the 5^{th}, 20^{th}, 50^{th}, 80^{th} and 95^{th} percentiles – using Welch's original data, civilian white men working full time. They suggest extremely strong differentials among income groups, in terms of the effects of changing birth and current cohort size on hourly wages. Focusing just on those variables, we can see that, as expected, the effect of birth cohort size monotonically declines from a very significant -0.323 at the 5^{th} percentile, to a barely significant -0.021 at the 95^{th}. Those at the bottom of the income distribution are hit far harder by the adverse supply effects of large cohort size, than are those at the top. The first difference of the birth cohort size variable, which signals ameliorating effects for those born on the leading edge of a boom, is insignificant at the tails of the distribution, but positively significant in between. However, in results not presented here, for all men regardless of full time status, the coefficient on this variable at the 5^{th} percentile is a significant 0.136, probably indicating some compositional effects in the full time group. This result is again consistent with the hypothesis that the differential effect of cohort size is greatest at the lowest skill levels.


college grads, 1-5 years of experience
relative to 25-34 years of experience
college grads, 6-9 years of experience
relative to 25-34 years of experience
college grads, 10-14 years of experience
relative to 25-34 years of experience
hourly wage ratio
year
observed
model 1
model 4
model 5
model 6
models 4,5,6

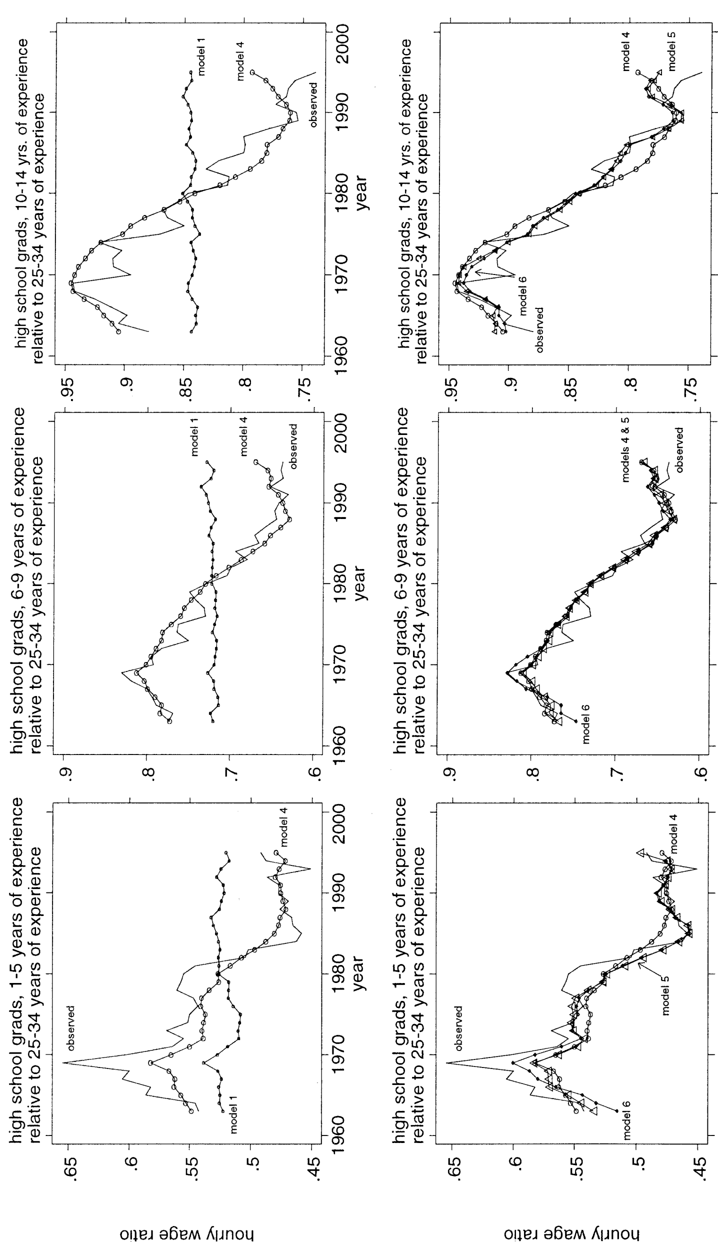


Fig. 8. Comparing observed and predicted values for the relative wages of young men, by education group, using Models 1, 4, 5 and 6.

Table 5. Partial listing of standardized regression coefficients explaining the within-cell variance of ln(hourly wages), using Model 7.

Dependent variable:	***Within-cell variance in ln(hourly wage)***	
	Welch data	***Topcoded Welch data***
Birth cohort size:		
level	**0.018**	**0.045**
	(5.2)	*(9.4)*
first difference	**0.024**	**0.052**
	(5.6)	*(10.3)*
Current cohort size:		
level	**−0.039**	**−0.077**
	(−2.7)	*(−3.5)*
first difference	**−0.001**	**−0.025**
	(−0.1)	*(−1.2)*
Experience interactions with current cohort size:		
*level * experience*	**−0.023**	**−0.085**
	(−0.2)	*(−0.4)*
exp^2	**0.052**	**−0.592**
	(0.1)	*(−0.6)*
exp^3	**0.586**	**3.136**
	(0.4)	*(1.6)*
exp^4	**−1.167**	**−4.328**
	(−0.9)	*(−2.3)*
exp^5	**0.579**	**1.861**
	(1.2)	*(2.7)*
*1st diff * experience*	**−0.434**	**−0.535**
	(−1.9)	*(−2.8)*
exp^2	**2.027**	**1.616**
	(1.9)	*(1.9)*
exp^3	**−4.140**	**−1.798**
	(−1.7)	*(−1.0)*
exp^4	**3.759**	**0.437**
	(1.5)	*(0.3)*
exp^5	**−1.267**	**0.242**
	(−1.4)	*(0.4)*
Number of obs	**141394**	**141202**
F statistic	**23.45**	**107.74**
R-square	**0.0092**	**0.0520**
Root MSE	**0.55535**	**0.14483**

Notes: All coefficients are standardized. t-statistics in parentheses. Topcoded data has 1980 uniform topcode imposed on earnings, to correct for bias introduced by changes in CPS topcode. Full regressions included all variables as in Model 7.

The same effect occurs – although opposite in sign – in the current cohort size variable: those at the bottom of the distribution are boosted disproportionately during population-induced highs in the economy, with a strongly significant positive coefficient of 1.279 on the level of the current cohort size variable, as opposed to the negative coefficient (−0.288) for those at the top of the distribution. Those at the bottom are estimated to receive an even stronger boost on upswings, of 1.052 as compared with the estimated 0.754 for those at the top of the distribution. These differentials imply that individuals at

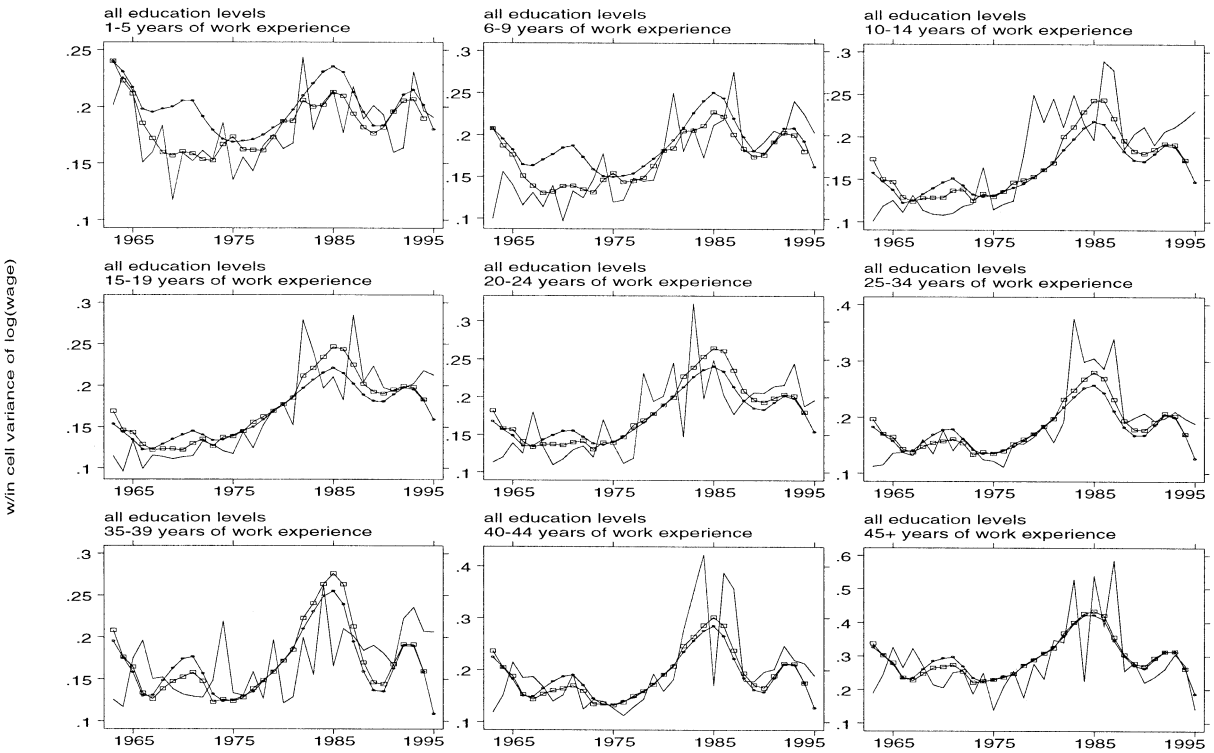


Fig. 9. Observed (–), simulated (○) and predicted (□) variance of ln(hourly wages) within year-state-education-experience cells, for white males working full time, using Model 7.

Table 6. Standardized regressions results for proportion working full time and hours and weeks worked, using Model 7.

Dependent variable:	***Proportion working full time***	***Hours worked per week***	***Weeks worked per year***	***Within-cell Variance in***	
				Hours worked	***Weeks worked***
Birth cohort size:					
level	**−0.044**	**−0.031**	**−0.036**	**0.032**	**0.048**
	(−13.6)	*(−9.2)*	*(−10.2)*	*(8.2)*	*(12.7)*
first difference	**−0.024**	**−0.010**	**−0.050**	**0.047**	**0.030**
	(−5.4)	*(−2.5)*	*(−11.4)*	*(10.5)*	*(6.8)*
Current cohort size:					
level	**0.229**	**0.245**	**0.618**	**−0.041**	**−0.237**
	(6.5)	*(8.4)*	*(23.4)*	*(−1.7)*	*(−11.3)*
first difference	**−0.145**	**−0.153**	**−0.025**	**0.064**	**0.014**
	(−4.4)	*(−5.9)*	*(−1.1)*	*(2.7)*	*(0.6)*
Experience interactions with current cohort size:					
*level * experience*	**−1.055**	**−1.873**	**−4.838**	**−0.229**	**1.971**
	(−3.7)	*(−7.9)*	*(−22.1)*	*(−1.1)*	*(10.3)*
exp^2	**3.542**	**6.807**	**18.018**	**0.586**	**−7.110**
	(3.1)	*(7.1)*	*(20.0)*	*(0.7)*	*(−8.5)*
exp^3	**−7.633**	**−13.12**	**−32.72**	**0.288**	**12.305**
	(−3.4)	*(−6.9)*	*(−18.3)*	*(0.2)*	*(7.2)*
exp^4	**8.299**	**12.370**	**28.212**	**−1.463**	**−10.05**
	(4.0)	*(7.0)*	*(16.9)*	*(−0.8)*	*(−6.1)*
exp^5	**−3.361**	**−4.444**	**−9.228**	**0.828**	**3.097**
	(−4.5)	*(−7.1)*	*(−15.7)*	*(1.2)*	*(5.2)*
*1st diff * experience*	**2.008**	**1.722**	**1.177**	**−1.342**	**−0.927**
	(7.9)	*(8.5)*	*(6.3)*	*(−7.0)*	*(−5.1)*
exp^2	**−8.437**	**−6.343**	**−4.042**	**5.690**	**2.770**
	(−8.3)	*(−7.7)*	*(−5.2)*	*(6.9)*	*(3.5)*
exp^3	**16.053**	**11.315**	**6.469**	**−9.921**	**−3.812**
	(8.1)	*(7.0)*	*(4.2)*	*(−5.9)*	*(−2.4)*
exp^4	**−14.18**	**−9.651**	**−4.680**	**7.627**	**2.266**
	(−7.7)	*(−6.4)*	*(−3.3)*	*(4.7)*	*(1.5)*
exp^5	**4.783**	**3.197**	**1.211**	**−2.147**	**−0.395**
	(7.4)	*(6.0)*	*(2.4)*	*(−3.6)*	*(−0.7)*
Time trend	**−0.048**	**−0.046**	**−0.015**	**0.035**	**0.054**
	(−13.7)	*(−13.3)*	*(−4.1)*	*(9.0)*	*(14.3)*
Experience	**8.931**	**7.733**	**4.837**	**−4.059**	**−2.262**
	(52.5)	*(54.1)*	*(37.1)*	*(−34.2)*	*(−20.8)*
$Experience^2$	**−38.19**	**−31.57**	**−18.83**	**15.210**	**6.729**
	(−42.9)	*(−41.8)*	*(−27.0)*	*(22.6)*	*(10.8)*
$Experience^3$	**66.519**	**54.086**	**32.736**	**−21.90**	**−8.445**
	(35.0)	*(33.4)*	*(21.7)*	*(−14.3)*	*(−6.0)*
$Experience^4$	**−51.35**	**−42.14**	**−26.78**	**11.993**	**4.268**
	(−27.9)	*(−26.8)*	*(−18.3)*	*(7.7)*	*(3.0)*
$Experience^5$	**14.166**	**11.966**	**8.355**	**−1.251**	**−0.491**
	(21.2)	*(21.1)*	*(15.9)*	*(−2.1)*	*(−0.9)*
GDP change	**−0.004**	**0.028**	**−0.003**	**0.017**	**0.006**
	(−1.2)	*(9.4)*	*(−0.9)*	*(4.8)*	*(1.6)*
Military					
level	**0.015**	**0.024**	**0.020**	**0.012**	**−0.011**
	(5.6)	*(8.2)*	*(6.4)*	*(3.4)*	*(−3.2)*
change	**−0.006**	**0.003**	**0.020**	**0.008**	**−0.020**
	(−2.5)	*(1.2)*	*(8.3)*	*(3.0)*	*(−7.8)*
*level * experience < 10*	**−0.009**	**−0.006**	**0.033**	**−0.015**	**−0.017**
	(−2.4)	*(−2.0)*	*(10.0)*	*(−4.3)*	*(−4.9)*

Table 6. (Continued)

Dependent variable:	*Proportion working full time*	*Hours worked per week*	*Weeks worked per year*	*Within-cell Variance in*	
				Hours worked	*Weeks worked*
Trade deficit					
level	**0.021**	**0.048**	**0.100**	**−0.003**	**−0.098**
	(4.4)	*(10.5)*	*(19.3)*	*(−0.6)*	*(−15.4)*
*level * experience < 10*	**0.003**	**−0.004**	**0.004**	**−0.010**	**−0.004**
	(0.8)	*(−1.0)*	*(0.8)*	*(−2.1)*	*(−0.7)*
*level * education > 15*	**0.006**	**−0.005**	**−0.001**	**−0.013**	**0.000**
	(2.5)	*(−2.0)*	*(−0.4)*	*(−4.0)*	*(0.1)*
*level * education < 12*	**0.017**	**0.006**	**0.005**	**−0.011**	**0.010**
	(5.8)	*(2.2)*	*(1.5)*	*(−3.7)*	*(2.8)*
Completed years of education					
<8	**−0.050**	**−0.083**	**−0.157**	**−0.048**	**0.028**
	(−18.8)	*(−37.3)*	*(−51.8)*	*(−18.9)*	*(10.4)*
8–11	**−0.073**	**−0.095**	**−0.200**	**−0.015**	**0.094**
	(−23.5)	*(−35.4)*	*(−60.3)*	*(−5.1)*	*(27.7)*
13–15	**−0.026**	**0.037**	**0.092**	**0.013**	**−0.112**
	(−10.2)	*(15.6)*	*(36.1)*	*(4.4)*	*(−35.9)*
16	**0.031**	**0.120**	**0.157**	**−0.019**	**−0.174**
	(14.0)	*(51.8)*	*(71.9)*	*(−6.6)*	*(−67.3)*
17+	**0.005**	**0.204**	**0.137**	**0.039**	**−0.162**
	(2.2)	*(80.6)*	*(71.5)*	*(13.0)*	*(−75.1)*
Number of obs	**149923**	**149923**	**149923**	**198014**	**198014**
F statistic	**284.26**	**587.54**	**496.70**	**202.59**	**359.53**
Adj. R-square	**0.2911**	**0.3406**	**0.2476**	**0.1209**	**0.1466**
Root MSE	**0.10619**	**3.318**	**4.0617**	**37.773**	**76.179**

Notes: All coefficients are standardized. t-statistics in parentheses. Data included all civilian non-enrolled white males who worked in the previous year, regardless of race or full time status. All regressions included twenty state dummies not reported here.

Table 7. Generalized quantile regression results using Model 7.

Quantile:	*5th*	*20th*	*50th*	*80th*	*95th*
ln(wage) at quantile:	**1.796**	**2.308**	**2.700**	**3.049**	**3.433**
Birth cohort size:					
level	**−0.323**	**−0.207**	**−0.144**	**−0.101**	**−0.021**
	(−13.7)	*(−20.2)*	*(−19.6)*	*(−12.1)*	*(−1.3)*
first difference	**0.056**	**0.155**	**0.138**	**0.098**	**0.010**
	(1.4)	*(8.8)*	*(10.9)*	*(6.8)*	*(0.4)*
Current cohort size:					
level	**1.279**	**0.659**	**0.372**	**0.082**	**−0.288**
	(11.2)	*(13.2)*	*(10.6)*	*(2.1)*	*(−3.5)*
first difference	**1.052**	**0.964**	**0.927**	**0.653**	**0.754**
	(2.3)	*(5.2)*	*(7.6)*	*(4.9)*	*(2.9)*
Time trend	**0.002**	**0.001**	**0.001**	**0.002**	**0.002**
	(4.5)	*(3.8)*	*(8.6)*	*(12.7)*	*(8.1)*
GDP change	**−0.083**	**−0.114**	**−0.062**	**0.033**	**−0.137**
	(−0.5)	*(−1.5)*	*(−1.2)*	*(0.6)*	*(−1.2)*
Military					
level	**0.133**	**0.047**	**−0.004**	**−0.030**	**−0.064**
	(5.5)	*(4.5)*	*(−0.5)*	*(−3.5)*	*(−3.9)*

Table 7. (Continued)

Quantile:	*5th*	*20th*	*50th*	*80th*	*95th*
change	**−0.084**	**−0.087**	**−0.088**	**−0.087**	**−0.103**
	(−6.7)	*(−15.8)*	*(−22.3)*	*(−19.8)*	*(−12.3)*
*level * experience < 10*	**−0.049**	**0.043**	**0.107**	**0.127**	**0.157**
	(−1.1)	*(2.2)*	*(7.4)*	*(7.8)*	*(5.1)*
Trade deficit					
level	**0.138**	**0.144**	**0.117**	**0.105**	**0.121**
	(4.0)	*(9.7)*	*(10.9)*	*(8.7)*	*(5.3)*
*level * experience < 10*	**−0.094**	**−0.093**	**−0.029**	**−0.031**	**−0.089**
	(−2.0)	*(−4.4)*	*(−1.9)*	*(−1.8)*	*(−2.7)*
*level * education > 15*	**0.002**	**0.046**	**0.030**	**0.029**	**0.029**
	(0.0)	*(3.0)*	*(2.7)*	*(2.3)*	*(4.1)*
*level * education < 12*	**0.000**	**−0.030**	**−0.022**	**−0.041**	**−0.023**
	(0.0)	*(−1.9)*	*(−2.0)*	*(−3.3)*	*(−0.9)*
Completed years of education					
<8	**−0.833**	**−0.594**	**−0.422**	**−0.279**	**−0.129**
	(−86.4)	*(141.8)*	*(140.7)*	*(−82.8)*	*(−19.7)*
8–11	**−0.431**	**−0.273**	**−0.192**	**−0.141**	**−0.071**
	(−54.0)	*(−78.2)*	*(−76.7)*	*(−50.4)*	*(−13.2)*
13–15	**−0.006**	**0.086**	**0.145**	**0.194**	**0.270**
	(−0.7)	*(24.0)*	*(56.1)*	*(67.2)*	*(49.1)*
16	**0.136**	**0.287**	**0.384**	**0.468**	**0.569**
	(16.0)	*(77.2)*	*(143.7)*	*(156.4)*	*(99.7)*
17+	**0.075**	**0.301**	**0.454**	**0.583**	**0.718**
	(8.4)	*(77.6)*	*(163.7)*	*(188.3)*	*(122.0)*
Intercept	**2.339**	**2.410**	**2.426**	**2.422**	**2.245**
	(21.3)	*(50.2)*	*(70.1)*	*(61.6)*	*(29.2)*
Pseudo R-squared	**0.2897**	**0.3354**	**0.3846**	**0.3570**	**0.3405**

Notes:
– Number of observations in each regression is 141,394.
– Dependent variable is ln(hourly wage) for white men working full time. t-statistics in parentheses. *Coefficients are not standardized.*
– Each regression also included twenty state dummies, a fifth-degree polynomial in years of experience, and interactions between experience and the current cohort size variables – results available on request.
– An attempt was made to estimate standard errors using bootstrap resampling. The time needed for estimation proved to be prohibitive. However, after twenty iterations the estimated standard errors were not sufficiently different from those used to calculate the t-statistics above, to substantially alter the results reported above.

the bottom of the distribution will have markedly different experiences on the leading and lagging edge of any population-induced economic boom – consistent with their marginal positions in the labor market.

The different experiences of white men working full time, at the top and bottom of the income distribution, is depicted in Fig. 10. Although the declining size of entry cohorts in the 1980s led to a greater proportion of men at the bottom of the distribution working full time, the slower growth in economic activity associated with that decline meant that as marginal and presumably less-skilled workers they put in fewer hours, on average, in that status – while the hours worked by those at the top of the distribution – presumably the more skilled – rose sharply.

Figure 11 presents a simulation of wage profiles at these two percentiles for various years, solely as a result of changing population age structure (using the regression results in Table 7). The similarities between the changing patterns of these profiles, and the average wage curves in Fig. 10 is striking.[9]

8. Discussion

The work presented here has attempted to test the hypothesis that changing demographic structure has been a major factor in the changes in relative – and absolute – wages which have occurred over the last thirty years, leading to the observed sharp decline in the wages of young males relative to prime age workers, as well as to the decline and then steep increase in the wages of the college-educated relative to high school graduates. The belief is that studies which have attempted to quantify such effects in the past have erred both in their method of representing age structure changes in their models – their choice of relative cohort size measures – and in their failure to allow for the possibility that changing age structure might have strong aggregate demand as well as aggregate labor supply effects in the economy.

Previous studies have selected labor force measures of cohort size which control for many of the very factors known to be affected by changing cohort size – hours and weeks worked, unemployment, and labor force participation, thus eliminating at the outset much of what they were trying to measure. And, when they have determined that changing demand for labor played a major role in shifting the structure of wages, they have assumed that any change in demand must emanate from outside the population – from international trade, or technological change. The results presented here show that those external factors have indeed played a role – but that by far the larger role has been played by changes in the population itself.

The analysis has identified pronounced effects of changing age structure on the wage structure, to the extent that almost all of the changes in the experience premium over the past thirty years, and a significant proportion of the change in the college wage premium, can be explained solely as a function of changing age structure. Indeed, it appears that even the marked increase we have observed in within-group variance of wages has been due largely to changing age structure. Figure 12 presents observed quinquennial wage profiles over the last 30 years, and superimposes on them the simulated profiles generated simply by changing demographics, as indicated by model (7). There it can be seen that apart from effects of the Vietnam War in 1970, and international trade in 1985, changing age structure explains all of the observed changes in the wage-experience profile. It can be shown that the same holds true by education level (see Macunovich 1998).

In addition, the model's predictive capabilities appear to be very good: when fitted only on data through 1985, it is able to 'predict' the observed pattern of wages over the following ten years; and coefficients derived by fitting on only a subset of the data fit the remaining data very closely. Tests for bias due to common group errors (as described in Moulton 1987) indicate that the coefficients on the birth and current cohort size variables retain their significance even in a fully aggregated (time series) data set (see Macunovich 1998).

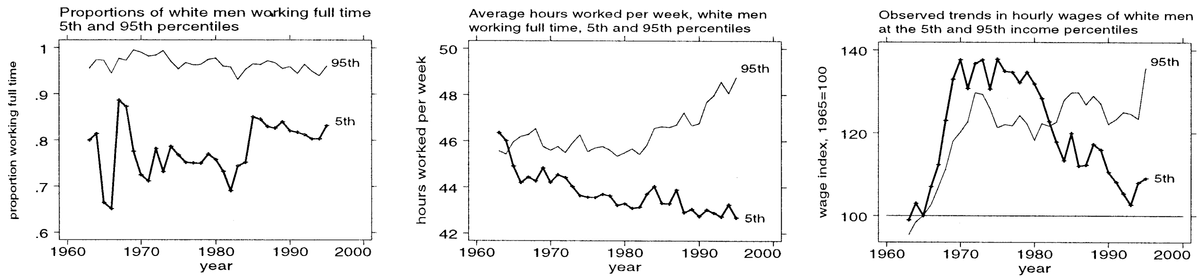


Fig. 10. Observed trends in proportions working full time, and hours worked and hourly wages of white men working full time, at the 5th and 95th income percentiles.

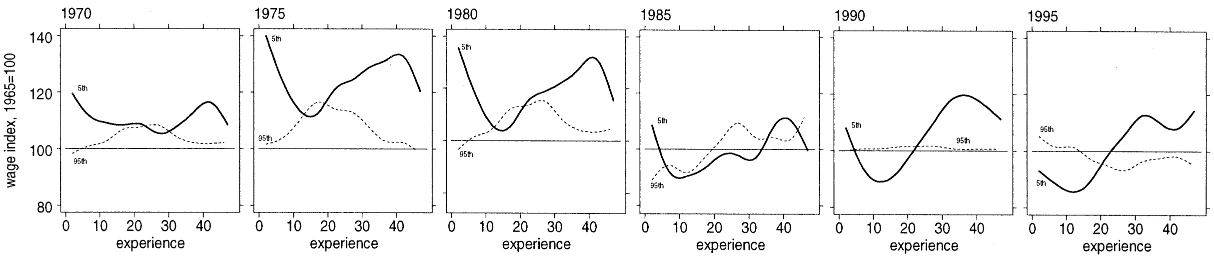


Fig. 11. Simulations of wage profiles at the 5th and 95th percentiles of white men working full time, for various years, based on changing demographics as estimated using the models in Table 7. Each wage is expressed using an index with the 1965 wage for that experience group in that income quantile set equal to 100.

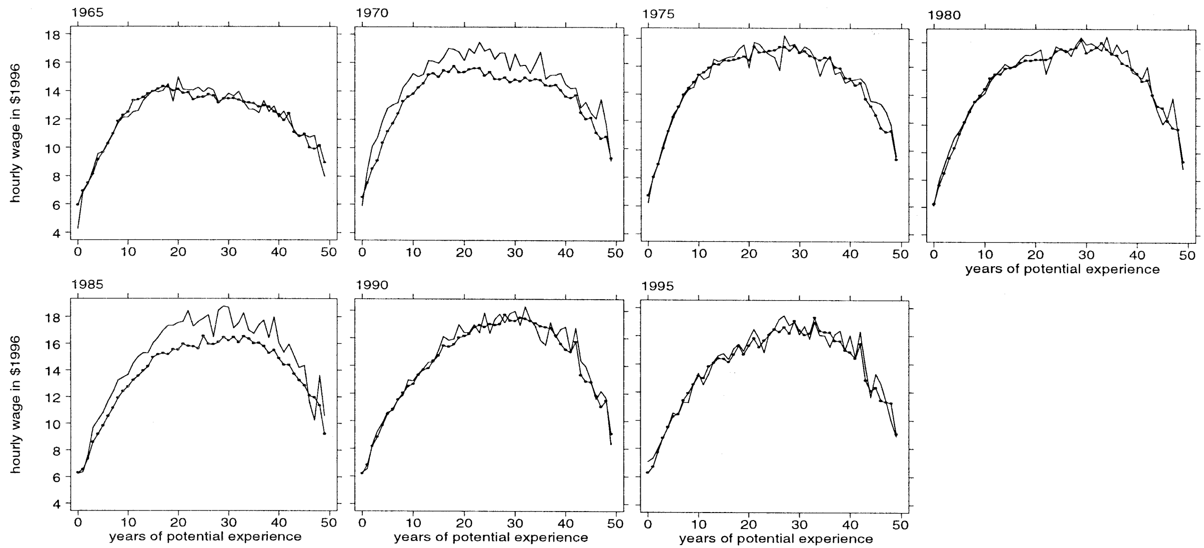


Fig. 12. Observed (–) wage profiles for selected years, with simulated (•) wage profiles based only on changing demographics, using the model in Table 4 (all education levels).

These findings imply that the U.S. baby boom was in fact a mixed curse – or blessing, depending on one's point of view. Those born in the first half of the boom fared poorly, but only in relative terms, because the older members of the population fared so well in an expanding economy fueled by the expenditures of the baby boomers' parents, and later by the boomers themselves. Those who were born as the flow ebbed have been hit hardest because they were also relatively large cohorts, and had to compete with peak boomers who were still trying to find their appropriate niche in the labor market – and in addition they emerged into an economy reeling from the sudden slowdown in growth associated with the declining cohort size of those born after them. The results in this analysis demonstrate that the aggregate demand effects of current cohort size in the population disproportionately affect those at lower skill and experience levels, through what are hypothesized to be full employment effects, boosting them more in upswings, and dropping them further on downswings. They present what appears to be a coherent explanation of the various shifts in experience and skill premiums we have observed over the past 30 years.

Endnotes

[1] See also the work of David (1962), Barnes and Gillingham (1984), Deaton et al. (1989), Browning et al. (1985) and Pollak and Wales (1981), as well as much of the literature on dependency rates and savings rates, such as Leff (1969).

[2] Macunovich (1998) extends the analysis to all African American and white males regardless of full time status, and shows that the effects presented in this paper hold even more strongly in the larger population.

[3] These turning points remain virtually unchanged, whether one uses an unsmoothed lagged GFR series or a 3- or 5-year moving average, and whether the first difference is calculated using the value at $t+2$ minus the value at $t-2$, or $t+1$ minus $t-1$.

[4] See the Appendix for a sensitivity analysis with respect to the degree of smoothing of the GFR, and the method of calculating its rate of change.

[5] Macunovich (1998) presents alternative results using two current population measures: the ratio of 20–22 year olds relative to 45–49 year olds at the national level, and the same ratio in an individual's own geographical region of the country (using the nine Census-defined regions).

[6] An attempt was made to de-trend the birth cohort size variable, over the period 1900–1995: regressions using this de-trended variable produced results virtually identical to those presented here, however, presumably since this variable in the regressions varies over cohorts as well as over time.

[7] The relative cohort size model suggests here an explanation for the observed negative relationship between the wage and unemployment levels documented by Blanchflower and Oswald (1994), and modeled in Campbell and Orszag (1998): current cohort size both increases the average wage level and reduces unemployment.

[8] Generalized quantile regression uses an iterative method to minimize the sum of absolute residuals, rather than the sum of squared residuals, and differentially weights positive and negative residuals in order to minimize the sum around the desired percentile. See StataCorp (1997).

[9] The patterns shown here for the 5th percentile are not unduly affected by compositional changes, as a result of men moving in and out of full time status. The patterns in Figs. 10 and 11 for all white men regardless of full time status at the 5th percentile are very similar.

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Appendix

Description of Data and Methodology Used

The data used in the analysis were taken from the standardized March CPS files made available by Unicon Corporation on CD-Rom for the years 1964–1995 (income years 1963–1994), and from the March CPS Public Use Tape for 1996 (income year 1995). Data from the 1996 CPS survey were not included in most of the regressions presented in this paper, however, because certain macroeconomic indicators (the trade deficit, and the military change variable since it was calculated using values in $t+2$) were not available for that year. Thus, although there were a total of 145,525 observations in the full wage sample, only 141,394 were used in most regressions. The data are described in Appendix Tables A-1 (the wage sample) and A-2 (additional observations added to the wage sample to provide the employment sample used in calculating the 'Welch' relative cohort size variable). Both the wage and the employment samples were restricted to civilian males aged 15+ who had worked in the previous year, but were not self employed. The wage sample was further restricted to whites who had worked full time for at least 40 weeks in the previous year and received no income from self-employment.

Macunovich (1998) reports regression results using two alternative CPS data sets: one imposes a uniform earnings topcode in all CPS years, and the other imposes the same topcode, and in addition includes both African Americans and whites, and men not working full time. Thus observations from Table A-2 were included in the latter data set. The effects of the birth and current cohort size variables are **more pronounced** using these alternative data sets, consistent with the finding that these variables affect not only wages, but also hours and weeks worked.

As in Murphy and Welch (1992), experience was calculated as age-minus-16 years for those having completed ten or fewer grades, and age-minus-grades-minus-6 for those with eleven or more years of schooling. Experience was set to zero if calculated as negative, and "topcoded at values ranging from 42 to 49 depending on educational category such that the top level refers to men 64 years or older. For educational level 1 (high school dropouts) the top experience level is 49 years; it is 48 years for high school graduates; 45 years for those with some college and 42 years for college graduates (Murphy and Welch 1992:290)." Observations were categorized by completed years of education: <8, 8–11, 12, 13–15, 16 and 17+. Hourly wages were calculated as weighted log averages within cells defined by the six education levels and fifty single-year experience groups, separately for each of the thirty-three survey years and for each of twenty-one state groupings which can be identified continuously in the CPS over the thirty-three year period.

The algorithm provided by Finis Welch, which was used to impute hours worked in the previous year prior to 1976, was described as follows in Murphy and Welch (1992:289):

> "For years prior to 1976, annual hours worked are the product of imputed hours and imputed weeks worked. For later surveys, annual hours are the product of observed weeks and imputed hours per week. The hourly wage is annual wage and salary earnings divided by annual hours.
>
> "The hours imputation is from a regression using 1976–1990 data of hours last year on hours this week and other variables (race, education, age, the presence of self-employment income, marital status, and whether weeks worked is 50 or more). Hours last year are divided according to the part time/full time split from all surveys. The imputed value used to calculate annual hours is the fitted value from this regression with predicted hours bottom coded at 10 and top coded at 48.
>
> "Imputed weeks are estimated from regressions within the weeks worked intervals given in the earlier surveys (1963–1975: 1–13, 14–26, 27–39,

Table A-1. Description of March CPS data used for the 'Welch' wage sample: civilian white males working full time for at least 40 weeks, with no self-employment or imputed earnings.

Income year	*Number of obs.*	*Sum of weights*	*Number of cells after aggregation*	*Average annual earnings*	*Average weeks worked*	*Average hours worked*	*log hourly wage*	*Years of education*	*Years of potential exp.*
1963	**10746**	**26136366.1**	**3715**	**$29857**	**51.16**	**43.66**	**2.467**	**11.20**	**23.04**
				(16528)	*(2.30)*	*(2.55)*	*(.541)*	*(3.21)*	*(12.66)*
1964	**10723**	**26774037.6**	**3689**	**30791**	**51.18**	**43.75**	**2.492**	**11.29**	**22.99**
				(16855)	*(2.28)*	*(2.60)*	*(.559)*	*(3.19)*	*(12.76)*
1965	**23061**	**28793124.7**	**4676**	**31750**	**51.25**	**44.03**	**2.512**	**11.43**	**22.76**
				(17262)	*(2.15)*	*(2.62)*	*(.564)*	*(3.15)*	*(12.92)*
1966	**14813**	**30013882.1**	**4184**	**32646**	**51.28**	**43.86**	**2.545**	**11.45**	**22.83**
				(18358)	*(2.13)*	*(2.62)*	*(.548)*	*(3.16)*	*(12.92)*
1967	**20901**	**27484359.0**	**4488**	**33460**	**51.29**	**43.85**	**2.570**	**11.54**	**22.39**
				(18470)	*(2.11)*	*(2.62)*	*(.545)*	*(3.17)*	*(12.90)*
1968	**20593**	**26919952.0**	**4507**	**34738**	**51.26**	**43.83**	**2.610**	**11.59**	**22.35**
				(18861)	*(2.16)*	*(2.63)*	*(.543)*	*(3.19)*	*(13.01)*
1969	**20177**	**28210707.1**	**4452**	**36653**	**51.21**	**43.66**	**2.676**	**11.70**	**22.47**
				(19804)	*(2.23)*	*(2.62)*	*(.510)*	*(3.11)*	*(12.99)*
1970	**19685**	**27590796.7**	**4437**	**37109**	**51.14**	**43.55**	**2.691**	**11.87**	**22.03**
				(20078)	*(2.35)*	*(2.59)*	*(.517)*	*(3.09)*	*(13.04)*
1971	**18952**	**28206312.4**	**4473**	**37051**	**51.19**	**43.60**	**2.680**	**11.91**	**21.68**
				(20370)	*(2.27)*	*(2.60)*	*(.535)*	*(3.11)*	*(13.12)*
1972	**18650**	**28501514.0**	**4553**	**38773**	**51.23**	**43.75**	**2.717**	**12.02**	**21.09**
				(21509)	*(2.21)*	*(2.63)*	*(.541)*	*(3.11)*	*(13.16)*
1973	**18178**	**28846349.2**	**4457**	**38822**	**51.22**	**43.58**	**2.723**	**12.14**	**20.49**
				(21178)	*(2.23)*	*(2.62)*	*(.537)*	*(3.08)*	*(13.22)*
1974	**17245**	**28275249.2**	**4381**	**37417**	**51.18**	**43.27**	**2.689**	**12.30**	**20.19**
				(20397)	*(2.29)*	*(2.56)*	*(.574)*	*(3.03)*	*(13.21)*
1975	**16697**	**26333629.9**	**4327**	**37086**	**51.15**	**43.33**	**2.692**	**12.44**	**20.13**
				(19352)	*(2.44)*	*(2.59)*	*(.520)*	*(3.01)*	*(13.09)*
1976	**20612**	**27831152.5**	**4522**	**37734**	**51.15**	**43.59**	**2.702**	**12.50**	**19.80**
				(19468)	*(2.39)*	*(2.63)*	*(.521)*	*(3.02)*	*(13.11)*

1977	**20135**	**28188341.2**	**4495**	**38091**	**51.15**	**43.69**	**2.704**	**12.56**	**19.45**
				(19822)	*(2.42)*	*(2.64)*	*(.540)*	*(2.98)*	*(12.92)*
1978	**20215**	**29070133.2**	**4543**	**38307**	**51.16**	**43.69**	**2.703**	**12.67**	**19.22**
				(19979)	*(2.43)*	*(2.66)*	*(.568)*	*(2.94)*	*(12.96)*
1979	**24629**	**30252040.1**	**4646**	**38424**	**51.15**	**43.50**	**2.710**	**12.74**	**19.19**
				(19796)	*(2.43)*	*(2.61)*	*(.573)*	*(2.94)*	*(12.91)*
1980	**23665**	**29814226.1**	**4650**	**37415**	**51.16**	**43.35**	**2.690**	**12.79**	**19.06**
				(18902)	*(2.47)*	*(2.61)*	*(.571)*	*(2.97)*	*(12.75)*
1981	**20951**	**29876795.1**	**4505**	**37459**	**51.12**	**43.22**	**2.680**	**12.87**	**19.11**
				(20685)	*(2.51)*	*(2.57)*	*(.603)*	*(2.96)*	*(12.57)*
1982	**19902**	**28504840.0**	**4422**	**37848**	**51.13**	**43.29**	**2.681**	**13.06**	**19.13**
				(21378)	*(2.49)*	*(2.63)*	*(.631)*	*(2.94)*	*(12.49)*
1983	**19859**	**29184399.1**	**4423**	**38107**	**51.21**	**43.60**	**2.667**	**13.10**	**19.04**
				(21711)	*(2.41)*	*(2.67)*	*(.691)*	*(2.88)*	*(12.31)*
1984	**20342**	**29968284.4**	**4373**	**38997**	**51.27**	**43.74**	**2.679**	**13.10**	**18.87**
				(23501)	*(2.32)*	*(2.71)*	*(.667)*	*(2.87)*	*(12.08)*
1985	**20737**	**31732147.9**	**4407**	**39210**	**51.26**	**43.70**	**2.686**	**13.11**	**18.71**
				(23679)	*(2.34)*	*(2.72)*	*(.652)*	*(2.87)*	*(12.05)*
1986	**20397**	**31920946.7**	**4351**	**40309**	**51.31**	**43.78**	**2.704**	**13.17**	**18.93**
				(24664)	*(2.26)*	*(2.73)*	*(.678)*	*(2.87)*	*(11.99)*
1987	**20917**	**32699835.8**	**4386**	**39926**	**51.33**	**43.89**	**2.688**	**13.16**	**18.86**
				(24292)	*(2.23)*	*(2.75)*	*(.705)*	*(2.88)*	*(11.82)*
1988	**23634**	**40395704.7**	**4587**	**39863**	**51.31**	**43.92**	**2.693**	**13.17**	**18.98**
				(24694)	*(2.29)*	*(2.77)*	*(.612)*	*(2.90)*	*(11.79)*
1989	**25798**	**40910811.9**	**4648**	**39938**	**51.28**	**43.87**	**2.692**	**13.17**	**19.25**
				(24947)	*(2.33)*	*(2.74)*	*(.625)*	*(2.91)*	*(11.73)*
1990	**25438**	**40732100.3**	**4576**	**38386**	**51.23**	**43.69**	**2.660**	**13.20**	**19.36**
				(23683)	*(2.40)*	*(2.73)*	*(.619)*	*(2.86)*	*(11.62)*
1991	**24372**	**39915232.3**	**4422**	**38061**	**51.20**	**43.78**	**2.650**	**13.50**	**19.39**
				(23446)	*(2.50)*	*(2.75)*	*(.615)*	*(2.89)*	*(11.48)*
1992	**23821**	**39789381.2**	**4394**	**38579**	**51.28**	**43.94**	**2.653**	**13.62**	**19.55**
				(23871)	*(2.33)*	*(2.78)*	*(.631)*	*(2.88)*	*(11.40)*
1993	**23119**	**40710594.1**	**4357**	**37959**	**51.30**	**44.06**	**2.624**	**13.62**	**19.38**
				(23968)	*(2.38)*	*(2.75)*	*(.655)*	*(2.90)*	*(11.28)*

Table A-1. (Continued)

Income year	*Number of obs.*	*Sum of weights*	*Number of cells after aggregation*	*Average annual earnings*	*Average weeks worked*	*Average hours worked*	*log hourly wage*	*Years of education*	*years of Potential exp.*
1994	**23116**	**41657767.1**	**4348**	**38318**	**51.36**	**44.08**	**2.636**	**13.66**	**19.51**
				(24188)	*(2.22)*	*(2.77)*	*(.635)*	*(2.90)*	*(11.26)*
1995	**17776**	**36523547.4**	**4131**	**36853**	**51.35**	**42.73**	**2.623**	**13.39**	**19.14**
				(23962)	*(2.24)*	*(3.84)*	*(.643)*	*(2.85)*	*(11.35)*

Notes:
– annual earnings and hourly wage are expressed in constant 1996 dollars (using CPI-X).
– standard deviations in parentheses.
– income year is the year in which the income was received (CPS survey year minus one).
– original observations from the CPS (column 2) were aggregated into cells (column 4) on the basis of 6 education groups (<8, 8–11, 12, 13–5, 16, 17+), 50 single years of experience (0–49), and 21 CPS/Census state aggregates which can be identified over all years. March CPS weights were used in the aggregation. Ln (hourly wage) is the average of the log of individual hourly wages.

Table A-2. Description of March CPS data used for the ‘Welch’ employment sample, but excluded from the wage sample: civilian males who worked during the year but were non-white or worked less than full time (or both).

Income year	*Number of obs.*	*Sum of weights*	*Average annual earnings*	*Average weeks worked*	*Average hours worked*	*log hourly wage*	*Years of education*	*Years of potential exp.*
1963	**6336**	**15560771.0**	**12953**	**35.19**	**35.91**	**1.865**	**10.26**	**18.95**
			(16590)	*(6.67)*	*(2.07)*	*(1.070)*	*(3.60)*	*(16.73)*
1964	**6442**	**15947905.6**	**13336**	**35.38**	**36.21**	**1.867**	**10.37**	**18.78**
			(19098)	*(6.70)*	*(2.02)*	*(1.082)*	*(3.62)*	*(16.83)*
1965	**12609**	**15993034.8**	**13228**	**34.92**	**35.57**	**1.940**	**10.25**	**17.39**
			(15796)	*(6.83)*	*(2.09)*	*(1.039)*	*(3.54)*	*(16.68)*
1966	**7922**	**16347866.9**	**13505**	**35.07**	**35.12**	**1.984**	**10.45**	**16.80**
			(15052)	*(7.01)*	*(1.91)*	*(1.014)*	*(3.43)*	*(16.73)*
1967	**14678**	**19330298.9**	**16701**	**37.74**	**36.29**	**2.080**	**10.71**	**18.00**
			(17530)	*(6.64)*	*(1.56)*	*(9.991)*	*(3.44)*	*(16.64)*
1968	**15617**	**20734997.0**	**18113**	**38.23**	**36.40**	**2.146**	**10.88**	**18.00**
			(18577)	*(6.68)*	*(1.38)*	*(0.964)*	*(3.38)*	*(16.62)*
1969	**14679**	**20826334.6**	**17685**	**37.08**	**35.53**	**2.168**	**10.97**	**17.09**
			(19295)	*(6.98)*	*(1.79)*	*(0.902)*	*(3.35)*	*(16.64)*
1970	**15507**	**21972683.4**	**17906**	**36.58**	**35.72**	**2.191**	**11.04**	**17.33**
			(19596)	*(6.79)*	*(1.66)*	*(0.907)*	*(3.28)*	*(16.50)*
1971	**15000**	**22441581.3**	**17703**	**36.11**	**35.56**	**2.194**	**11.19**	**16.99**
			(19425)	*(6.81)*	*(1.71)*	*(0.900)*	*(3.29)*	*(16.50)*
1972	**14712**	**23208696.4**	**19442**	**36.83**	**36.20**	**2.249**	**11.35**	**16.81**
			(21405)	*(6.62)*	*(1.24)*	*(0.882)*	*(3.21)*	*(16.34)*
1973	**15085**	**24586925.7**	**20189**	**37.48**	**35.91**	**2.269**	**11.42**	**16.74**
			(21526)	*(6.72)*	*(1.25)*	*(0.892)*	*(3.22)*	*(16.37)*
1974	**15154**	**25596989.4**	**19685**	**37.82**	**35.96**	**2.244**	**11.56**	**16.60**
			(20630)	*(6.32)*	*(1.05)*	*(0.912)*	*(3.23)*	*(16.12)*
1975	**16473**	**27278326.7**	**20343**	**36.87**	**36.75**	**2.274**	**11.73**	**16.65**
			(21231)	*(6.84)*	*(0.80)*	*(0.863)*	*(3.20)*	*(15.73)*
1976	**19523**	**26887623.4**	**19974**	**36.45**	**36.82**	**2.247**	**11.77**	**16.28**
			(21324)	*(7.05)*	*(0.88)*	*(0.895)*	*(3.16)*	*(15.69)*
1977	**19301**	**27621649.0**	**20644**	**36.93**	**36.74**	**2.271**	**11.82**	**16.31**
			(21722)	*(6.97)*	*(0.84)*	*(0.885)*	*(3.16)*	*(15.70)*
1978	**19052**	**27840683.2**	**21606**	**37.52**	**36.97**	**2.293**	**11.95**	**16.13**
			(22066)	*(6.83)*	*(0.53)*	*(0.881)*	*(3.13)*	*(15.58)*
1979	**22029**	**27482844.5**	**20701**	**37.63**	**36.58**	**2.247**	**11.92**	**16.03**
			(21068)	*(6.74)*	*(0.64)*	*(0.946)*	*(3.10)*	*(15.55)*
1980	**22678**	**29311348.0**	**20279**	**37.26**	**36.55**	**2.250**	**12.04**	**16.07**
			(20248)	*(6.84)*	*(0.73)*	*(0.923)*	*(3.02)*	*(15.22)*
1981	**20288**	**29555324.0**	**20357**	**37.14**	**36.17**	**2.236**	**12.13**	**15.98**
			(21928)	*(6.86)*	*(0.94)*	*(0.921)*	*(3.03)*	*(15.10)*
1982	**20665**	**30340538.1**	**19853**	**36.48**	**36.08**	**2.231**	**12.26**	**16.11**
			(21503)	*(6.94)*	*(0.89)*	*(0.959)*	*(3.01)*	*(14.82)*
1983	**19707**	**29537276.7**	**20106**	**36.98**	**36.24**	**2.211**	**12.33**	**16.13**
			(21367)	*(7.11)*	*(0.88)*	*(0.993)*	*(2.99)*	*(14.76)*
1984	**19792**	**30041996.3**	**21107**	**38.22**	**36.71**	**2.203**	**12.35**	**16.30**
			(22962)	*(6.79)*	*(0.71)*	*(0.948)*	*(2.99)*	*(14.78)*
1985	**18932**	**29745559.8**	**21200**	**38.22**	**36.55**	**2.210**	**12.38**	**16.24**
			(23301)	*(6.68)*	*(0.75)*	*(0.958)*	*(2.97)*	*(14.66)*
1986	**18714**	**30264439.2**	**21943**	**38.27**	**36.78**	**2.251**	**12.39**	**16.34**
			(23879)	*(6.79)*	*(0.70)*	*(0.960)*	*(2.95)*	*(14.58)*
1987	**18303**	**29992700.3**	**22111**	**38.63**	**36.81**	**2.229**	**12.44**	**16.31**
			(23968)	*(6.65)*	*(0.59)*	*(0.987)*	*(2.96)*	*(14.56)*

Table A-2. (Continued)

Income year	*Number of obs.*	*Sum of weights*	*Average annual earnings*	*Average weeks worked*	*Average hours worked*	*log hourly wage*	*Years of education*	*Years of potential exp.*
1988	**13579**	**24054706.7**	**17378**	**35.61**	**34.77**	**2.131**	**12.28**	**15.61**
			(20845)	*(7.10)*	*(1.30)*	*(0.937)*	*(2.97)*	*(14.96)*
1989	**14762**	**24329260.1**	**17138**	**36.26**	**34.78**	**2.116**	**12.32**	**15.60**
			(20210)	*(6.89)*	*(1.23)*	*(0.927)*	*(2.97)*	*(14.70)*
1990	**14586**	**24419196.1**	**16879**	**36.06**	**34.69**	**2.138**	**12.36**	**15.96**
			(19502)	*(6.97)*	*(1.17)*	*(0.918)*	*(2.97)*	*(14.70)*
1991	**14800**	**25200527.0**	**16547**	**35.48**	**34.80**	**2.130**	**12.73**	**16.13**
			(19162)	*(6.84)*	*(1.25)*	*(0.922)*	*(2.91)*	*(14.56)*
1992	**14588**	**25367439.4**	**16201**	**35.36**	**34.78**	**2.113**	**12.73**	**15.85**
			(18768)	*(6.92)*	*(1.18)*	*(0.902)*	*(2.88)*	*(14.30)*
1993	**13737**	**25552178.9**	**16420**	**35.58**	**34.71**	**2.100**	**12.79**	**15.78**
			(19126)	*(7.23)*	*(1.32)*	*(0.950)*	*(2.90)*	*(14.27)*
1994	**13951**	**26058376.8**	**17478**	**36.51**	**34.92**	**2.146**	**12.85**	**16.02**
			(20421)	*(7.04)*	*(1.27)*	*(0.925)*	*(2.97)*	*(14.26)*
1995	**15131**	**32765746.5**	**23313**	**40.20**	**36.12**	**2.309**	**13.31**	**17.82**
			(24450)	*(6.14)*	*(0.80)*	*(0.917)*	*(3.04)*	*(14.04)*

Notes:
– annual earnings and hourly wage are expressed in constant 1996 dollars (using CPI-X).
– standard deviations in parentheses.
– income year is the year in which the income was received (CPS survey year minus one).
– these observations were included with those in the wage sample (Table A-1) in calculating total hours worked each year, at each level of education and experience. These cell totals of hours worked were in turn used to calculate the 'Welch' relative cohort size measure.

> 40–47, 48–49 and 50+). These regressions use the 1976–1990 surveys and condition on the same variables used in the hours imputation except that a full-time hours variable replaces the full-year variable."

The present analysis used the full data through 1996, rather than through 1990 for the hours and weeks worked regressions, and the author takes full responsibility for errors which she may have made using the algorithms provided.

The macroeconomic variables which were used in the analysis are presented – in their original and de-trended form – in Table A-3, which also describes the sources and methodology used to derive them.

Selecting the experience polynomial

The first step in identifying the most appropriate polynomial for representing experience was the estimation of an unconstrained model using seventeen dummy variables (one per year for years 0–9, and one per five-year grouping thereafter, to 45+). The experience profile identified there was then used as a benchmark for evaluating the profiles produced using experience polynomials of degree 3 through 7. The polynomial models were estimated in three forms: with only state and education dummies and a time trend; then including all of the macro controls (military, trade and GDP); and finally adding in the GFR-based cohort size measures. It was found that the fifth degree polynomial produced an experience profile which was virtually identical with the un-

Table A-3. Macroeconomic variables used in the regressions.

	Logged General Fertility Rate (lagged 20 years)		*Annual Change in logged real GDP*		*Military Ratio*		*Trade Deficit*	
year	*original*	*detrended*	*original*	*detrended*	*original*	*detrended*	*original*	*detrended*
62	4.4532	−0.2138	0.0503	0.0120	−0.4251	−0.2748	0.0200	−0.0379
63	4.4760	−0.1853	0.0403	0.0025	−0.3487	−0.1747	−0.0378	−0.0833
64	4.4965	−0.1590	0.0549	0.0177	−0.2664	−0.0689	−0.1200	−0.1532
65	4.5387	−0.1111	0.0540	0.0174	−0.3051	−0.0838	−0.0604	−0.0814
66	4.5798	−0.0644	0.0573	0.0213	−0.2443	0.0006	−0.0040	−0.0127
67	4.6087	−0.0297	0.0260	−0.0094	−0.0006	0.2679	0.0103	0.0139
68	4.6455	0.0128	0.0408	0.0059	0.1072	0.3994	0.1496	0.1656
69	4.6787	0.0518	0.0268	−0.0074	0.1146	0.4304	0.1257	0.1540
70	4.6921	0.0709	0.0003	−0.0334	0.1359	0.4753	0.0507	0.0913
71	4.6963	0.0808	0.0281	−0.0050	0.0015	0.3645	0.1419	0.1948
72	4.7117	0.1019	0.0499	0.0174	−0.2641	0.1226	0.1701	0.2353
73	4.7315	0.1274	0.0507	0.0187	−0.3782	0.0322	0.0006	0.0780
74	4.7515	0.1532	−0.0063	−0.0377	−0.4711	−0.0371	−0.1513	−0.0616
75	4.7677	0.1751	−0.0082	−0.0390	−0.5410	−0.0834	−0.3445	−0.2425
76	4.7811	0.1942	0.0482	0.0180	−0.5660	−0.0848	−0.1679	−0.0536
77	4.7882	0.2070	0.0441	0.0145	−0.5746	−0.0697	−0.0545	0.0721
78	4.7905	0.2151	0.0470	0.0180	−0.5488	−0.0202	−0.0308	0.1081
79	4.7885	0.2188	0.0249	−0.0036	−0.5386	0.0136	−0.1499	0.0013
80	4.7792	.2152	−0.0054	−0.0333	−0.5825	−0.0067	−0.2636	−0.1000
81	4.7606	0.2023	0.0175	−0.0098	−0.5647	0.0348	−0.1607	0.0151
82	4.7388	0.1863	−0.0218	−0.0485	−0.5998	0.0233	−0.0209	0.1672
83	4.7089	0.1621	0.0382	0.0120	−0.6196	0.0272	0.1745	0.3749
84	4.6669	0.1258	0.0601	0.0345	−0.6368	0.0336	0.3452	0.5579
85	4.6169	0.0815	0.0312	0.0062	−0.6775	0.0166	0.3501	0.5751
86	4.5675	0.0379	0.0287	0.0043	−0.7354	−0.0177	0.3701	0.6074
87	4.5208	−0.0031	0.0303	0.0065	−0.7627	−0.0214	0.2694	0.5190
88	4.4853	−0.0329	0.0386	0.0153	−0.8253	−0.0604	0.0826	0.3445
89	4.4657	0.0468	0.0250	0.0023	−0.8640	−0.0754	−0.0285	0.2457
90	4.4414	−0.0653	0.0122	−0.0099	−0.8898	−0.0776	−0.1077	0.1789
91	4.4062	−0.0948	−0.0061	−0.0276	−0.8604	−0.0245	−0.1868	0.1120
92	4.3642	−0.1311	0.0227	0.0018	−0.8909	−0.0314	−0.1701	0.1410
93	4.3141	−0.1755	0.0307	0.0104	−0.9252	−0.0420	−0.1204	0.2030
94	4.2575	−0.2264	0.0400	0.0202	−0.9319	−0.0251	−0.0946	0.2412
95	4.2169	−0.2612	.	.	−0.9776	−0.0471	.	.
96	4.2004	−0.2720	.	.	−1.0389	−0.0849	.	.

Notes:

– Logged General Fertility Rate is a five year moving average of the annual number of births per 1000 women aged 15–44. Source: "U.S. Vital Statistics: Natality".

– Military Ratio is the logged ratio of active military aged 20–24 relative to total active military of all other ages. Source: author's calculation using DoD publication "Selected Manpower Statistics" DIOR/M01-96. Table 2–17, various years.

– Trade Deficit is calculated as the logged per capita level of durable goods imports minus the logged per capita level of durable goods exports, all expressed in chained 1992 dollars. Source: author's calculation using imports and exports data provided by David Wasshausen, Bureau of Economic Analysis, and population data from BLS "Current Population Reports" series P-24, P25 and PPL-21 (Appendix B), various years.

– real GDP taken from "The Statistical Abstract of the United States", various years.

– detrended series are the residuals obtained after regressing the original series on a time trend.

constrained profile, and was impervious to the introduction of the macro and cohort size variables. Alternative regression results using various polynomials are presented in Table A-4.

Sensitivity of results to smoothing in the cohort size variables

At the request of an anonymous referee, alternative regression results are presented in Table A-5 to demonstrate the effect of different levels of smoothing in the General Fertility Rate used, and different time periods for the first differences of that variable. The estimated coefficients on the levels of the birth and current cohort size variables are fairly impervious to the changes. The coefficients on the differences vary, of course, given the change in absolute value of the variable in moving from a five- to a three-year difference, but the significance of the differences only diminishes as we pick up more noise close to an unsmoothed rate.

Heteroscedasticity

Because cell sizes vary across the samples and over time, all models were estimated with weighted least squares using the "regress" procedure in Stata-Corp (1997, vol. 3: pp. 118–138), which produces White-corrected standard errors in the presence of any heteroscedasticity. Several different weighting methods are permitted with this software, one of which ("analytic weights") is designed for use with data which are themselves cell means, and another of which ("sampling weights") is designed for use with data obtained from probability-weighted random samples. Because the analysis here was performed on observations from a probability-weighted random sample (the March *Current Population Survey*), which were aggregated into cell means, the models were estimated using both of these weighting methods, as well as unweighted. The results presented here (estimated using the "probability weights") are the most conservative in that they produced the lowest t- and F-statistics. Alternative sets of results – not substantially different from those presented here – estimated using other weighting schemes, are available on request from the author.

As an additional test, the models were estimated on successively more aggregated data, first aggregating into just four education groups (<12, 12, 13–15, and 16+) and eighteen experience groups (single years through nine and five-year groupings thereafter, ending in 45–49+), and then over all state groupings. These more aggregated models were estimated using various combinations of weighting schemes, using as weights both weighted and unweighted cell counts. The most aggregated data set used in these regressions contained just 2,272 observations, and produced an adjusted R^2 of 0.953 and coefficients on all birth- and current- cohort-size variables still significant at least at the 0.0001 level, with signs unchanged from those presented here. These results too are available on request.

Testing for bias due to common group errors

There is a danger, when using macro level variables with micro data, that t-statistics will be inflated due to common group errors (Moulton 1987). The

Table A-4. Alternative regression results using different formulations of the experience variable.

Birth cohort size:					
level	**−0.077**	**−0.127**	**−0.133**	**−0.129**	**−0.142**
	(−10.9)	*(−17.5)*	*(−18.1)*	*(−17.6)*	*(−19.6)*
first difference	**0.140**	**0.151**	**0.166**	**0.176**	**0.162**
	(11.6)	*(12.0)*	*(12.9)*	*(13.6)*	*(12.8)*
Current cohort size:					
level	**0.495**	**0.533**	**0.454**	**0.383**	**0.264**
	(15.9)	*(14.7)*	*(10.2)*	*(7.2)*	*(15.6)*
first difference	**0.573**	**0.722**	**0.618**	**0.464**	**0.740**
	(4.9)	*(5.5)*	*(3.9)*	*(2.4)*	*(13.5)*
Experience interactions with current cohort size:					
*level * experience*	**−0.028**	**−0.015**	**0.034**	**0.090**	*
	(−5.1)	*(−1.6)*	*(2.1)*	*(3.4)*	
exp^2	**0.001**	**−0.001**	**−0.009**	**−0.021**	*
	(5.5)	*(−1.2)*	*(−4.3)*	*(−4.7)*	
exp^3	**−2.1e−5**	**8.3e−5**	**0.001**	**0.002**	*
	(−5.5)	*(3.2)*	*(4.9)*	*(4.6)*	
exp^4		**−1.2e−6**	**−1.2e−4**	**−5.4e−5**	*
		(−4.4)	*(−4.8)*	*(−4.2)*	
exp^5			**9.0e−8**	**8.7e−7**	*
			(4.3)	*(3.7)*	
exp^6				**−5.4e−9**	*
				(−3.3)	
*1^{st} diff * experience*	**0.031**	**−0.028**	**0.043**	**0.194**	*
	(1.6)	*(−0.8)*	*(0.7)*	*(2.1)*	
exp^2	**−0.001**	**0.004**	**−0.007**	**−0.038**	*
	(−0.9)	*(1.5)*	*(−0.9)*	*(−2.4)*	
exp^3	**−6.6e−7**	**−1.6e−4**	**4.6e−4**	**0.003**	*
	(−0.1)	*(−1.7)*	*(1.2)*	*(2.5)*	
exp^4		**1.7e−6**	**−1.3e−5**	**−1.1e−4**	*
		(1.7)	*(−1.4)*	*(−2.4)*	
exp^5			**1.2e−7**	**1.9e−6**	*
			(1.5)	*(2.2)*	
exp^6				**−1.2e−8**	*
				(−2.0)	
Time trend	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
	(7.4)	*(7.0)*	*(7.0)*	*(7.0)*	*(7.0)*
Experience	**0.081**	**0.126**	**0.148**	**0.192**	*
	(113.1)	*(91.7)*	*(60.4)*	*(48.7)*	
Experience^2	**−0.002**	**−0.007**	**−0.010**	**−0.018**	*
	(−67.0)	*(−57.9)*	*(−32.4)*	*(−28.0)*	
Experience^3	**2.1e−5**	**1.6e−4**	**3.3e−4**	**0.001**	*
	(41.6)	*(44.3)*	*(21.2)*	*(21.2)*	
Experience^4		**−1.4e−6**	**−5.4e−6**	**−3.4e−5**	*
		(−38.1)	*(−15.1)*	*(−18.1)*	
Experience^5			**3.3e−8**	**5.5e−7**	*
			(11.0)	*(16.4)*	
Experience^6				**−3.6e−9**	*
				(−15.4)	
GDP change	**−0.055**	**−0.066**	**−0.071**	**−0.070**	**−0.071**
	(−1.1)	*(−1.3)*	*(−1.4)*	*(−1.4)*	*(−1.4)*
Military					
level	**0.011**	**0.017**	**0.020**	**0.023**	**0.019**
	(1.6)	*(2.4)*	*(2.9)*	*(3.4)*	*(2.7)*
change	**−0.083**	**−0.083**	**−0.083**	**−0.083**	**−0.083**
	(−24.5)	*(−25.2)*	*(−25.0)*	*(−25.2)*	*(−24.9)*

Table A-4. (Continued)

*level * experience < 10*	**0.107**	**0.077**	**0.059**	**0.045**	**0.064**
	(8.7)	*(6.5)*	*(4.9)*	*(3.7)*	*(5.1)*
Trade deficit					
level	**0.125**	**0.125**	**0.122**	**0.119**	**0.125**
	(12.6)	*(12.7)*	*(12.4)*	*(12.0)*	*(12.5)*
*level * experience < 10*	**−0.051**	**−0.049**	**−0.040**	**−0.030**	**−0.049**
	(−3.8)	*(−3.8)*	*(−3.0)*	*(−2.3)*	*(−3.5)*
*level * education > 15*	**0.011**	**0.010**	**0.012**	**0.013**	**0.013**
	(1.0)	*(0.9)*	*(1.1)*	*(1.1)*	*(1.2)*
*level * education < 12*	**−0.034**	**−0.032**	**−0.032**	**−0.032**	**−0.033**
	(−2.8)	*(−2.6)*	*(−2.6)*	*(−2.7)*	*(−2.7)*
Completed years of education					
<8	**−0.474**	**−0.468**	**−0.469**	**−0.468**	**−0.471**
	(115.4)	*(114.9)*	*(115.1)*	*(115.1)*	*(115.5)*
8–11	**−0.208**	**−0.206**	**−0.207**	**−0.206**	**−0.207**
	(−91.4)	*(−91.8)*	*(−92.0)*	*(−92.0)*	*(−92.2)*
13–15	**0.139**	**0.140**	**0.140**	**0.140**	**0.141**
	(65.1)	*(66.5)*	*(66.9)*	*(66.9)*	*(67.2)*
16	**0.385**	**0.385**	**0.384**	**0.384**	**0.384**
	(155.3)	*(156.0)*	*(156.0)*	*(156.0)*	*(155.4)*
17+	**0.457**	**0.456**	**0.456**	**0.456**	**0.456**
	(140.4)	*(140.4)*	*(140.4)*	*(140.4)*	*(140.3)*
Intercept	**2.229**	**2.336**	**2.324**	**2.250**	**3.201**
	(67.9)	*(69.6)*	*(68.4)*	*(65.8)*	*(95.7)*
Number of obs	**141394**	**141394**	**141394**	**141394**	**141394**
F statistic	**3033.81**	**2950.29**	**2890.22**	**2656.96**	**1696.29**
R-squared	**0.5607**	**0.5682**	**0.5689**	**0.5702**	**0.5682**
Root MSE	**0.27827**	**0.27589**	**0.27565**	**0.27525**	**0.27592**

Notes: Dependent variable is ln(hourly wages). t-statistics in parentheses. *Coefficients are not standardized.* Regression in final column included a set of seventeen experience dummies.

N used in calculating standard errors will be the *N* associated with the number of observations in the data set, rather than the much smaller number of independent observations of the macro level variables.

In order to check for the possibility that the significance of the birth and current cohort size variables might be spurious due to this problem, they were tested with time series data sets constructed by aggregating the state-education-experience cells in the original data set (of civilian white males working full time). Three data sets were prepared:

- one containing 132 year-experience cells only (with experience differentiated into only four groups: < 10, 10–24, 25–34 and 35+ years of experience);
- another containing 132 year-education cells only (with education differentiated into only four groups: < 12, 12, 13–15 and 16+ completed years of education); and
- a third containing only 33 single year cells.

Each cell contained a weighted mean ln(hourly wage) and weighted mean birth cohort size variables, using the March CPS weights applied to individual observations in the cell.

Appendix G in Macunovich (1998) presents detailed results of the tests using these data sets, and it is demonstrated there that the birth and current

Table A-5. Partial regression results (using Model 5) examining the sensitivity of estimates to various formulations of the General Fertility Rate and its first difference.

	(1) 5-year moving average of GFR*	(2)	(3) 3-year moving average of GFR*	(4)	(5) unsmoothed GFR*	(6)
	(t + 2) − (t − 2)	*(t + 1) − (t − 1)*	*(t + 2) − (t − 2)*	*(t + 1) − (t − 1)*	*(t + 2) − (t − 2)*	*(t + 1) − (t − 1)*
Birth cohort size:						
Level	**−0.159**	**−0.168**	**−0.169**	**−0.177**	**−0.169**	**−0.178**
	(−16.7)	*(−18.8)*	*(−19.9)*	*(−22.1)*	*(−21.2)*	*(−23.3)*
*First difference***	**0.407**	**0.723**	**0.352**	**0.548**	**0.315**	**0.354**
	(25.1)	*(24.5)*	*(25.2)*	*(24.1)*	*(25.0)*	*(21.1)*
Current cohort size:						
Level	**0.427**	**0.428**	**0.407**	**0.417**	**0.391**	**0.418**
	(8.4)	*(8.5)*	*(8.3)*	*(8.5)*	*(8.2)*	*(8.7)*
*First difference***	**0.481**	**0.904**	**0.307**	**0.275**	**0.225**	**0.077**
	(2.6)	*(2.8)*	*(2.1)*	*(1.3)*	*(1.8)*	*(0.5)*
Experience interactions with current cohort size:						
Level:						
exp	**0.090**	**0.095**	**0.095**	**0.099**	**0.094**	**0.099**
	(4.7)	*(5.0)*	*(5.1)*	*(5.3)*	*(5.1)*	*(5.3)*
exp^2	**−0.018**	**−0.018**	**−0.018**	**−0.018**	**−0.017**	**−0.017**
	(−7.5)	*(−7.6)*	*(−7.7)*	*(−7.7)*	*(−7.6)*	*(−7.3)*
exp^3	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
	(8.6)	*(8.6)*	*(8.6)*	*(8.2)*	*(8.3)*	*(7.5)*
exp^4	**−2.6e–5**	**−2.5e–5**	**−2.4e–5**	**−2.3e–5**	**−2.3e–5**	**−1.9e–5**
	(−8.9)	*(−8.6)*	*(−8.6)*	*(−8.0)*	*(−8.2)*	*(−7.0)*
exp^5	**2.1e–7**	**2.0e–7**	**1.9e–7**	**1.7e–7**	**1.8e–7**	**1.4e–7**
	(8.6)	*(8.2)*	*(8.2)*	*(7.5)*	*(7.7)*	*(6.3)*
*First difference:***						
exp	**−0.013**	**−0.028**	**0.020**	**0.063**	**0.023**	**0.059**
	(−0.2)	*(−0.2)*	*(0.4)*	*(0.8)*	*(0.5)*	*(1.1)*
exp^2	**−0.005**	**−0.008**	**−0.008**	**−0.014**	**−0.007**	**−0.010**
	(−0.5)	*(−0.6)*	*(−1.1)*	*(−1.5)*	*(−1.2)*	*(−1.7)*

Table A-5. (Continued)

	(1) **5-year moving average of GFR***	**(2)**	**(3)** **3-year moving average of GFR***	**(4)**	**(5)** **unsmoothed GFR***	**(6)**
	$(t+2)-(t-2)$	$(t+1)-(t-1)$	$(t+2)-(t-2)$	$(t+1)-(t-1)$	$(t+2)-(t-2)$	$(t+1)-(t-1)$
exp^3	**5.9e–4**	**0.001**	**0.001**	**0.001**	**4.6e–4**	**0.001**
	(1.3)	*(1.2)*	*(1.6)*	*(1.8)*	*(1.6)*	*(1.9)*
exp^4	**−2.1e–5**	**−9.2e–4**	**−1.7e–5**	**−2.1e–5**	**−1.2e–5**	**−1.4e–5**
	(−2.0)	*(−1.7)*	*(−2.1)*	*(−2.0)*	*(−1.9)*	*(−2.0)*
exp^5	**2.2e–7**	**3.1e–7**	**1.6e–7**	**1.8e–7**	**1.1e–7**	**1.1e–7**
	(2.5)	*(2.1)*	*(2.3)*	*(2.0)*	*(2.0)*	*(2.0)*
Time trend:	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**	**0.005**
	(40.5)	*(41.2)*	*(41.0)*	*(41.6)*	*(40.9)*	*(41.8)*
Number of obs	**145,525**	**145,525**	**145,525**	**145,525**	**145,525**	**145,525**
R-squared	**0.2852**	**0.2845**	**0.2838**	**0.2827**	**0.2824**	**0.2805**
F (38, 145484)	**1281.31**	**1269.86**	**1261.95**	**1250.04**	**1280.65**	**1267.54**

* Columns 1 and 2 report results using a 5-year moving average of the General Fertility Rate (GFR), Columns 3 and 4 use a 3-year moving average, and Columns 5 and 6 use the unsmoothed rate.

** In the odd-numbered Columns, the cohort size difference variables are calculated using the logged value of the GFR at time $t+2$ minus the logged value at time $t-2$. In the even-numbered columns the difference is the logged value at time $t+1$ minus the logged value at time $t-1$.

Notes:

– Dependent variable is ln(hourly wages) for all white males working full time. t-statistics in parentheses. Each regression also included twenty state dummies and a fifth-degree experience polynomial: estimated coefficients available on request.

– *Coefficients reported above are not standardized.*

cohort size variables retain their significance (both statistical and substantial) and their signs in these highly aggregated series.

Serial correlation

In addition, since cross-section time-series models may potentially exhibit serial correlation, the models were tested using the "xtgee" procedure provided by Stata, which estimates generalized linear models (GLM) in which the user can either specify the within-group correlation structure for the "panels", or have it estimated iteratively. (See Deaton, 1985, for a discussion of issues involved in using time series of cross-sections as "panel" data). The GEE (generalized error estimation) method used in this iterative procedure is presented in Liang and Zeger (1986), and discussed in StataCorp (1997, vol. 3: pp. 610–614). The estimated correlation matrix of error terms obtained using this procedure (using for each cell weight its mean weight over time) produced matrices in which the off-diagonal elements were all less than 0.05.

Multicollinearity

And finally, because of dominant time trends which tend to cause multicollinearity among variables, all macro level variables (the macroeconomic indicators described in Sect. 4 of the main text, together with the *current cohort size* measures) were used in their de-trended form. That is, each variable has been regressed on a constant and a time trend, and only the residuals have been used in all regressions described in this paper.

Controlling for other fixed effects

An anonymous referee has suggested that based on Card and Lemieux (1995), the model should control for possible cell fixed effects which might be correlated with the macro variables. Of course, in the models estimated here, there are already controls for fixed effects associated with experience, education and location, as well as cohort, while Card and Lemieux estimated a "one-dimensional skill model" to explain the changing structure of wages in single-year age-education cells. The need to control for additional fixed effects might be readily anticipated because their model included no cohort-specific variables. "For example, women of a given age from earlier cohorts may have lower actual labor market experience than women of the same age from later cohorts (p. 324)". It might be argued that in a model such as the one presented in this paper, such fixed effects are not only controlled for, but explained, through the use of birth cohort size variables. Similarly, the de-trending of all current cohort size and other macro level variables has removed any time-related fixed effects associated with these variables.

However, two different approaches were used here in order to examine the effect of further controls for cell fixed effects. The first used as the dependent variable, just the deviations from the individual cell mean wage:

$$\underline{ln\ W}_{exp,ed,S,t} = ln\ W_{exp,ed,S,t} - (1/N) \sum_{t=1963}^{1995} ln\ W_{exp,ed,S,t} \tag{A-1}$$

The second differenced the individual cell wages (as well as the time-varying independent variables) through time:

$$\Delta\, ln\, W_{exp,ed,S,t} = ln\, W_{exp,ed,S,t} - ln\, W_{exp,ed,S,t-1} \tag{A-2}$$

This latter approach has several drawbacks, including the fact that the large variance in cell means associated with small cell sizes tends to produce more "noise" than "signal" in differences. Black et al. (1998) have examined the effects of using different types of control for fixed effects, and emphasize that results vary depending on the method used, and that first-differencing and fixed-effects models may introduce measurement-error bias causing an underestimate of the effect of interest. They demonstrate that measurement-error bias is often most severe when using first-differencing. Obviously this same problem holds with regard to the "deviations from means", but there it is less severe because more information is included in the deviations, along with the noise. In addition, cohort size effects have been shown to affect the *overall level* of wages through their marked effect on entry-level wages. Thus we can expect a model in first-differences to severely understate the full effect of relative cohort size.

The results of applying these two methods are presented in Table A-6, alongside the original estimate from Table 3 (column 7). A comparison of the first two columns shows that converting the dependent variable to deviations from cell means results in an *increase* in the estimated effect of the cohort size variables: the estimated (standardized) coefficients on the current cohort size variables are increased by 40–60%, while that on the level of the birth cohort size variable is increased by about 40%.

We see a very different story in column (3) of Table A-6, however: The (standardized) estimated coefficients on the levels of the two cohort size variables are now only about 15–25% of their original size. They remain significant, however, as does the coefficient on the first difference of the current cohort size variable, whose coefficient increases in magnitude.

Table A-6. Standardized regression results for models with controls for possible cell fixed effects.

	Table 3 (7)	***Deviations from cell means***	***Differenced across cells***
Birth cohort size:			
level	**−0.050**	**−0.070**	**−0.008**
	(−18.1)	*(−17.8)*	*(−2.0)*
first difference	**0.038**	**0.046**	**0.003**
	(12.9)	*(10.7)*	*(1.0)*
Current cohort size:			
level	**0.148**	**0.239**	**0.039**
	(10.2)	*(11.7)*	*(2.4)*
first difference	**0.059**	**0.140**	**0.065**
	(3.9)	*(6.7)*	*(3.7)*
Experience interactions with current cohort size:			
*level * experience*	**0.261**	**0.219**	**0.062**
	(2.1)	*(1.2)*	*(0.4)*
exp^2	**−2.306**	**−2.485**	**−0.632**
	(−4.3)	*(−3.2)*	*(−0.9)*

Table A-6. (Continued)

	Table 3 (7)	*Deviations from cell means*	*Differenced across cells*
exp^3	**5.415**	**6.010**	**1.606**
	(4.9)	*(3.8)*	*(1.0)*
exp^4	**−5.033**	**−5.600**	**−1.651**
	(−4.8)	*(−3.7)*	*(−1.1)*
exp^5	**1.634**	**1.798**	**0.600**
	(4.3)	*(3.3)*	*(1.1)*
*1st diff * experience*	**0.096**	**−0.023**	**−0.326**
	(0.7)	*(−0.1)*	*(−2.0)*
exp^2	**−0.515**	**−0.432**	**1.033**
	(−0.9)	*(−0.6)*	*(1.4)*
exp^3	**1.351**	**1.622**	**−1.840**
	(1.2)	*(1.0)*	*(−1.3)*
exp^4	**−1.541**	**−2.087**	**1.690**
	(−1.4)	*(−1.3)*	*(1.2)*
exp^5	**0.610**	**0.870**	**−0.607**
	(1.5)	*(1.5)*	*(−1.2)*
Time trend	**0.019**	**0.040**	**−0.015**
	(7.0)	*(10.4)*	*(−2.6)*
Experience	**4.403**	**0.096**	**−0.124**
	(60.4)	*(0.9)*	*(−1.4)*
Experience^2	**−13.46**	**0.011**	**0.649**
	(−32.4)	*(0.0)*	*(1.3)*
Experience^3	**19.967**	**−0.633**	**−1.359**
	(21.2)	*(−0.5)*	*(−1.1)*
Experience^4	**−14.42**	**0.886**	**1.303**
	(−15.1)	*(0.7)*	*(1.1)*
Experience^5	**3.911**	**−0.328**	**−0.469**
	(11.0)	*(−0.6)*	*(−1.1)*
GDP change	**−0.003**	**−0.004**	**0.026**
	(−1.4)	*(−1.2)*	*(7.3)*
Military			
level	**0.007**	**0.010**	**0.006**
	(2.9)	*(2.6)*	*(1.8)*
change	**−0.044**	**−0.066**	**−0.028**
	(−25.0)	*(−25.7)*	*(−9.7)*
*level * experience < 10*	**0.010**	**0.020**	**0.004**
	(4.9)	*(6.3)*	*(1.4)*
Trade deficit			
level	**0.051**	**0.075**	**0.005**
	(12.4)	*(12.4)*	*(1.0)*
*level * experience < 10*	**−0.008**	**−0.007**	**−0.006**
	(−3.0)	*(−1.6)*	*(−1.6)*
*level * education > 15*	**0.003**	**0.003**	**0.007**
	(1.1)	*(1.0)*	*(2.2)*
*level * education < 12*	**−0.006**	**−0.011**	**0.002**
	(−2.6)	*(−3.5)*	*(0.6)*
Completed years of education			
<8	**−0.240**	**0.004**	**−0.001**
	(−115.)	*(1.5)*	*(−0.4)*
8–11	**−0.185**	**0.003**	**−0.002**
	(−92.0)	*(0.9)*	*(−0.6)*
13–15	**0.128**	**0.010**	**0.001**
	(66.9)	*(3.5)*	*(0.3)*

Table A-6. (Continued)

16	**0.312**	**0.006**	**0.008**
	(156.0)	*(2.1)*	*(2.6)*
17+	**0.313**	**−0.013**	**0.010**
	(140.4)	*(−4.2)*	*(3.3)*
Intercept	**(2.324)**	**(0.513)**	**0.022**
(not standardized)	*(68.4)*	*(16.2)*	*(2.4)*
Number of obs	**141394**	**141394**	**135503**
F statistic	**2890.22**	**176.09**	**9.77**
R-squared	**0.5689**	**0.0647**	**0.0034**
Root MSE	**0.27565**	**0.26351**	**0.38229**

Notes: All coefficients in the table are standardized. Dependent variable is cell mean ln(hourly wage), transformed as indicated at the top of each column. t-statistics in parentheses. Each regression also included twenty state dummies, not reported here.