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Why Does Trend Growth Affect Equilibrium Employment? A New Explanation of an Old Puzzle†

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That the employment rate appears to respond to changes in trend growth is an enduring macroeconomic puzzle. This paper shows that, in the presence of a return to experience, a slowdown in productivity growth raises reservation wages, thereby lowering aggregate employment. The paper develops new evidence that shows this mechanism is important for explaining the growth-employment puzzle. The combined effects of changes in aggregate wage growth and returns to experience account for all the increase from 1968 to 2006 in nonemployment among low-skilled men and for approximately half the increase in nonemployment among all men. (*JEL* E24, J24, J31)

Explaining the variation in rates of employment over time has been a central question for labor and macroeconomics and for public policy for several decades. The sudden and sustained increase in nonemployment beginning in the early 1970s occurred at the same time that the rate of growth of productivity and wages slowed. From 1970 to 1980, the nonemployment rate of prime-age adult males in the United States rose from 6 percent to 12 percent (see Figure 1A). These trends were associated with dramatic declines in labor market attachment among the low-skilled. For high school dropouts, rates of nonemployment rose from 10 percent to 23 percent over the same period (Figure 1B). The 1970s also saw a dramatic slowing of the rate of productivity and wage growth. Trend growth in wages for all adult males fell five percentage points over the 1970s (Figure 2). Economists have long been tempted to relate the decline in economy-wide wage growth associated with the productivity slowdown of the 1970s to the persistent deterioration in equilibrium employment beginning in the early to mid-1970s.[1]

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[1] A prominent early example is Bruno and Sachs (1985). More recently, see Blanchard and Wolfers (2000) and Staiger, Stock, and Watson (2001).

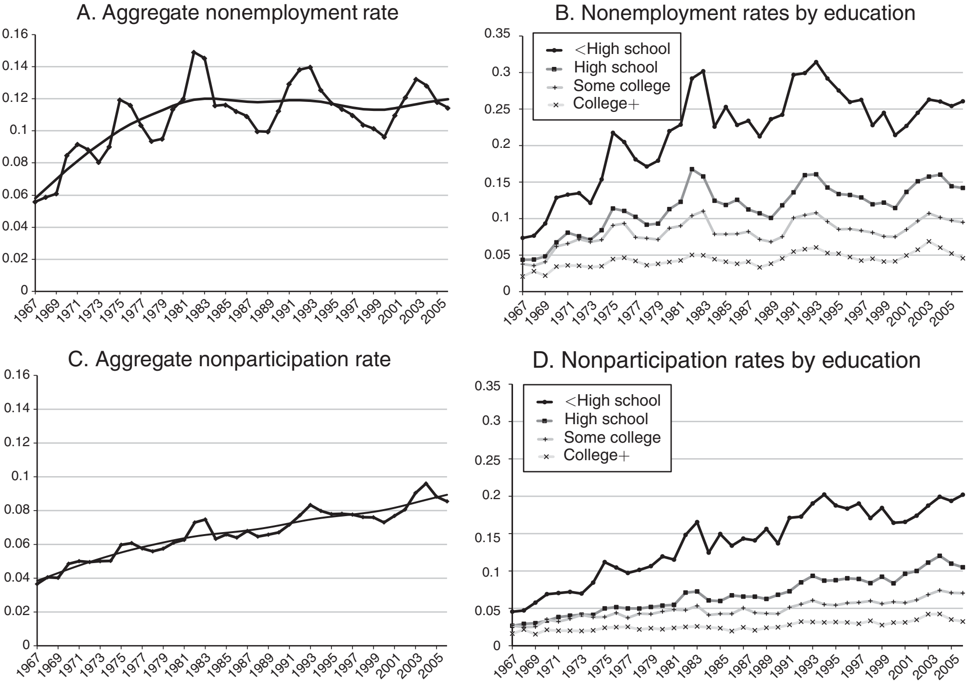

Figure 1. Nonemployment and Nonparticipation Rates for White Males: Aggregate and by Education

Notes: Data are taken from March Current Population Survey microdata for white males aged 16 to 64 with fewer than 30 years of potential experience, who report that they are neither students nor self-employed. Nonemployment and nonparticipation rates are computed as the fraction of year spent out of work and out of the labor force, respectively. Weeks worked prior to 1976 are intervalled. Rates prior to 1976 are computed by applying within-interval means from post-1976 data to pre-1976 data. Bold black lines are Hodrick-Prescott trends with an annual smoothing parameter of 100.

Superficially, the case for a link between productivity growth and employment rates appears simple: should it be surprising that employment declines when the returns to work have fallen? The theoretical link between productivity growth and equilibrium employment, however, has proved elusive. In traditional models of the aggregate labor market (Layard, Nickell, and Jackman 1991), changes in trend rates of growth of productivity and wages do not affect the steady-state rate of employment. That is, changes in productivity growth affect equally the returns to work and the returns to not working, as any violation of this relation will cause an economy to converge either to full employment or zero employment in the long run. Indeed, in his survey of traditional models of employment determination, Blanchard (2007, p. 416) concludes that they "deliver, to a first order, long run neutrality of unemployment to productivity growth." Shimer (2010) demonstrates that the same neutrality result arises in a balanced-growth version of the Mortensen and Pissarides (1994) model. While existing theories have clearer implications for the short- to medium-run link between productivity growth and the rate of employment, the understanding of the link between them in the long run is weaker. To quote Blanchard (2007, p. 416), "The truth is we do not know. And this is a serious hole in knowledge."

Existing literature has attempted to break this employment/growth neutrality result. Theoretical work on unemployment in labor markets with frictions has

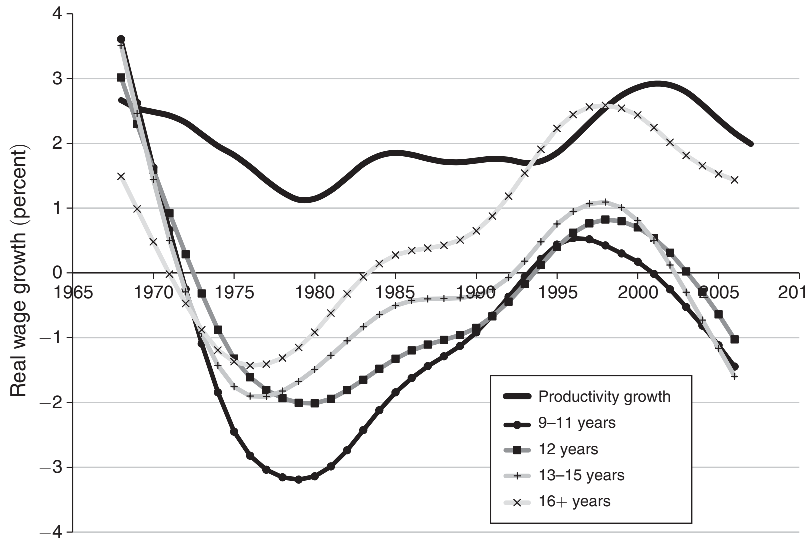

Figure 2. Trend Hourly Wage Growth by Education

Notes: Authors' calculations based on March Current Population Survey microdata from 1967 to 2006. The series report Hodrick-Prescott filtered real annual wage growth by education group. Data are for white males aged 16 to 64 with fewer than 30 years of labor market experience. Hourly wages are computed by dividing weekly wages by weekly hours. Aggregate wages are computed as the mean of the distribution of hourly wages, reweighted to hold constant the distribution of experience using the method of DiNardo, Fortin, and Lemieux (1996). Productivity growth is computed from the BLS output per hour series for the business sector. The Hodrick-Prescott smoothing parameter is 100.

identified two channels through which growth can affect unemployment in the long run. If technological change is embodied in new jobs, a process of creative destruction arises whereby old jobs must be destroyed to update to the technological frontier (Aghion and Howitt 1994). In this environment, faster growth implies higher rates of obsolescence, increased job destruction, and increased unemployment, in contrast to the trends observed in the data. If new technologies are incorporated into all jobs, however, a capitalization effect can occur: if the costs of job creation are borne upfront, higher expected productivity growth causes future profits to be discounted at a lower rate, stimulating firms' demand for labor through job creation, and reducing unemployment (Mortensen and Pissarides 1998; Pissarides and Vallanti 2007).

This paper identifies a novel and complementary explanation for the longstanding puzzle of providing a theoretical explanation for the observed low-frequency comovement of productivity growth and the employment rate. Our explanation of the puzzle is motivated by an additional salient feature of the data: that the decline in male employment rates was accompanied by sustained declines in labor force attachment. Accordingly, our explanation highlights the role of wage growth in the decision of workers to *supply* labor.

We begin by showing that Blanchard's neutrality puzzle, which refers to the unemployment margin, applies with the same force to the labor supply margin. Absent the effects we emphasize, standard models of the work/nonwork decision imply that labor supply is unaffected by changes in trend productivity growth. We show that this result is overturned once one recognizes that workers face substantial returns to labor market experience. Since Weiss (1972), it has been well understood that the processes of the accumulation of labor market experience and the decision to supply labor are naturally intertwined. In order to accumulate experience, an individual must work. Consequently, changes in the experience-earnings profile that workers face affect the decision of a marginal worker to seek lifetime employment.

A novel and important outcome of our theoretical analysis, however, is that this interplay between the return to experience and labor supply also interacts with trend growth in wages in determining whether or not an individual chooses to work. Faster growth in aggregate wages compounds the return to experience, raising equilibrium employment. The interaction between these two processes in the model generates a strong theoretical rationale for a connection between the rate of wage growth and the level of equilibrium employment. Intuitively, if the "wage escalator" flattens, either from a decline in the return to experience or from a slowdown in productivity growth, the payoff to being engaged in the work force over a lifetime falls, and a marginal worker will find employment a less attractive prospect.

To examine the extent to which this new explanation can provide an account of long-run trends in measures of nonwork, we assess its predictions from two perspectives. We first confront the model with the most comprehensive measure of joblessness—nonemployment—grouping together nonparticipation and unemployment. This choice is informed by the analysis of Juhn, Murphy, and Topel (1991, 2002). While a clear distinction between unemployment and nonparticipation may exist over the business cycle, they argue that the boundary between these two states is blurred at low frequencies. In their words, "[t]he composition of unemployment has shifted toward less skilled workers, who suffer comparatively long spells of joblessness and whose rewards from work have fallen sharply. In both these respects, they resemble the growing class of men who have simply withdrawn from the labor market" (Juhn, Murphy, and Topel 1991, p. 125). Viewed from this perspective, the model suggests that the combined effects of changes in aggregate wage growth and returns to experience can account for all of the increase from 1968 to 2006 in nonemployment among low-skilled men, and around half of the increase in nonemployment among all men.

This view is not the only interpretation of the model, however. The second perspective we consider is to align the labor supply margin that we model with the participation decision, rather than with nonemployment, implicitly grouping together employment and unemployment. Thus, we also examine the extent to which our explanation can account for secular trends in nonparticipation. Rates of nonparticipation among prime-age men in the United States rose profoundly from four percent in the late 1960s to nine percent in the early 2000s (Figure 1C). Mirroring the skill profile of nonemployment shown in Figure 1B, the process of detachment from the labor market was concentrated among the low-skilled, with high school dropouts facing rises in nonparticipation rates from 5 percent to 20 percent over the same period (Figure 1D). Reassuringly, the model also provides a good account of these trends in male labor force participation, overpredicting slightly the rise in trend nonparticipation among low-skilled workers, and accounting for the majority of the secular rise in aggregate male nonparticipation since the 1960s. Hence, our novel channel for relating productivity growth to the employment rate finds empirical support whether viewed through the nonparticipation or nonemployment data.

The plan of the remainder of the paper is as follows.

In Section I, we present a very simple model of labor supply in the presence of a return to experience and aggregate wage growth in order to provide the basic qualitative intuition for the effects we emphasize. This theory demonstrates transparently and intuitively how the returns to experience and the aggregate rate of wage growth interact to explain the correlation of the level of the employment rate and the rate of growth of productivity and wages.

We also extend the model in Section I to examine whether the presence of labor market frictions may interact with the wage growth channel we emphasize in determining incentives to supply labor. Qualitatively, we show that frictions shade down the effect of wage growth on labor supply, and that reductions in job-finding prospects discourage labor supply. Quantitatively, however, we find that the magnitude of these effects is likely to be modest.

In Section II, we then present empirical results that confirm the substantial changes in aggregate wage growth and the return to experience among low-skilled, marginal workers. This section uses Decennial Census and Current Population Survey (CPS) data to study wage growth and the returns to experience for male workers by level of educational attainment. We find significant changes in aggregate wage growth and the return to experience that, when combined with our theoretical analysis, help explain the productivity/employment puzzle. A novel empirical finding is that the lowest-skilled workers have experienced declines in the return to experience. Previous work finds that the return to experience has generally increased. Our empirical work supports this finding, but shows how these increases in the return to experience are not shared by the least-skilled workers. This finding is pivotal for our analysis since these low-skilled workers are precisely the population on the margin for the work/nonwork decision.

In Section III, we extend the simple model of Section I to account for finite worker lifetimes, as well as nonlinear experience-earnings profiles. Using this generalized model, we then draw out the quantitative implications of the observed changes in wage growth documented in Section II for trends in male nonemployment and nonparticipation.

In Section IV we discuss how this paper relates to the literature. In Section V, we offer conclusions and discuss directions for future work.

I. The Productivity Growth/Employment Interaction: Basic Model

We first present a simple model that delivers our basic insights on the interaction of aggregate wage growth and the return to labor market experience, and its role in the determination of incentives for lifetime employment. Consider a simple environment in which there are two employment states, employment and nonemployment, and workers choose whether they want to supply their labor or not. Note that the phenomenon we are aiming to model is the lifelong choice that a worker makes to be committed to the labor market and therefore accrue the returns to experience. Consequently, we initially abstract from frictional episodes of unemployment between jobs.

The critical addition that we explore relative to previous literature is to allow for two forms of wage growth—aggregate productivity growth and an individual worker's return to labor market experience—as well as growth in the flow payoff from nonemployment. Consider an infinitely lived worker i who must make a once-and-for-all decision at the start of his (non)working life between working forever and not working forever. If he works, he accumulates a year of labor market experience x for every year he works, and faces a wage profile $w_i(x,t)$. Assume that there is a return to experience g_x, and aggregate wage growth g_w, such that

$$\ln w_i(x,t) = \ln w_i(0,0) + g_x x + g_w t. \tag{1}$$

It is straightforward to derive equation (1) as the labor demand equation implied by a constant returns to scale production technology with fully flexible inputs, in which a worker with experience x accounts for $e^{g_x x}$ efficiency units of labor, and labor augmenting technical progress occurs at rate g_w over time (see Appendix A for a derivation). If the individual decides not to work, he does not accumulate experience, and he receives a payoff from nonemployment equal to $b_i(t)$. Assume that the latter grows over time at rate g_b.[2]

In this simple environment, all the worker need do is choose the option that delivers the highest present value of lifetime earnings. In particular, if the discount rate is equal to r, it is straightforward to show that a newborn potential worker at time t will decide to work if his offered wage, $w_i(0,t)$, exceeds a reservation wage equal to

$$w_i(0,t) \geq w_{Ri}(t) = \alpha b_i(t), \quad \text{where } \alpha \equiv \frac{r - g_w - g_x}{r - g_b}. \tag{2}$$

This simple formulation for the reservation wage relies on an infinite horizon specification and an assumption of geometric growth in this simple model. In Section III, we present a more general model that preserves the intuition of this formulation for the reservation wage while taking into account a more realistic specification of the trajectory of wages.

A. *Wage Growth and Steady-State Employment*

A number of insights follow from the simple observation in equation (2). First note that, while the reservation wage grows over time at the same rate as the payoff from nonemployment, g_b, the wage of a newborn worker, $w(0,t)$, grows at the rate of aggregate wage growth, g_w. To see the significance of this, imagine an economy populated by workers facing different wage profiles, $w_i(x,t) = \omega_i w(x,t)$, and different payoffs from nonemployment, $b_i(t) = \beta_i b(t)$, but who otherwise face the same labor supply problem. The variables ω_i and β_i thus represent heterogeneity in skill

[2] In this context, the flow payoff from nonemployment b must include much more than unemployment compensation, which has short duration in the United States except during deep recessions. Empirically, much of the secular rise in nonemployment in the US is accounted for by increases in very persistent (full-year) nonemployment spells (Juhn, Murphy, and Topel 1991, 2002). In addition, the model we present is one of the lifelong decision to work. Possible interpretations of b include the income of other household members, income from employment in turbulent jobs with limited human capital accumulation, and the value of home production and leisure, as well as public health insurance, disability insurance, and social security.

and the payoff from nonemployment, respectively. It follows that the steady-state employment rate in this economy will be given by

$$(3) \qquad L^* = \Pr\left[w_i(0,t) \geq \alpha b_i(t)\right] = 1 - \Omega(\alpha\rho),$$

where $\Omega(\cdot)$ is the cumulative distribution function (CDF) of the ratio ω_i/β_i, and $\rho \equiv b(t)/w(0,t)$ is the replacement rate for newborn workers.

For employment to be in steady state, the replacement rate ρ must be stationary. The replacement rate will be stationary only if the growth rate of the payoff from nonemployment is equal to the rate of aggregate wage growth, $g_b = g_w$ in steady state. To see why, imagine for example that $g_b > g_w$. In this case, the employment rate will converge to zero over time as the payoff from nonemployment increasingly dominates the payoff from work. A symmetric logic holds for the case where $g_b < g_w$. Imposing the restriction required for a steady state to exist, $g_b = g_w$, implies that the reservation wage may be rewritten as

$$(4) \qquad w_{Ri}(t) = \alpha b_i(t), \quad \text{where } \alpha \equiv 1 - \frac{g_x}{r - g_w}.$$

Note that the constraint $g_w = g_b$ is not special to our formulation. Any model with a steady state will have to impose it.

Together, equations (3) and (4) characterize the determinants of incentives to work in this simple environment. We observe that changes in employment are driven by changes in either α or ρ. The effects of changes in the replacement rate ρ are simple and well understood: a higher replacement rate renders nonemployment more attractive and reduces steady-state labor supply. This effect is a very conventional long-run property of models of equilibrium employment (see Blanchard 2000, and Layard, Nickell, and Jackman 1991, among others). The determinants of the variable α are less common in the literature—the return to labor market experience, g_x, the rate of aggregate wage growth, g_w, and their interaction. We now explore these effects in more detail.

Consider first the effects of the return to experience. Note from equation (4) that a positive return to experience, $g_x > 0$, drives a worker's reservation wage below his flow payoff from nonemployment. The reason is simple. If workers anticipate positive returns to experience, they will forgo earnings in the short run in order to reap the returns to experience in the long run. This point has long been noted since Weiss (1972), and more recently by Imai and Keane (2004), but has been largely neglected in macroeconomic models where wage growth is linked only to the level of productivity and not to labor market experience.[3] A corollary of this observation is

[3] An abundant literature on postschooling investment in human capital, based on the seminal work of Ben-Porath (1967), has highlighted the implications of the joint determination of human capital accumulation and labor supply for the life-cycle profiles of earnings and hours worked (Blinder and Weiss 1976; Heckman 1976; Ryder, Stafford, and Stephan 1976), education choice (Willis and Rosen 1979), and the estimation of preference and technology parameters (Shaw 1989; Lee 2008). See Rubinstein and Weiss (2006) for a survey. Perhaps most related to the present paper is the analysis of Olivetti (2006), which emphasizes the role of changes in returns to experience among women since the 1970s. In contrast to our analysis of low-skilled males, she finds evidence of steepening experience-earnings profiles among women, and identifies it as a key driving force for increased female labor-force participation since the 1970s.

that increases in the return to experience will reduce reservation wages even further below the flow payoff from nonemployment, and therefore will lead to increased employment rates. The reason is that increases in the return to experience raise the present discounted value of earnings from working relative to not working.

The key implication of equation (4) that underlies our account for the comovement between productivity growth and employment is the effect of a change in the rate of aggregate wage growth, g_w. Equation (4) reveals that there is an interaction between g_x and g_w: when the return to experience is positive, increases in the rate of aggregate wage growth lead to reductions in reservation wages, thereby raising aggregate employment. The simple reason is that greater aggregate wage growth interacts with the return to experience by compounding the rate of wage growth relative to the growth of the payoff from nonemployment. Aggregate wage growth acts like compound interest on the return to experience.[4] It is important to note that the latter effect of aggregate wage growth on incentives to supply labor is absent in traditional models of aggregate employment determination, which abstract from returns to experience and implicitly set $g_x = 0$. Highlighting how a positive return to experience creates an effect of the trend rate of growth on employment is a central contribution of this paper.

The perceptive reader will observe that the effect of aggregate wage growth in our model is driven by the specification that experience is multiplicative, not additive, in determining wages; i.e., that the Mincerian wage equation be specified in logarithms rather than in levels. The specification that experience and productivity are multiplicative is, however, much deeper than a functional form restriction. If the returns to experience were additive in wages, i.e., a fixed amount rather than fixed percentage, then the returns to experience would become vanishingly small over time if there is a positive trend to productivity. So a linearly additive specification for experience is equivalent to assuming no steady-state return to experience whatsoever.

B. *Where Shocks Hit Hardest: The Importance of Marginal Workers*

The simple model of this section adds two novel determinants of variation in the aggregate employment rate: the return to experience and the rate of aggregate wage growth. A more precise expression for the effects of changes in g_w and g_x on steady state employment can be obtained from logarithmic differentiation of equation (3) to obtain

$$\Delta \ln L^* = -\varepsilon \cdot \Delta \ln \alpha, \tag{5}$$

where ε is the steady state elasticity of labor supply with respect to the wage

$$\varepsilon = \alpha\rho \frac{\Omega'(\alpha\rho)}{1 - \Omega(\alpha\rho)}. \tag{6}$$

[4] The mechanism for the effect of g_w on employment incentives, though simple, can appear subtle. A natural question is whether this mechanism requires any more than the usual ingenuity that we ask of individuals when we apply our economic models to the real world. Our sense is that it does not. Individuals in the model do not care about the composition of wage growth between aggregate wage growth, and returns to experience; they only have to keep track of overall growth in wages. The mechanism can appear subtle to economists because we care about delineating the separate effects of g_w and g_x.

Note that ε is the elasticity of labor supply on the extensive margin; i.e., the employment versus nonemployment margin. Consequently, it measures the elasticity of the inverse CDF of reservation wages in the economy.[5]

Thus, we see that the employment effects of changes in the rates of aggregate wage growth and the return to experience are increasing in the size of the wage-elasticity of aggregate labor supply, ε. The intuition for this result is simple. A small value of ε implies that there are few incentive effects of wages on workers' choice to supply labor. This in turn extinguishes the labor supply effects of wage growth, which rely on the notion that wages incentivize labor supply.

The employment elasticity ε will be particularly large for workers who are low-skilled. To see this, note that we can write the steady-state employment rate among workers of a given skill ω as

$$L^*(\omega) = 1 - \Lambda(\alpha\rho/\omega), \tag{7}$$

where $\Lambda(\cdot)$ is the CDF of the inverse of workers' idiosyncratic payoffs from not working, $1/\beta_i$. It follows that the wage elasticity of the employment rate for workers of skill ω is equal to

$$\varepsilon(\omega) = \frac{\alpha\rho}{\omega}\frac{\Lambda'(\alpha\rho/\omega)}{1 - \Lambda(\alpha\rho/\omega)}. \tag{8}$$

A sufficient condition for this elasticity to decline with skill, ω, is that the modal worker of that skill is employed.[6] Thus, the model predicts that low-skilled workers respond to changes in the rate of aggregate productivity growth and the return to experience to a greater extent. The simple reason is that low-skilled workers are more likely to be on the margin of the employment decision than high-skilled workers, and therefore are more responsive to changes in the incentives to work.

This prediction of the model formalizes the intuition underlying the empirical analysis of Juhn, Murphy, and Topel (1991, 2002). They show that much of the increase in joblessness in the United States from the 1970s onward is concentrated among low-skilled workers, an observation that is replicated in Figure 1B. In addition, they provide estimates of the elasticity of labor supply by skill group (see Table 9 of their 1991 article and Table 10 of their 2002 article) that confirm that low-skilled labor supply is much more elastic than for higher-skilled workers. Both of these results are consistent with the formal implications of our model. We will see later in Section III that the tight correspondence between our theoretical model and the empirical results of Juhn, Murphy, and Topel will enable to us to interpret and quantify the implications of our model for observed trends in joblessness in the United States over time.

[5] Focusing on the extensive margin of labor supply abstracts from the possibilities that, facing lower returns to lifetime work, (a) individuals who work may choose to work more hours per week via the income effect and (b) individuals who do not work may have chosen to work if they had the option of working more hours per week.

[6] To see this, note that since $\alpha\rho/\omega$ is declining in ω, the elasticity of aggregate labor supply for workers with skill ω will decline with skill if $\Lambda''(\alpha\rho/\omega) > 0$. If $\Lambda(\cdot)$ is unimodal, a sufficient condition for the latter is that the modal worker with skill ω chooses to work.

C. *Interactions with Labor Market Frictions*

Thus far, our analysis has demonstrated the important role of wage growth in shaping reservation wages in a model in which individuals face no frictions to obtaining work. A natural question is whether the existence of labor market frictions may interact with wage growth in determining incentives to supply labor. One of the determinants of the decision to seek work might be the difficulty of obtaining work itself.

To explore this possibility, in this subsection we extend our basic model to incorporate such frictions. Specifically, if employed workers lose their job at rate s, and new job offers arrive at rate f, we show in the Appendix that the reservation wage mirrors equation (4), except that the α coefficient is modified slightly:

$$(9) \qquad w_{Ri}(t) = \tilde{\alpha} b_i(t), \quad \text{where } \tilde{\alpha} \equiv 1 - \frac{g_x}{r - g_w}\frac{r + f - g_w}{r + s + f - g_w}.$$

This result motivates a number of observations. First, the addition of frictions shades down the effects of wage growth by a factor $\frac{r + f - g_w}{r + s + f - g_w} < 1$. Intuitively, episodes of frictional unemployment impede the accumulation of labor market experience for an individual who supplies his labor. Second, consistent with the intuition that motivated this extension, reductions in the job-finding rate lower the factor $\frac{r + f - g_w}{r + s + f - g_w}$, raising reservation wages, and disincentivizing labor supply.

In addition to these qualitative effects, however, equation (9) also provides guidance on the likely quantitative magnitude of these effects. Specifically, for empirically plausible values of the flow transition rates s and f, an excellent approximation to the additional term $\frac{r + f - g_w}{r + s + f - g_w}$ is simply $\frac{f}{s + f}$.[7] A useful interpretation of the latter is that it is equal to one minus the steady-state rate of frictional unemployment. Thus, a very good intuitive rule of thumb is to imagine that an individual who supplies his labor will be employed a fraction $\frac{f}{s + f}$ of his working life, and so will accrue the same fraction of the total possible returns to experience.

By the same token, this interpretation clarifies that any interactions between the effects we emphasize and labor market frictions are likely to be modest in magnitude. The reason is that empirically plausible values for the rate of unemployment imply values of $\frac{f}{s + f}$ that are very close to one. This suggests that the effects of wage growth on reservation wages implied by the frictionless model underlying equation (4) are a very good guide to the same effects in the presence of frictions in equation (9). This point does not preclude that changes in wage growth may affect rates of job-finding, and thereby rates of unemployment, for example via the capitalization effects emphasized by Mortensen and Pissarides (1998) and Pissarides and Vallanti (2007). We return to this point in Section IV.[8]

[7] For example, estimates for prime-age males reported by Fujita and Ramey (2006) suggest job-finding rates of approximately 0.33 and job-loss rates of approximately 0.015 on a *monthly* basis. These imply annual job-finding and job-loss hazards of approximately 4 and 0.18, respectively, dwarfing analogous values for r and g_w.

[8] Our approach in this subsection mirrors a recent literature that has sought to incorporate both unemployment frictions as well as a labor supply margin. See, for example, Garibaldi and Wasmer (2005), and Krusell et al. (2011) and the references therein.

D. *Summary of Qualitative Predictions*

This section has used a very simple model to elucidate the effects of wage growth on aggregate employment in an environment that incorporates a return to labor market experience. It has established the following qualitative predictions: First, increases in the rate of return to experience reduce reservation wages and stimulate aggregate employment by increasing the present discounted value of working over not working. Second, if there is a positive return to experience, increases in the rate of aggregate wage growth will also reduce reservation wages and raise aggregate employment. And finally, the employment effects of wage growth, of the return to experience, and of the interaction of wage growth and the return to experience, will be greatest among low-skilled workers who are the most marginal to the employment decision. The evidence discussed in the next section bears directly on these effects and how they might inform the growth rate/employment puzzle.

II. Evidence

In this section we take on the task of documenting evidence on changes in aggregate wage growth and in the returns to experience by skill for workers in the US over time. In Section III, we use this evidence, together with a generalization of the model of Section I, to simulate the effects on employment rates of changes in the return to experience and its interaction with real wage growth.

A. *Changes in Aggregate Wage Growth by Skill*

To measure changes in the rate of aggregate wage growth, we use March CPS microdata for the period 1967 to 2006. We restrict our samples along several dimensions. First, we concentrate on outcomes for white men since labor force participation issues for nonwhites and women are significantly more complicated (Smith and Welch 1989; Welch 1990; Blau 1998). In particular, we restrict the samples to nonimmigrant white males aged 16 to 64. Mirroring the influential analyses of wages and employment by skill in the United States in Juhn, Murphy, and Topel (1991, 2002), we focus additionally on respondents with fewer than 30 years of potential experience who report that they were out of school for the entire year and are not self-employed. Wages are measured by dividing annual wages and salary by annual hours worked. As our theory makes clear, we are especially interested in changes in wage growth for marginal workers who are relatively low in the skill distribution. We use educational attainment as a proxy measure of skill. We distinguish among high school dropouts (9 to 11 years of education), high school graduates (12 years), those with some college education (13 to 15 years), and those with a college or higher degree (16+ years).[9] Finally, to ensure that measured changes in aggregate wage growth are not driven by changes in the experience composition of our samples over time, we compute average wage growth from the distribution of wages reweighted to hold constant the distribution of experience using the method of DiNardo, Fortin, and Lemieux (1996).

[9] Juhn, Murphy, and Topel (1991, 2002) measure skill by percentiles of the wage distribution, rather than by educational groups. Reassuringly, they obtain similar results.

Figure 2 plots trend hourly wage growth by education from 1968 through to 2006 based on these CPS samples. Specifically, this takes estimates of real hourly wages by education, computes implied annual wage growth by education, and reports the HP-filtered series. This exercise reveals a clear picture of aggregate wage growth in recent decades. For all educational groups, aggregate wage growth fell in the 1970s, rebounded in the 1980s and 1990s, and has fallen off again in recent years. In addition, we observe that trend wage growth declined more acutely among low-skilled workers in the 1970s. Among high school dropouts, wage growth declined secularly in the 1970s from around three percent per year to trend real wage *declines* of approximately three percent in the late 1970s and early 1980s. In contrast, real wage growth among college-educated workers declined more slowly in the 1970s, and rebounded more robustly in the 1990s.[10]

These observations echo well-documented facts on aggregate growth, as well as wages by skill. The secular decline and subsequent rebound in aggregate wage growth over time mirrors the productivity slowdown of the 1970s as well as the so-called "productivity miracle" of the 1990s in the United States. Figure 2 overlays the trend productivity growth rate over the same period to emphasize these trends. Likewise, the observation that wage growth declined more sharply among the low-skilled in the late 1970s and 1980s is consistent with the widely documented increase in wage inequality that emerged over that period.

B. *Changes in the Experience-Earnings Profile by Skill*

To measure changes in the experience-earnings profile over time, we employ data taken from the decennial censuses from 1960 to 2000, and the American Community Surveys (ACS) from 2001 to 2007 for the United States.[11] Earnings are measured by the annual wage and salary income of respondents. Mirroring our analysis of aggregate wage growth, we again proxy skill using discrete education categories: high school dropouts (9 to 11 years), high school graduates (12 years), some college (13 to 15 years), and college degree or higher (16+ years). Experience is measured by potential experience; i.e., age minus years of education minus six.

We focus on the return to experience among full-time, full-year workers, defined as those who work 35 hours or more per week, and who are employed for 50 or more weeks per year. We do this for a number of reasons. By focusing on such workers, we can be more confident that respondents have left full-time education when we observe their earnings. Moreover, the observed profiles are more likely to reflect variation in wages rather than hours or weeks worked. Finally, the fact that we are able to measure only potential experience raises a concern that a changing

[10] A potentially important confound to the trends in Figure 2 is the growth of nonwage compensation (such as health insurance, pensions, and paid leave) that emerged over the period. It is difficult to get an accurate sense of this from the data sources we use. Using the microdata underlying the Employment Cost Index, however, Pierce (2001) shows that wage growth understated compensation growth among high-skilled workers in the 1980s, but that it overstated compensation growth among the low-skilled in the 1990s. Hence, for total compensation the relative growth rate in wages for low-skilled workers is likely to be even less favorable than shown in Figure 2.

[11] Our census samples are taken from the public use one percent sample for 1960, two percent sample for 1970, and five percent samples for 1980 to 2000 available from IPUMS. They parallel those used by Heckman, Lochner, and Todd (2006) in their important study of the returns to schooling. We are grateful to those authors for providing us with detailed tabulations from their work that we used in the preliminary version of this paper.

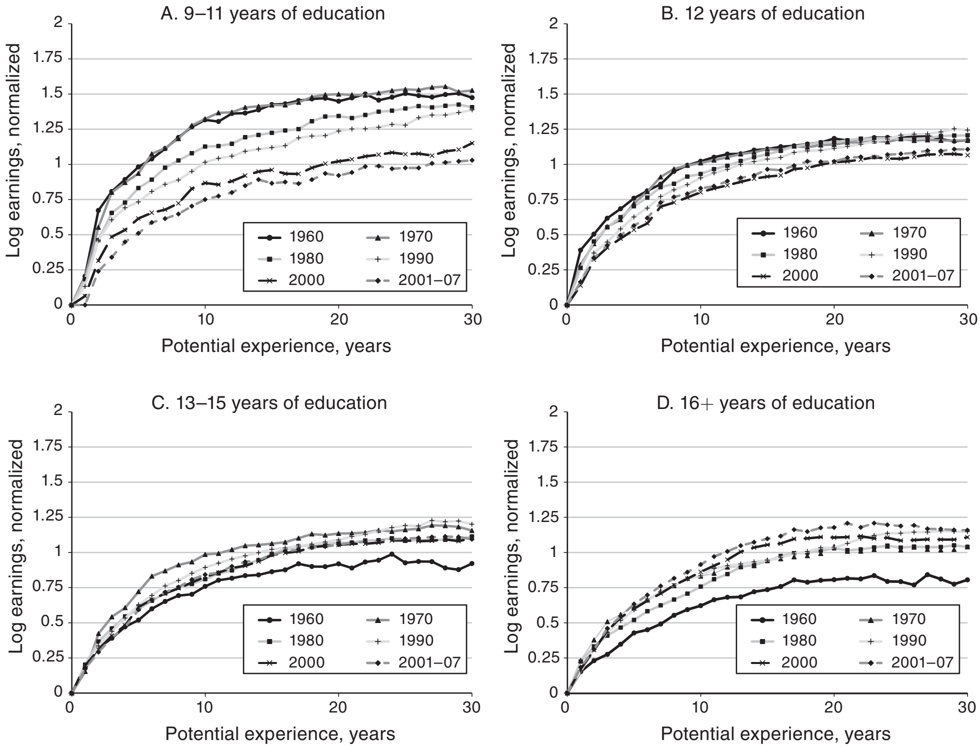

Figure 3. Experience-Earnings Profiles, by Education and Census Year

Notes: Profiles are based on data for full-time, full-year white males aged 16 to 64 from the 1960 to 2000 decennial censuses, and pooled 2001 to 2007 American Community Survey samples. Mean log earnings are normalized by the mean log earnings of workers entering the labor market.

relationship between potential and actual experience could confound observed changes in experience-earnings profiles. By concentrating on full-time, full-year workers, such a confound is minimized.

Figure 3 plots average log earnings as a function of potential experience by education group, normalized to the mean log earnings of workers entering the labor market. Log earnings are normalized to equal zero at zero experience to abstract from the significant differences in levels of earnings across education groups and of aggregate wages across time. These level shifts in wages do not affect equilibrium employment in our model. Within each panel, the lines correspond to the experience-earnings profiles for different census years for a given education group.[12] Figure 3A displays the experience-earnings profile for high school dropouts (9–11 years of education) over time. Note that outcomes for these lower-skilled workers are of particular interest for our purposes because they are more likely to be marginal to the employment decision. Figure 3A tells a striking story. The experience-earnings profile among

[12] Prior to 1980, census data record only hours last week, and after 1990 only usual hours of work. Reacting to this, we impose the full-time restriction for the 1960 to 1990 profiles based on hours last week. After 2000, we compute the difference in the experience-earnings profile generated by implementing the full-time restriction using these alternative hours measures in 1990, when both measures are available. We then apply that difference to impute the experience-earnings profiles from 2000 on.

high school dropouts flattened dramatically after 1970. At 5 to 10 years of potential experience, earnings are around 50 log points lower in the later period compared to the earlier period. In addition, the gap in the experience-earnings profile persists at higher levels of experience.

Figure 3B plots the experience profile for high school graduates. This reveals a mild drop in midcareer earnings between 1970 and 1990, with a more substantial drop in the experience-earnings profile between 1990 and 2000. In comparison to the outcomes for high school dropouts, the changes are relatively modest.[13]

As emphasized above, workers with schooling beyond high school are unlikely to be at the point in the skill distribution where employment is a marginal decision, so that patterns in experience profiles among these groups are less relevant to employment rates. By way of comparison, however, we include results in Figures 3C and 3D for workers with some college education and a college degree or higher, respectively. For these higher-skilled workers, an opposite trend can be discerned, especially for college-educated workers, with experience-earnings profiles steepening over time.

A number of questions arise in the light of the substantial decline in the experience-earnings profile for high school dropouts in Figure 3A. First, in the online Appendix, we consider the robustness of the result to a range of possibilities, including: a widening gap between potential and actual experience driven by the increases in joblessness documented in Figure 1; selection associated with the possibility of high school dropouts becoming less skilled over time; and consistency with alternative measures of the experience premium. On all these dimensions, we find that the central message, that the experience-earnings profile for high school dropouts has flattened substantially, remains robust.

Second, given the robustness of this result, one might ask how big a reduction this is. A natural way to quantify the decline is to compute the capitalized value of the experience-earnings profiles illustrated in Figure 3A. Figure 4 performs this exercise. It plots the capitalized value of the experience-earnings profiles in Figure 3A, normalized to equal 100 in 1970, for a range of values for the discount rate. A clear picture emerges: regardless of the discount rate, the value of the experience-earnings profile for high school dropouts declined by almost 50 percent between 1970 and 2007, a substantial reduction.

C. *Synthetic versus Actual Cohorts*

The preceding results report cross-sectional experience-earnings profiles at given points in time. For the purposes of our analysis of the likely employment effects of any changes in these profiles, we would like to obtain information on workers' expectations of their likely experience profile at the time that they are making their labor supply decisions. It is likely that these cross-sectional profiles are informative

[13] For high school graduates and college-educated workers, a number of studies in the empirical literature on changes in wage inequality have estimated the "experience premium," measured as the log wage gap between experienced workers (typically with 25 years of experience) and less experienced workers (5 years of experience) using CPS data (see, for example, Katz and Autor 1999; Weinberg 2005; Autor, Katz, and Kearney 2008). These studies all have documented evidence for a rise in the experience premium among high school graduates and college graduates over time. The evidence presented in Section II and the online Appendix shows the new finding that the returns to experience among high school dropouts have declined since 1970 and also confirms the findings of this earlier literature for higher-educated workers.

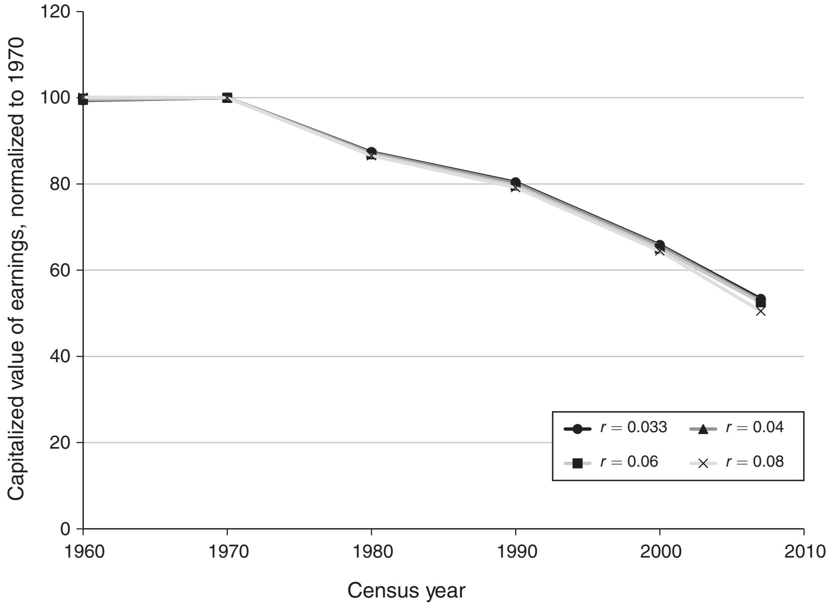

Figure 4. Capitalized Value of Experience-Earnings Profile, Normalized to 1970, 9–11 Years of Education, by Census Year and Discount Rate

Notes: Authors' calculations of the capitalized value of earnings over a 30-year horizon, discounted at rate *r*, and normalized to equal 100 in 1970. Data used for the calculation are the experience profiles for 9–11 years of education underlying Figure 3A.

to some degree on these expectations—for instance, if workers have static expectations or changes are permanent, so that static expectations are rational.

An alternative way of slicing the data, however, would be to plot the realized experience-earnings profiles of individual cohorts. This alternative approach would be consistent with workers' expectations if they were endowed with perfect foresight. The truth, of course, is likely to lie somewhere between these two extremes, so it is natural to check whether the basic message of the data changes by shifting perspective in this way.

Figure 5 presents the realized experience-earnings profiles for the cohorts entering the labor market in 1960, 1970, 1980, 1990, and 2000. Since the census data we use is available only at a decadal frequency, we plot earnings for members of these cohorts every ten years.

For high school dropouts, while the cohort profiles in Figure 5A are noticeably flatter after ten years of experience, the trends across cohorts tell exactly the same story as the cross-sectional picture in Figure 3A. Wage growth declines for each consecutive cohort entering the labor market after 1960, and the declines are of similar magnitude as those indicated by the cross-sectional profiles in Figure 3A. These cohort-based profiles mirror the findings of Kambourov and Manovskii (2009) using CPS and Panel Study of Income Dynamics data. The profiles for high school graduates and those with college education in Figures 5B, 5C, and 5D also echo the patterns observed in their cross-sectional counterparts in Figure 3. Most noticeably, it is again possible to discern a steepening of experience-earnings profile among

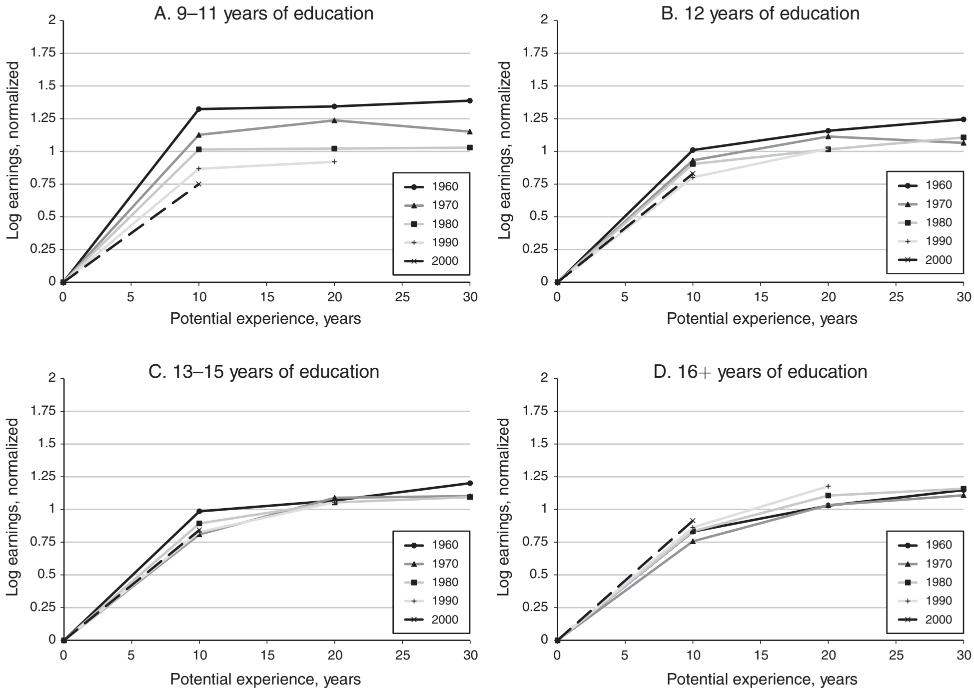

Figure 5. Earnings Profiles by Cohort and Education

Notes: Profiles are based on same data as those underlying Figure 3. Mean log earnings are normalized by the mean log earnings of workers entering the labor market. Data points for 2010 are imputed under the assumption that the experience-earnings profile from pooled 2001 to 2007 ACS data is time invariant.

younger cohorts of college graduates. It is reassuring that these two different slices of the data have similar implications with respect to the changes in returns to experience over time.

III. Quantitative Implications

To what the extent do the changes in aggregate wage growth and experience-earnings profiles documented in Section II account for changes in the rate of nonemployment documented in Figure 1? In this section, we extend the simple model of Section I. The extended model retains the transparent qualitative predictions of the simple model while adding enough generality to allow for analysis based on the earnings profiles quantified in Section II.

A. *A More General Model*

The model of Section I is simplified in a number of respects. In this section we relax some of these simplifying assumptions. First, we allow for finite worker lifetimes. This enables discussion of the differential effects of changes in wage growth across different cohorts of workers in a natural way. Second, we allow the return to experience to be nonlinear to allow for the concavity of the experience-log earnings profile observed in Figures 3 and 5. This allows us to match the experience-earnings profile in the model with that observed in the data. Third, we allow workers to choose whether to work or not at each point in their lives, thereby relaxing the once-and-for-all labor supply decision of Section I. Extending the model in this manner allows us to draw out the dynamic effects of changes in rates of wage growth on employment in and out of steady state. Though more realistic, we will see that these changes do not change the basic qualitative message of the simple model of Section I.

Consider a worker entering the labor market at time s with a working life of length T. At each point in time the individual chooses whether he wants to work $(h = 1)$ or not work $(h = 0)$. As in the model of Section I, for every year he works, he accumulates a year of labor market experience, x; he does not accumulate experience while not working. A worker of experience x at time t receives a flow wage equal to $w(x,t)$.[14] An individual who does not work at time t receives a flow payoff $b(t)$. The worker makes his labor supply decision in order to maximize the present discounted value of his lifetime income.

Thus, we can state the optimization problem of an individual entering the labor market at time s as follows:

$$(10) \qquad \max_{h(t)} \int_s^{s+T} e^{-r(t-s)} y(x,t,h)\, dt \ \text{ s.t. } \ \dot{x} = h, h \in \{0,1\}, x(s) = 0,$$

where r is the real interest rate. The individual's income at time t is given by $y(x,t,h) = hw(x,t) + (1-h)b(t)$. If the individual works $(h = 1)$ he receives the wage; otherwise, he receives the payoff from not working. The first constraint in equation (10) regulates the accumulation of experience over the worker's lifetime such that experience is accumulated only when the individual works. The second emphasizes our focus on the extensive margin of the labor supply decision. And the third constraint states the initial condition that new entrants into the labor market enter with no accumulated experience.

The maximization problem in equation (10) can be restated more simply as an optimal control problem with associated Hamiltonian

$$(11) \qquad H(x,t,h,\lambda) = hw(x,t) + (1-h)b(t) + \lambda h.$$

Note that the Hamiltonian is linear in the labor supply variable, h. It follows that an individual with experience x at time t will work if the wage offer $w(x,t)$ exceeds a reservation wage given by

$$(12) \qquad w_R(t) = b(t) - \lambda(t),$$

where we will see that $\lambda(t) \geq 0$. Thus, just as in the simple model of Section I, we observe that the reservation wage lies below the flow payoff from nonemployment. As before, individuals are willing to forgo payoffs in the short run in order to reap the returns to experience in the long run.

[14] In this more elaborate model, we suppress the i subscript that indexes individuals for purposes of clarity.

To characterize the reservation wage more precisely, however, we must describe the variable λ in more detail. Using the principles of optimal control, it is simple to show that λ can be expressed as[15]

$$\lambda(t) = \int_t^{s+T} e^{-r(\tau-t)} h\big(x(\tau),\tau\big)\, w_x\big(x(\tau),\tau\big)\, d\tau. \tag{13}$$

Thus, λ has a very intuitive interpretation. It is the cumulative discounted sum of future returns to experience, $w_x\big(x(\tau),\tau\big)$, taking into account that these future returns accrue only in the event that the individual works in the future $\big(h\big(x(\tau),\tau\big) = 1\big)$. In short, λ is the marginal value of experience to a worker.

This intuition in turn delivers a simple interpretation of the reservation wage. In particular, we can rewrite the reservation wage as

$$w_R(t) = b(t) - \int_t^{s+T} e^{-r(\tau-t)} h\big(x(\tau),\tau\big)\, w_x\big(x(\tau),\tau\big)\, d\tau. \tag{14}$$

Thus, the reservation wage is equal to the flow benefit from not working, $b(t)$, less the opportunity cost of not working, which equals the forgone returns to experience. As stated, the reservation wage is a very forward-looking object—it depends on the entire sequence of future labor supply decisions from time t until the end of the individual's life, $s + T$. To obtain a more concrete sense of the form of the reservation wage, we need to partition the individual's remaining lifetime into episodes allocated to employment and nonemployment, respectively. This is aided by the following result:

PROPOSITION 1: *If* (i) $r - g_w > 0$, *so that workers discount the future;* (ii) *the experience-earnings profile is monotonically increasing;*[16] *and* (iii) *there are no shocks, then a worker who decides to work at time t subsequently will work for the remainder of his working life.*

Intuitively, consider an individual who is just about to start working. By definition, such an individual only just prefers working over not working. As the individual works, however, he accumulates human capital which in turn serves only to make employment increasingly preferable relative to not working. As a result, the individual continues to work until he retires.

In light of this, we adopt the convention that, whenever the individual is offered his reservation wage, he works thereafter. It follows that, for an individual with experience x at time t, we can substitute $h\big(x(\tau),\tau\big) = 1$ and $x(\tau) = x + \tau - t$ for all $\tau > t$ into the reservation wage equation above to derive

[15] From the principles of optimal control, we can write $\dot{\lambda} = r\lambda(t) - \partial H/\partial x = r\lambda(t) - h(x,t)\, w_x(x,t)$. The solution to this differential equation is given in equation (13). The constant of integration is equal to zero because of the transversality condition that $\lambda(s + T) = 0$.

[16] Assuming that $w_x(x,t) > 0$ for all x and t is not entirely innocuous. Evidence suggests that average real wages can decline with experience at the end of a worker's career. It is not clear, however, whether this is driven by (partial) retirement. For the horizons we focus on in what follows (the first 40 years of working life), nondeclining wages is not a bad assumption. An extension of the model to account for optimal retirement would be an interesting topic for future research.

$$(15) \qquad w_R(x,s,t) = b(t) - \int_t^{s+T} e^{-r(\tau-t)} w_x(x + \tau - t, \tau)\, d\tau.$$

To complete our characterization of the reservation wage, we must be more explicit about the form of the wage equation. Denoting aggregate wage growth by g_w, and the return to experience at x years of experience as $g_x(x) \equiv \partial \ln w(x,\tau)/\partial x$, allows one to write

$$w_R(x,s,t) = \alpha(x,s,t)\, b(t),$$

$$(16) \quad \text{where } \alpha(x,s,t) = \left[1 + \int_t^{s+T} e^{-\int_t^{\tau}[r - g_w - g_x(x+z-t)]\,dz} g_x(x + \tau - t)\, d\tau\right]^{-1}.$$

Although the form of the reservation wage in this more general model is not as transparent as equation (4), a number of observations can be made in light of it. First, note that the reservation wage takes a form that is reminiscent of equation (4) from the simple model of Section I. The reservation wage is equal to the flow payoff from not working $b(t)$, scaled down by a factor $\alpha(x,s,t) \leq 1$. As emphasized before, workers are willing to forgo current earnings to reap the returns to experience in the future. The return to experience drives a wedge $\alpha(x,s,t)$ between the payoff from nonemployment and the reservation wage.

Second, note that in the case where individuals are infinitely lived, $T \to \infty$, and the return to experience is constant for all levels of x, $g_x(x) \equiv g_x$, then $\alpha(x,s,t) \to 1 - [g_x/(r - g_w)] = \alpha$ from equation (4). Thus, the general model nests the simple model of Section I as a special case.[17]

Third, we again observe that changes in the experience-earnings profile, summarized by $g_x(\cdot)$, and aggregate wage growth, g_w, affect the reservation wage. As before, increases in the experience-earnings profile and aggregate wage growth reduce $\alpha(x,s,t)$, thereby lowering the reservation wage and stimulating work incentives. Equation (16) is different from equation (4) because it takes into account finite lifetimes and concave experience-earnings profiles, leading to more sensible magnitudes of these effects.

Fourth, a key message of equation (16) is the implied life-cycle effects of changes in $g_x(\cdot)$ and g_w. Specifically, the marginal effects of these changes on the reservation wage are stronger for younger cohorts at a given point in time t and weaker for older cohorts. To see this, consider equation (16) and recall that s denotes time of entry into the labor market, so that higher values of s refer to younger cohorts. Mechanically, this result arises because older workers have a shorter remaining working life, over which changes in wage growth of any variety can affect the present value of their remaining earnings stream. More intuitively, as workers age, they become increasingly less marginal to the employment decision, and consequently respond less to changes in wage growth.[18] We will see in what follows that these

[17] Note also that the once-and-for-all labor supply assumption in the simple model of Section I is therefore not a binding one. This, of course, follows from Proposition 1.

[18] By the same token, it is also true that the reservation wage coefficient $\alpha(x,s,t)$ is larger for older cohorts. One might imagine that this reduces work incentives for older workers. We know from Proposition 1, however, that any

life-cycle effects have distinctive implications for the dynamics of employment generated by the model.

Finally, to parallel the analysis of Section IC, the Appendix presents an analogous solution for the reservation wage that generalizes the more elaborate model of this section to allow for labor market frictions. Mirroring the results of Section IC, it shows that the existence of frictions has a quantitatively modest effect on the reservation wage in the more general model.

B. *Simulations*

The results of Section II documented evidence for reductions in the return to labor market experience for low-skilled, marginal workers since 1970, as well as important changes in aggregate wage growth for such workers over the same period. We now seek to provide a quantitative sense of the implications of these trends for work incentives and equilibrium employment. To do this, we feed the observed trends in the experience-earnings profile and aggregate wage growth into a simulated version of the general model summarized in equation (16). Since the trends in the aggregate nonemployment rate are driven by the increase in nonemployment among low-skilled workers, we focus first on generating the implied outcomes for high school dropouts.

We set the length of a working life to 40 years, and initialize the model in steady state in 1968. We set the initial steady-state employment rate to equal 90.7 percent based on the observed trend nonemployment rate for high school dropouts in 1968 (see Figure 1B). We then compute the implied paths of the employment rate for each experience x, cohort s and time t configuration by extending the simple insight of equation (5):

$$\Delta \ln L(x,s,t) = -\varepsilon \cdot \Delta \ln \alpha(x,s,t), \tag{17}$$

where variation in the reservation wage coefficient $\alpha(x,s,t)$ is induced by variation in aggregate wage growth g_w and the experience-earnings profile $g_x(\cdot)$. Finally, we aggregate across (x,s,t) cells to compute the path of aggregate employment, $L(t)$.

Our simulation procedure therefore requires finding a value of ε, the elasticity of labor supply. Recall from our earlier discussion that, for our purposes, ε is the elasticity of labor supply on the extensive margin—the elasticity of the inverse distribution function of reservation wages (see equations (6) and (8)). Estimates of ε for different skill groups are reported by Juhn, Murphy, and Topel (1991, 2002). Specifically, they compute estimates of the elasticity of the fraction of a year spent in employment with respect to wages by skill using CPS data. Juhn, Murphy, and Topel measure skill by ranges of percentiles of the wage distribution. Since high school dropouts lie in the bottom 20 percent of the education distribution, Juhn, Murphy, and Topel's estimates suggest that a reasonable value of ε is approximately 0.33.[19]

individual who starts working will work until retirement. The reason is the wage growth that workers receive as they accumulate experience.

[19] To do this, Juhn, Murphy, and Topel (1991, 2002) estimate the wage offers of those out of employment. They do this by imputing wages to nonworkers using the distribution of wages among individuals who worked between 1 and 13 weeks in a given year. Table 10 of their 2002 Brookings paper reports partial elasticities (i.e.,

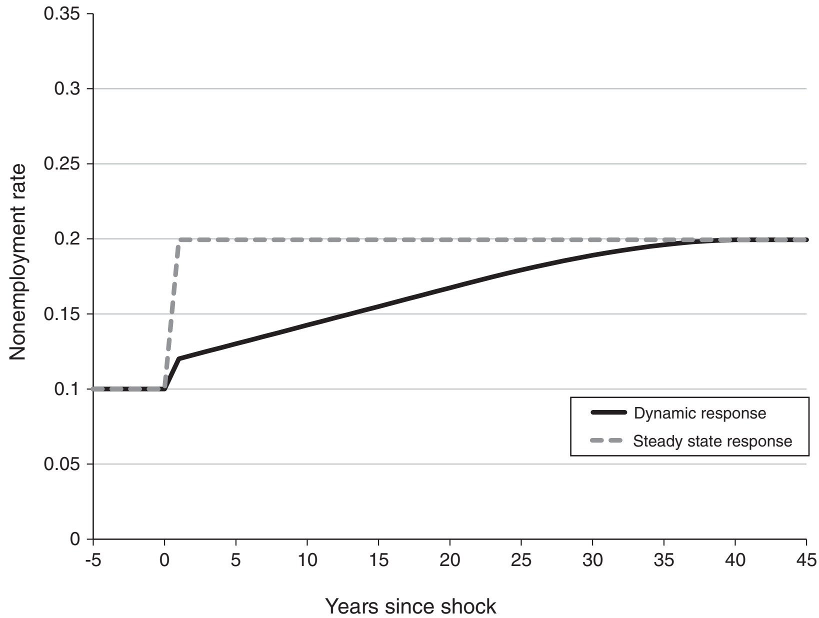

Figure 6. Simulated Response of Nonemployment Rate to an Unanticipated, Permanent Decline in Aggregate Wage Growth

Notes: Authors' calculations based on general model of Section IV. Figure plots the response to a permanent unanticipated decline in g_w from 3 percent to –3 percent. The discount rate $r = 0.04$, and the experience-earnings profile is fixed at its 1980 level in Figure 3A.

It is worth noting that our simulation strategy has a number of virtues. First, by reducing the procedure simply to obtaining a value for ε, we have avoided having to calibrate explicitly variables such as the replacement rate ρ, or the distribution of worker heterogeneity $\Omega(\cdot)$ in equation (3). Since we might be less confident in the correct calibration of these objects, this is a useful simplification. In addition, the simulation strategy is very transparent. If one has different priors about the appropriate value for the supply elasticity ε, all one need do is scale the implied employment effects up or down accordingly. For example, if one believed ε were double the value we use, then the implied employment effects will be double what we report.

A Simple Example.—To get a sense for the dynamic response of aggregate employment implied by the model, we first consider the effects of a very simple shock. Figure 6 plots the response of aggregate nonemployment to a one-time, permanent, unanticipated decline in aggregate wage growth g_w from 3 percent (as observed in the early 1970s among dropouts) to –3 percent (as observed in the mid-1980s among dropouts). The dashed line plots the steady state nonemployment rate

the change in employment divided by the log change in wage) by skill percentiles for the years 1972 to 2000. For the first to tenth percentiles, their estimate of the partial elasticity is 0.287; for the eleventh to twentieth percentiles, 0.217. The average employment rates for these groups, respectively, are 0.73 and 0.80. These imply elasticities of approximately $0.287/0.73 = 0.39$ and $0.217/0.80 = 0.27$, respectively. Our choice of $\varepsilon = 0.33$ is an approximate midpoint of these estimates.

before and after the shock. This rises substantially from 10 percent to approximately 20 percent.

The response of the nonemployment rate out of steady state, however, reveals important transitional dynamics in the model. On impact, a discrete fraction of workers immediately leaves employment, deciding that the reduction in lifetime earnings renders working no longer worthwhile. Subsequently, the nonemployment rate exhibits very slow transitional dynamics, eventually reaching the new steady state after 40 years. These transitional dynamics are a direct consequence of the life-cycle response to shocks emphasized in the general model above. As workers age, they become increasingly less marginal to the employment decision, and thereby become less responsive to shocks. What is driving the dynamics in Figure 6 is the turnover of successive cohorts in the labor market as older cohorts retire, and younger, more marginal workers enter. The period of transition is exactly 40 years, the specified length of a working life, since that is the time it takes for all older cohorts at the time of the shock to leave the labor market.

Implications for Low-Skilled Nonemployment.—We can now address the question of the effects of observed changes in the experience-earnings profile and aggregate wage growth for rates of nonemployment. We begin with results for high school dropouts, who are more likely to be marginal to the work/nonwork decision. In this first simulation, we match the return to experience in the model, $g_x(\cdot)$, to smoothed versions of the cross-sectional profiles for high school dropouts in Figure 3A. Aggregate wage growth in the model, g_w, is matched to trend wage growth among high school dropouts based on the estimates in Figure 2. We initially feed these trends into the model as a series of *unanticipated shocks*.

Figure 7A displays the results of this simulation based on these unanticipated shocks, together with the trend nonemployment rate among high school dropouts from Figure 1B for comparison. The model predicts a substantial rise in the nonemployment rate for low-skilled workers. Figure 7A reveals that the joint trends in $g_x(\cdot)$ and g_w together imply an increase in low-skilled nonemployment from approximately 10 percent to 27 percent between 1968 and 2006. Comparing these outcomes to the observed trend from the data, this suggests that the model can account for all of the secular rise in nonemployment among high school dropouts over this period. Thus, variation in the returns to experience, together with changes in the rate of aggregate wage growth, have the potential to go a long way toward explaining the long-run variation in nonemployment for low-skilled workers in the context of this model.

Figure 7A also plots the implied trends in nonemployment from allowing the return to experience and aggregate wage growth to vary separately. This decomposition suggests that, between 1968 and 2006, changes in aggregate wage growth and experience-earnings profiles accounted for about an equal share of the implied increase in low-skilled nonemployment in the model. It also reveals, however, that the effects of g_w are relatively more important earlier on, whereas the return to experience plays more of a role later on. This finding is consistent with the trends depicted in Figures 2 and 3A. Declines in aggregate wage growth occur predominantly in the early part of the sample period, whereas declines in the return to experience among dropouts occur much more uniformly over the period.

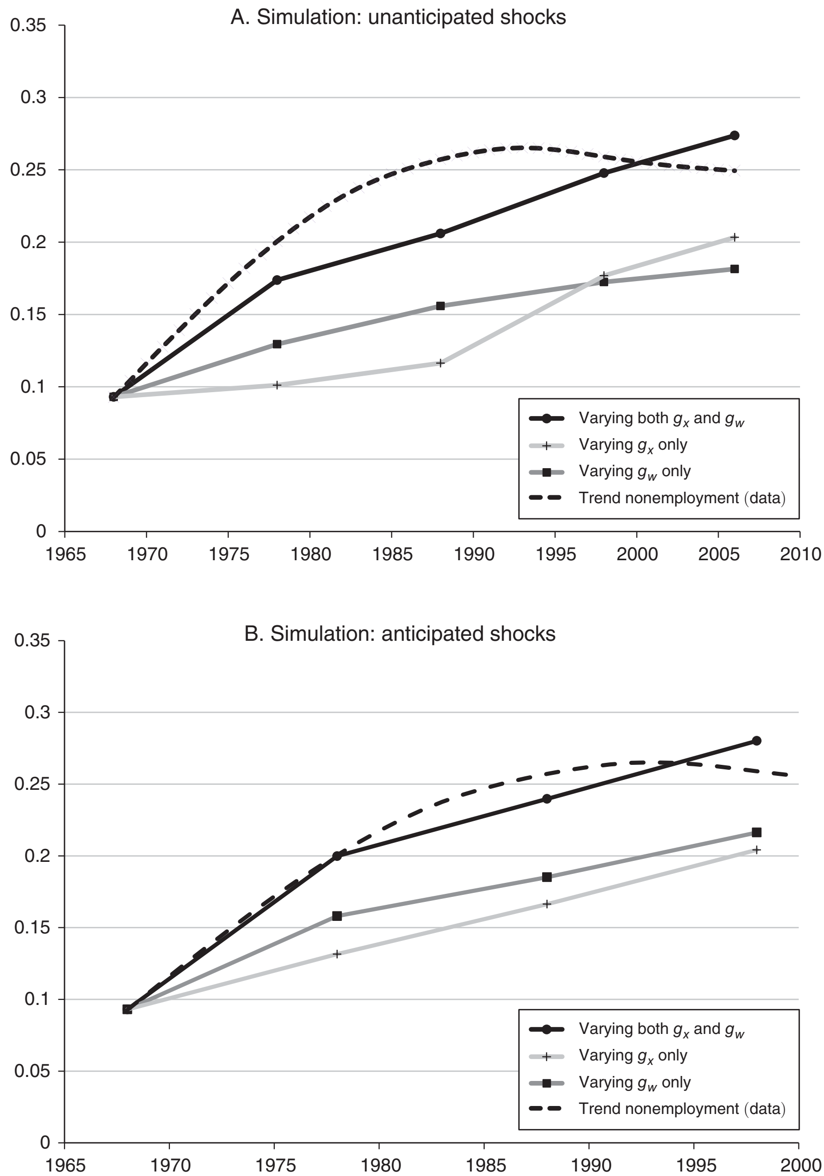

Figure 7. Model Response of Nonemployment among High School Dropouts

Notes: Authors' calculations based on general model of Section IV. Unanticipated shocks: cross-sectional experience profiles (Figure 3A) and aggregate wage growth (Figure 2) are fed through as unanticipated shocks. Anticipated shocks: cohort experience profiles (Figure 5A) and aggregate wage growth (Figure 2) are fed through the model as anticipated shocks. The discount rate $r = 0.04$. Simulations that vary g_w only (squares) hold the experience profile fixed at its 1980 level. Simulations that vary g_x only (pluses) hold aggregate wage growth fixed at the temporal mean of the series for high school dropouts in Figure 2 (approximately zero).

Another feature of the results in Figure 7A is that the model is less successful in matching the observed timing of the increase in trend nonemployment among high school dropouts. The data reveal a substantial medium-run rise in nonemployment in the 1970s and 1980s that the model does not fully predict. We do not necessarily view this as a problem, as it provides room for other explanations to play a role, a point we return to in Section IV when we discuss how our explanation dovetails with prior literature.

The model's inability to predict the medium-run rise in joblessness also may be related to our choice to feed variation in $g_x(\cdot)$ and g_w through the model as unanticipated shocks. It is possible that some of these changes may eventually have been anticipated. For example, workers may have become wise to the downward trend in aggregate wage growth seen in Figure 2. This would speed up the response of nonemployment to these shocks.

To highlight this point, we consider an alternative simulation. As before, the labor market is assumed to be in steady state at the beginning of the simulation in 1968. In this case, however, we assume that the time path of aggregate wage growth g_w in Figure 2 is subsequently realized by all cohorts. Symmetrically, instead of using the cross-sectional experience profiles from Figure 3, we reveal smoothed versions of the realized experience profiles to successive cohorts of workers.[20]

Figure 7B displays the results of this simulation based on these *anticipated shocks* to wage growth. Consistent with the intuition above, it can be seen that implied nonemployment in the model tracks the medium-run rise in nonemployment in the data remarkably well, though implied joblessness in the model overshoots the data in the late 1990s.

Implications for Nonemployment by Skill.—Up to now, we have focused on implied trends in joblessness among low-skilled high school dropouts. In this subsection, we compute implied trends in nonemployment rates for the remaining skill groups. Our simulation procedure mirrors exactly the method described above for high school dropouts. For each skill group, we feed the observed changes in the experience-earnings profile and aggregate wage growth in Figures 2 and 3 through the model as a series of unanticipated shocks. The only adjustment made is for differences in the extensive elasticity of labor supply ε across skill groups. The results of Section IB lead us to expect that ε declines with skill, as more skilled workers are less marginal to the employment decision. The estimates reported in Juhn, Murphy, and Topel (1991, 2002) confirm this intuition. Based on those estimates, we apply values of ε equal to 0.2, 0.1, and 0.066 for high school graduates, those with some college education, and those with a college degree or higher, respectively. Again, note that the effects of different assumptions on the magnitude of these elasticities are simply to rescale our reported employment effects up or down, respectively.

Figure 8 plots trend nonemployment rates implied by our simulations, together with trend nonemployment rates from the data. Figure 8A repeats Figure 7A for ease of comparison. Figure 8 suggests that observed trends in experience-earnings profiles and aggregate wage growth can account for around five of the ten percentage point increase in nonemployment among high school graduates, and three of the five percentage point increase for those with some college education. Consistent with the relative stability of the experience-earnings profiles for these groups in Figure 3, the majority of the implied increase in joblessness among both groups is driven by declines in aggregate wage growth. Figure 8 also reveals that trends in

[20] Since this simulation uses the realized cohort experience profiles, it can be peformed up to 2000 only.

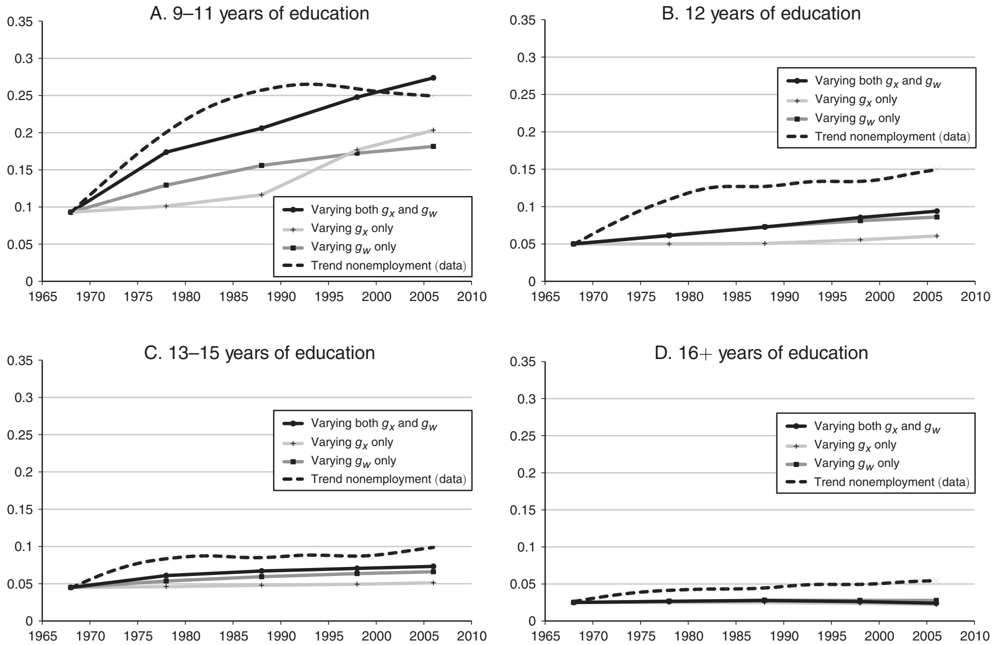

Figure 8. Implied Response of Nonemployment by Education to Observed Changes in Experience-Earnings Profile and Aggregate Wage Growth

Notes: Authors' calculations based on general model of Section IV. Observed changes in the experience-earnings profile and aggregate wage growth are fed through the model as unanticipated shocks (as in Figure 7A). The discount rate $r = 0.04$. When the experience-earnings profile is fixed, it is held at its 1980 level. When aggregate wage growth is fixed, it is held at zero.

either form of wage growth can explain none of the two to three percentage point increase in nonemployment among college graduates. The reason, of course, the participation of high-skilled workers is not elastic is because so few of them are on the work/nonwork margin.[21]

Implications for Overall Nonemployment.—The simulation results allow us to gauge the extent to which variation in wage growth can account for the increase in aggregate nonemployment depicted in Figure 1A. We take a share-weighted average of the simulations in Figure 8. These simulated changes in the nonemployment rates by education group aggregate to 3.4 percentage points—a little more than half of the six percentage point rise observed in Figure 1A. Hence, taken together, the mechanisms identified in the paper can account for all of the increase in

[21] In the working paper version of this paper (Elsby and Shapiro 2009), we also explore the age structure of the rise in nonemployment. In the model, older workers are less responsive to wage growth shocks, because they have a smaller impact on their remaining lifetime earnings. Consistent with this, rates of nonemployment among men aged 16 to 45 rose earlier and more rapidly among younger workers. For those aged 46 to 55, however, the model undepredicts the rise in nonemployment. This feature of the data is consistent with an abundant literature that has emphasized, to differing degrees, the role of changes in the generosity of disability insurance in declining labor force participation among older prime-aged men (Bound 1989; Bound and Waidmann 1992; Autor and Duggan 2003). In the context of our model, this would correspond to a change in b, the payoff from not working. Since we abstract from changes in b, we would not expect our simulations to account for all the changes in nonemployment, such as the well-documented decline in employment for older workers resulting from an expansion in disability payments.

nonemployment among white male high school dropouts, and for approximately one-half of the increase in the aggregate nonemployment rate over between 1968 and 2006.

An important aspect of the simulations is that they take into account the dynamics of the adjustments to changes in growth in wages and the return to experience. As seen in Figure 6, these dynamics can be quite slow. Taking them into account is crucial for understanding the movement in employment rates. In the simulations, the upturn in wage growth has a very delayed effect on aggregate employment rates owing to the decisions of older workers made well before the wage-growth increased. Consequently, the upturn in wage growth exhibited in Figure 2 does not lead to a contemporaneous reversal of the decline in employment.

Implications for Nonparticipation.—Until now, we have interpreted the predictions of the model as being aligned with secular trends in nonemployment—the sum of nonparticipation and unemployment. This is motivated by influential research noting that the distinction between unemployment and nonparticipation has become blurred at low frequencies, as low-skilled unemployed workers increasingly have become detached from the labor market, reporting very long spells of unemployment (Juhn, Murphy, and Topel 1991, 2002). As we noted in the introduction, however, an alternative view would be to interpret the labor supply margin that we model as corresponding to the participation margin. There are institutional, measurement, and theoretical considerations that potentially blur the distinction between nonparticipation and unemployment. While we incline to the the Juhn, Murphy, and Topel perspective, the alternative perspective that the labor supply margin addressed by our model bears more directly on nonparticipation has substantial merit. Hence, in this subsection we explore the predictions of our model when viewed through the lens of trends in nonparticipation.

Our simulation approach mirrors the preceding analysis of nonemployment; the results are depicted in Figure 9. Nonparticipation among low-skilled high school dropouts is predicted by the model to rise substantially from 5 percent in the late 1960s to 24 percent in the mid 2000s. This tracks the increase seen in the data quite closely, though overpredicts slightly the rise in nonparticipation by 2 to 4 percentage points over time. As in the results in Figure 8, declines in returns to experience and aggregate wage growth appear to account for roughly equal parts of the rise in low-skilled nonparticipation, with the productivity slowdown the more dominant earlier in the period.

For the remaining skill groups, the model accounts for 4.5 of the 8 percentage point rise in nonparticipation among high school graduates, and for three of the four percentage point rise among those with some college. As in the results for nonemployment in Figure 8, almost all of the rise in nonparticipation predicted by the model for these workers can be traced to declines in aggregate wage growth that accompanied the productivity slowdown, reflecting the more modest changes in the experience-earnings profile among these skill groups compared to high school dropouts (Figure 3).

Taking a share-weighted average of these predicted effects suggests that the model predicts four of the five percentage point rise in aggregate nonparticipation among prime-age men. Thus, viewed from either the participation margin or the employment margin, the model is able to account for a substantial fraction of the rise in labor force detachment among American men since the late 1960s. The model is able to account for a larger fraction of the secular rise in nonparticipation than in

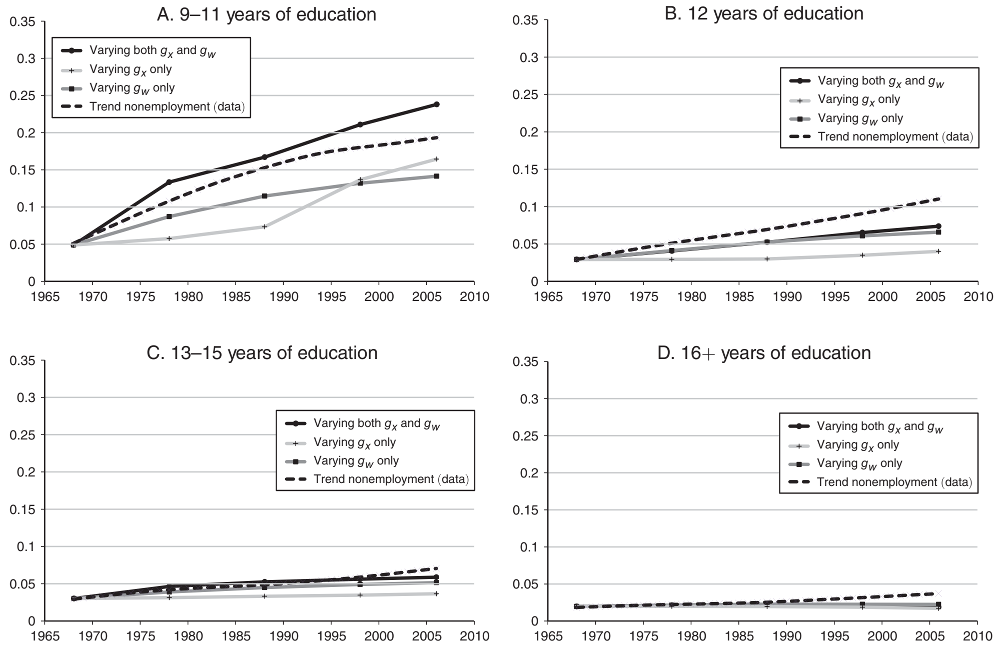

FIGURE 9. IMPLIED RESPONSE OF NONPARTICIPATION BY EDUCATION TO OBSERVED CHANGES IN EXPERIENCE-EARNINGS PROFILE AND AGGREGATE WAGE GROWTH

Notes: Authors' calculations based on general model of Section IV. Observed changes in the experience-earnings profile and aggregate wage growth are fed through the model as unanticipated shocks (as in Figure 7A). The discount rate $r = 0.04$. When the experience-earnings profile is fixed, it is held at its 1980 level. When aggregate wage growth is fixed, it is held at zero.

nonemployment, however. The simple reason is that the long-run increase in nonparticipation across skill groups is slightly smaller than that for nonemployment.

IV. Related Literature

This paper identifies a novel explanation for why reductions in trend productivity growth are associated with secular declines in rates of employment. A natural question is how this new explanation contrasts with existing stories for the decline in male employment, and its coincidence with the productivity slowdown.

A. *Search, Creative Destruction, and Capitalization Effects*

As noted in the introduction, an important class of models of labor markets with frictions has explored the link between productivity growth and unemployment. As emphasized by Mortensen and Pissarides (1998), the predictions of these models rely crucially on the degree to which new technologies are embodied in newly created jobs. In models of creative destruction (Aghion and Howitt 1994), the productivity of a job is fixed according to the state-of-the-art technology available upon creation of the employment relationship. In order to update productivity back to the frontier, older relationships must be severed, hence "creative destruction." A drawback to models in this vein is that they can have counterfactual predictions with respect to the effects of productivity growth on rates of worker reallocation and the level of unemployment (Blanchard 1998). Viewed through the lens of these models, declines in productivity growth, such as the slowdown in the 1970s, imply that the rate at which jobs become obsolete slows, reducing job destruction, and thereby unemployment. In contrast to these predictions, the productivity slowdown in the United States was characterized by increased rates of job destruction and increased unemployment.[22]

If new technologies may be incorporated into jobs of all vintages, however, a capitalization effect can arise (Mortensen and Pissarides 1998). The idea is that the creation of new jobs involves the costly process of filling a vacancy. These costs are borne upfront and are set against the stream of future profits generated by the employment relationship. A slowdown in productivity growth raises the rate at which these future profits are discounted, reducing the returns to job creation, and raising unemployment.[23]

The mechanism put forward in the present paper complements this capitalization effect in a number of respects. First, the two approaches capture quite different aspects of the decline in employment that followed the productivity slowdown. The capitalization effect noted by Mortensen and Pissarides (1998) emphasizes the impact of declines in trend growth on the demand for labor over the long run. In doing so, it seeks to provide an account of the rise in episodes of frictional unemployment that accompanied the productivity slowdown. In contrast, the view put forward in this paper provides an account of the decline in labor market attachment, and the concomitant rise in long jobless spells, that were observed in the wake of the slowdown in productivity growth. Accordingly, the emphasis in the present paper is on the effects of aggregate wage growth on incentives to supply labor.

Second, the analysis of Section IC revealed that the existence of labor market frictions was likely to have only a modest effect on the impact of wage growth on reservation wages that we emphasize. The absence of such interactions suggests that the implications of our theory are approximately additive with the capitalization effects emphasized by Mortensen and Pissarides (1998), which operate through their effects on labor market frictions, in particular the job-finding rate.

Finally, the results of Section III revealed that the model of this paper could account for the magnitude of the secular rise in nonemployment among the lowest-skilled education group. This is precisely the subgroup of the labor market on the margin of the work/nonwork decision that experienced significant rises in long jobless spells (Juhn, Murphy, and Topel 1991, 2002), which in turn is also the phenomenon our model seeks to encapsulate. In contrast, the model could account for around one-half of the increase in aggregate nonemployment. The results of our quantitative analysis therefore leave room for other potential explanations, such as the capitalization effect emphasized by Mortensen and Pissarides. In their quantitative analysis, Pissarides and Vallanti (2007) find that plausible calibrations of

[22] For example, the data analyzed by Davis (2008) reveal that rates of job loss in the US rose secularly in the 1970s and 1980s when the productivity slowdown occurred, a trend that reversed in the late 1980s and 1990s when productivity growth rebounded.

[23] Manning (1992) identifies a capitalization effect in a different context within a dynamic model of union bargaining. In his model, slower productivity growth reduces the future rents from employment available to workers. Consequently, unions capture rents in the present, raising wage pressure and increasing unemployment.

the capitalization effect can account for part of the empirical relationship between unemployment and trend growth, perhaps around one-third.[24] This, in turn, leaves room for the effects emphasized in the present paper and vice versa.

Overall, this suggests that these two explanations are largely complementary, both in terms of being conceptually distinct, and in terms of their quantitative predictions.

B. *Does the Short Run Last a Long Time?*

Perhaps because traditional models tend to predict no long-run employment effects of changes in productivity growth, a prominent feature of previous literature has been in its emphasis on the potential short-run employment effects of variation in productivity growth (see, among others, Blanchard 2000; Bruno and Sachs 1985; Ball and Moffitt 2001). A popular idea that has been pursued is that the wage demands of workers are somewhat sluggish in their response to changes in productivity growth. Blanchard (2000) has suggested that a "comprehension lag" can arise between the moment of an initial decline in productivity growth and the time that workers become aware of it. Similarly, Ball and Moffitt (2001) have emphasized the possibility of sluggish "wage aspirations" that do not adjust immediately to declines in the sustainable rate of aggregate wage growth. Both of these possibilities will lead to a short-run rise in joblessness. Moreover, depending on the sluggishness of reservation wages, the short run can last a long time.

A limitation to this approach, emphasized in Blanchard (1998), is that it becomes difficult to explain very persistent declines in employment following a productivity slowdown, unless one is willing to impose extreme forms of sluggishness in reservation wages. Such a task becomes especially difficult given the observed rebound in aggregate wage growth that accompanied the productivity "miracle" of the 1990s. Models of sluggish adjustment in reservation wages would predict reductions in joblessness in the 1990s. There was a decline in unemployment across the board in the late 1990s, though not for a long enough period to change much the picture of trends in nonemployment shown in Figure 1. Interestingly, our model contrasts with these predictions. The results of Section III imply that the productivity slowdown of the 1970s led to increased joblessness over long (30-year) horizons, rather than short horizons. Thus, while models of sluggish adjustment in reservation wages may account for the short- to medium-run rise in joblessness in the 1970s and 1980s, our model can account for the persistent rise in nonemployment into the 1990s. Recall that this is driven by the important employment dynamics that are emphasized when one takes into account the effects of human capital accumulation on work incentives over the life cycle.

C. *Skill-Biased Technical Change and the Decline in Employment*

A final related explanation of the secular decline in male employment rates does not appeal to the productivity slowdown, but rather to the concurrent rise in wage

[24] Pissarides and Vallanti (2007) find that calibrations of the capitalization effect can account fully for the empirical relation between unemployment and productivity growth only if jobs last almost indefinitely, and wages are unresponsive to labor market conditions.

inequality in the 1970s and 1980s. Low-skilled workers in the United States experienced sustained declines in their real wages over this period (Bound and Johnson 1992; Juhn, Murphy, and Topel 1991, 2002), a fact reiterated in Figure 2. This fact in turn suggests a simple explanation for the decline in low-skilled employment: if marginal workers face reductions in their wage, it seems intuitive that they would respond by withdrawing their labor supply (Juhn 1992).

Our analysis provides a number of interesting perspectives on this hypothesis. First, it is worth reemphasizing that, since our model explains just part of the overall rise in trend nonemployment, other explanations play a complementary role. Consider the timing of the rise in nonwork predicted by our model compared to the timing of the rise in wage inequality. The decline in wages experienced by low-skilled workers starting in the 1970s halted by the early 1990s, and reversed significantly later that decade (Juhn, Murphy, and Topel 2002). In contrast, our simulations in Section III reveal that, while the model could account for the persistence of the rise in nonemployment into the late 1990s and 2000s, it underpredicts the medium-term rise in the 1980s. Thus, there is room for a joint explanation of the overall decline in trend employment rates.

In addition to this, however, our model further highlights an important necessary condition for declines in the level of wages—such as those associated with the rise in wage inequality—to have an impact on employment rates: it must be that the payoff from nonwork (denoted b in our model) did not fall in tandem with the wages of less-skilled workers. Prior literature often has assumed that it would, usually by appealing to the fact that unemployment compensation is often a fixed fraction of prior wages. To the extent that this were so, reductions in wage levels of low-skilled workers that accompanied the rise in wage inequality would have a muted effect on employment. Assessing the extent to which replacement rates have risen over time, especially among the low-skilled, is therefore a worthy topic for future research.

V. Conclusion

Rates of joblessness among males in the United States have risen dramatically since the 1970s. These trends are particularly acute among the low-skilled. This paper provides an economic rationale through which changes in wage growth—both aggregate wage growth across time, and wage growth associated with the accumulation of work experience—may have an effect on work incentives. In particular, the paper shows that in a generic model of labor supply, the interaction between a positive return to experience and the trend growth in wages driven by productivity will cause a decrease in the rate of productivity growth to increase equilibrium nonemployment. Accordingly, our modeling provides a novel explanation for correlation between the growth rate and the employment rates, a correlation that is difficult to derive in traditional models with steady states.

The paper examines both types of wage growth: the overall trend in real wages and the return to experience. It confirms the well-known finding that wage growth has fallen since the 1970s, especially for low-skilled workers. It presents novel evidence that the return to experience has also fallen sharply for the lowest-skilled workers. In contrast, as the previous literature has emphasized and as we confirm, for most workers the return to experience has increased.

The paper combines the evidence on wage growth and the returns to experience with its model of labor supply to show that much of the increase in nonemployment among low-skilled males in the United States since 1970, and around half of the increase in aggregate male nonemployment can be explained by the model. Thus, this paper introduces both a new explanation for the longstanding puzzle that productivity growth rates and employment rates move together, and provides evidence that this explanation has significant empirical relevance.

A number of important issues arise for future work in the light of these results. First, in an economy such as the United States, with limited social insurance mechanisms, it is natural to ask what sources of income individuals have at their disposal when they experience persistent periods out of work. Potential sources may include income from intermittent employment spells with limited scope for human capital accumulation, and income of other household members (which may interact with increases in female labor market participation over time). Future study of these alternative income sources would shed important light on why employment rates among the low-skilled have been so elastic over time.

Second, what caused the equilibrium deterioration in wage growth we see in the data? Of particular interest is why the experience-earnings profiles among male high school dropouts flattened since the 1970s. Our analysis suggests this is unlikely to be related to increased differences between potential and actual experience, sources of selection over time, or to particular data sources. Further analysis of the determinants of the returns to experience seems warranted to provide a coherent explanation for these trends.

Appendix

A. *Main Theoretical Results*

Derivation of Equation (1).—Imagine firms face a constant returns to scale production technology that uses efficiency units of labor $A(x,t)n$, as well as capital k to produce output y according to

$$\text{(A1)} \qquad y = F\big(A(x,t)\,n,k\big), \quad \text{where } A(x,t) \equiv e^{g_w t + g_x x}.$$

From the linear homogeneity of the production technology, the marginal products are homogeneous of degree zero, so that we can write

$$\text{(A2)} \qquad F_j\big(A(x,t)\,n,k\big) = F_j\Big(A(x,t)\,\frac{n}{k},1\Big) \equiv f_j\Big(A(x,t)\,\frac{n}{k}\Big), \quad \text{for } j = 1,2.$$

Using this, the first-order condition for optimal capital demand implies $A(x,t)\,\frac{n}{k} = f_2^{-1}(p_k)$, where p_k is the price of capital. Substituting into the first-order condition for optimal employment, we obtain $w(x,t) = A(x,t)f_1\big(f_2^{-1}(p_k)\big)$. Taking logs and defining $w(0,0) \equiv f_1\big(f_2^{-1}(p_k)\big)$ yields equation (1) stated in the main text.

PROOF OF PROPOSITION 1:

Consider a worker with experience x at time t who is just indifferent to working, so that $w(x,t) = w_R(x,t)$. Note that the time derivative of the market wage is given by

$$\dot{w} = g_w w(x,t) + h(x,t) w_x(x,t), \tag{A3}$$

since $\dot{x} = h(x,t)$. Likewise, noting that $\dot{b} = g_w b(t)$, and $\dot{\lambda} = r\lambda(t) - h(x,t) \times w_x(x,t)$, the time derivative of the reservation wage is given by

$$\dot{w}_R = g_w w_R(t) - (r - g_w)\lambda(t) + h(x,t) w_x(x,t). \tag{A4}$$

It follows that, when the individual is just indifferent between working or not, the time derivative of the difference between the wage and the reservation wage is given by

$$(\dot{w} - \dot{w}_R)|_{w=w_R} = (r - g_w)\lambda(t). \tag{A5}$$

Under the assumptions that $r - g_w > 0$ and $w_x(x(\tau),\tau) > 0$ for all τ, the shadow value of experience in equation (13) has the property that

$$\lambda(t)\begin{cases} > 0 & \text{if} \quad h(\tau) = 1 \text{ for any } \tau > t, \\ = 0 & \text{if} \quad h(\tau) = 0 \text{ for all } \tau > t. \end{cases} \tag{A6}$$

Given this, we can conclude that

$$(\dot{w} - \dot{w}_R)|_{w=w_R}\begin{cases} > 0 & \text{if} \quad h(\tau) = 1 \text{ for any } \tau > t, \\ = 0 & \text{if} \quad h(\tau) = 0 \text{ for all } \tau > t. \end{cases} \tag{A7}$$

Thus, whenever a worker is indifferent between working or not at a point in time, two outcomes are possible: If he intends to work at any point in the future, he will start working now and will work for the rest of his life, since his offered market wage is rising above his reservation wage from below. On the other hand, if he never intends to work in the future, he will be indifferent between working and not working for the rest of his life. It follows that any wage offer slightly above the reservation wage will lead a worker to work for the rest of his life, and any offer slightly below his reservation wage will lead a worker to not work for the rest of his life.

B. *Interactions with Labor Market Frictions*

Infinite Lifetimes and Linear Returns to Experience.—If employed workers flow into nonemployment at rate s, and nonemployed individuals receive job offers at rate

f, then the Bellman equations for the value of employment $E(x,t)$ and nonemployment $N(x,t)$ may be expressed as

$$\text{(A8)} \qquad rE(x,t) = w(x,t) + s[N(x,t) - E(x,t)] + \frac{dE(x,t)}{dt},$$

$$rN(x,t) = b(t) + f\max\{E(x,t) - N(x,t),0\} + \frac{dN(x,t)}{dt}.$$

We seek to solve for the reservation wage $w_R(x,t)$ that sets $E(x,t) = N(x,t) + \varepsilon$, for $\varepsilon > 0$ approaching zero. To solve this system of value functions, conjecture that they take the following simple form

$$\text{(A9)} \quad E(x,t) = E_w w(x,t) + E_b b(t), \quad \text{and} \quad N(x,t) = N_w w(x,t) + N_b b(t).$$

Imposing the conjecture, noting that $dE(x,t)/dt = E_w(g_w + g_x)w(x,t) + E_b g_w b(t)$ and $dN(x,t)/dt = N_w g_w w(x,t) + N_b g_w b(t)$ because there is no accumulation of experience while out of work, equating coefficients and solving yields

$$\text{(A10)} \qquad E_w = \frac{r + f - g_w}{(r + f - g_w)(r + s - g_w - g_x) - sf},$$

$$E_b = \frac{s}{(r - g_w)(r + s + f - g_w)},$$

$$N_w = \frac{f}{(r + f - g_w)(r + s - g_w - g_x) - sf},$$

$$N_b = \frac{r + s - g_w}{(r - g_w)(r + s + f - g_w)}.$$

Solving for the reservation wage yields equation (9) in the main text.

Finite Lifetimes and Nonlinear Returns to Experience.—In the presence of labor market frictions, the expression for the marginal value of experience (analogous to equation (12) in the main text) for an individual who enters the labor market is given by

$$\text{(A11)} \qquad \tilde{\lambda} = \mathbb{E}\int_0^T e^{-r\tau}\mathbb{I}(\tau)\, w_x(x(\tau),\tau)\, d\tau,$$

where $\mathbb{I}(\tau)$ is an indicator function that equals one if the individual is employed at time τ and zero otherwise, and where we have used the results of Proposition 1, which apply analogously to this more elaborate problem. Expanding and collecting the relevant terms implies that we can rewrite the opportunity cost of not working as

$$\text{(A12)} \qquad \tilde{\lambda} = w(0,0)\,\mathbb{E}\int_0^T e^{-(r-g_w)\tau+\int_0^{x(\tau)} g_x(z)\,dz}\,\mathbb{I}(\tau)\,g_x\big(x(\tau)\big)\,d\tau.$$

In general, solving this expression further is complicated by the presence of the terms in $\mathbb{I}(\tau)$ and $x(\tau)$, which are (related) random variables. It is possible, however, to get a sense of its likely form by noting that the job-finding rate f is very large in practice. For example, estimates reported in Fujita and Ramey (2006) suggest that $f \approx 4$ on an annual basis over the period 1976 to 2006. This observation has a number of useful implications in the present context:

(i) The probability of employment $\mathbb{E}[\mathbb{I}(\tau)] \equiv p(\tau)$ evolves according to the differential equation $p'(\tau) = f[1 - p(\tau)] - sp(\tau)$. Together with the initial condition $p(0) = 0$, this implies that $p(\tau) = [1 - e^{-(s+f)\tau}]\frac{f}{s+f}$. For large f, a very good approximation to the latter is $p(\tau) \approx \frac{f}{s+f} \equiv p$.

(ii) The variance of an individual's employment status $\text{var}[\mathbb{I}(\tau)] = p(\tau)[1 - p(\tau)] \approx p(1-p)$ for large f. In addition, since $p \equiv \frac{f}{s+f} \approx 1$, it follows that $\text{var}[\mathbb{I}(\tau)] \approx 0$.

(iii) Finally, note that an individual's experience $x(\tau) = \int_0^\tau \mathbb{I}(\tau)\,d\tau$. It follows from the above that $\mathbb{E}[x(\tau)] \approx p\tau$ and $\text{var}[x(\tau)] \approx 0$.

Given these approximations, it is possible to write

$$\text{(A13)} \qquad \tilde{\lambda} \approx w(0,0)\int_0^T e^{-(r-g_w)\tau+\int_0^{p\tau} g_x(z)\,dz}\,pg_x(p\tau)\,d\tau.$$

Solving for the reservation wage of an individual entering the labor market yields

$$\text{(A14)} \qquad w_R(0,0) \approx \tilde{\alpha}b(0),$$

$$\text{where } \tilde{\alpha} = \left[1 + \int_0^T e^{-(r-g_w)\tau+\int_0^{p\tau} g_x(z)\,dz}\,pg_x(p\tau)\,d\tau\right]^{-1}.$$

Comparison of the latter with equation (15) in the main text reiterates the message of Section IC. The approximate effect of allowing for labor market frictions is to attenuate slightly the return to experience by a factor equal to $p \equiv \frac{f}{s+f} \approx 1$.

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