Minimum Wages and Youth Employment*

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Abstract

This paper constructs a labor search model where job experience reduces the rate of job separations to explores the effect of minimum wages on youth employment. Minimum wages can have large employment effects when they interact with worker's ability to gain job experience in an aggregate equilibrium model. Through this mechanism minimum wages help to explain recent high levels of youth unemployment in the United States and large differences in youth unemployment outcomes between the United States and France.

Keywords: Minimum Wage, Youth Employment, United States, France

JEL codes: E24, J08, J24, J64

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1 Introduction

Youth unemployment is an important issue for economies around the world. The recent financial crisis and following global downturn disproportionately impacted young workers. *International Labor Organization* (2009) report that youth unemployment was at the highest level ever recorded. In June 2010, the unemployment rate for young workers in the United States reached 20%. Jaimovich and Siu (2009) show that young workers account for a majority of business cycle fluctuations in unemployment. Understanding the causes of youth employment outcomes is essential. Early career outcomes are important to a worker's development and later career outcomes. Additionally, cross country differences in employment outcomes are concentrated among young and older workers. Understanding differences among young workers is a key piece in explaining these cross country facts. Finally, high levels of youth employment have become explosive political issues as they have been a motivating factor for recent protests across Europe and unrest in the Middle East.

This paper constructs a labor search model that accounts for early life cycle changes in unemployment outcomes and explores the effects of minimum wages on youth employment outcomes. To generate the observed higher levels of youth unemployment, workers are one of two types: experienced and inexperienced. Workers enter the labor force inexperienced and unemployed and can later become experienced when employed. The key assumption is that experienced workers separate from their jobs at a lower rate. This exogenous decline is used to calibrate the model so that it is consistent with the observed decline in job separation rates with age in the US economy[1]. The model assumes both types of workers draw jobs from the same productivity distribution. However, experienced workers have a higher reservation productivity level which leads to differences in job finding rates and wages between groups. The model matches the age employment patterns for young workers in the United States.

[1]One potential concern with this approach is that separation rates are not invariant to changes in the minimum wage. However, in models with endogenous separations like Jovanovic (1979) and Gorry (2010) minimum wages increase the job separation rate and hence amplify the unemployment effects of minimum wages for young workers. This approach provides a convenient lower bound for the observed employment effects of minimum wages.

Using this life-cycle model of employment patterns, this paper contributes to the literature by studying how minimum wages impact employment outcomes through the experience channel and to explore the effects of changes in minimum wage policy on aggregate economic outcomes. Minimum wages can potentially have a large impact on youth employment outcomes because they interact with the worker's ability to gain experience. While the interaction of minimum wages with optimal human capital accumulation has been been recognized at least since Rosen (1972), this paper applies such a distortion to a macroeconomic equilibrium setting. In particular, inexperienced workers are unable to pay for their training through reductions in their wages, but instead must gain experience in a segment of the labor market characterized by high job separation rates. This paper contributes to the literature by using the equilibrium nature of the model to understand the effects of minimum wages on the aggregate labor market.

In the model, the minimum wage restricts a worker's access to jobs below a productivity cutoff. This has three effects. First, jobs that were previously above the worker's reservation productivity level and below the minimum wage are now no longer available. This prevents young workers from accepting such jobs and gaining valuable experience. Second, since some profitable matches are no longer turned into jobs, firms find it less profitable to enter the sector to post jobs for inexperienced workers. This drives down the endogenous match rate for workers further reducing their ability to accept jobs. Finally, workers who earn the minimum wage get a larger share of the match surplus than they would have without the minimum, making them better off (and firms worse off). An important result from the aggregate equilibrium analysis is that minimum wages have nonlinear effects on unemployment as the total employment effect of a change in the minimum wage depends on the mass of the productivity distribution between the minimum profitable productivity levels for the varying minimum wages.

To get a rough quantitative sense for the importance of the first effect one can examine the number of workers who would be impacted by changes in minimum wages. Figure 1 draws on 2000 census data to depict the cumulative distribution function of US wages with cutoffs

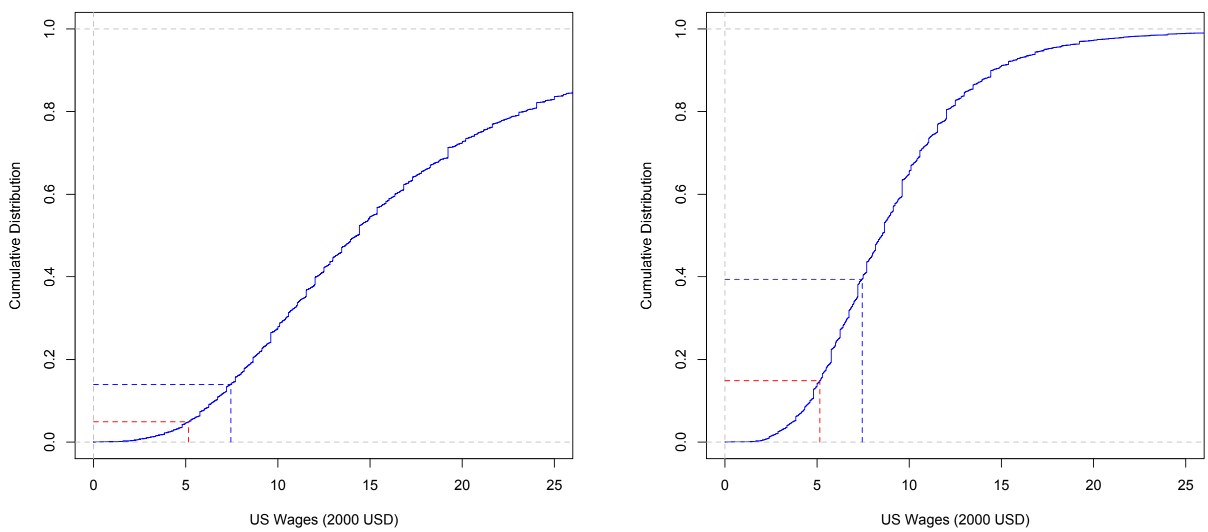

Figure 1: *CDF of US wage distribution with US minimum wage (lower dashed lines) and French minimum wage (upper dashed lines). Total population in left panel workers aged 15-24 in right panel.*

for the minimum wage level in the US and France. The left panel shows the distribution for all workers while the right panel shows wages for workers aged 15-24. In the left panel, 5% of workers earn less than the US minimum wage while 14% of workers earn less than the French minimum wage. This means that 9% of workers would be impacted by a change of the US minimum wage to the level of France. Young workers are impacted much more by such a change. The right panel shows that almost 15% of workers aged 15-24 earn less than the US minimum wage and almost 40% earn less than the French minimum wage. This implies that about 25% of young workers in the US would be impacted by raising the minimum wage to French levels. Of course not all impacted workers would become unemployed. Some workers would be below the productivity needed to remain employed and lose their jobs while for others the firms may be able to adjust their wages to keep them employed. To understand the full effects of such changes an equilibrium model is needed. Figure 1 depicts the primary mechanism in the model: minimum wages restrict access to jobs at the low end of the productivity distribution. While the figure is not a complete story as both firms and workers have the opportunity to adjust in response to the new wage, the graph shows the potential effects for young workers from significant changes in the minimum wage. Moreover, it highlights the first important result from the model that minimum wages can have nonlinear effects on unemployment rates. At low levels of the minimum wage, there is not much mass in the distribution of productivity, so minimum wages have little effect. As minimum wages get higher, they are likely to have larger effects when they cut more deeply into the underlying productivity distribution.

After constructing the model and exploring the impact of minimum wages on youth unemployment, the paper will use the model to assess the impacts of recent minimum wage changes in the US and explore the effects of differing minimum wages between the US and France. While neither of these questions lends itself to clean empirical designs, the model can shed light on potential effects of policy changes. In May 2007 the US government passed a law to raise the minimum wage from $5.15 per hour to $7.25 per hour over three annual increases ending in July 2009. An important question is, how much this increase in minimum wages increased youth unemployment? Unfortunately, it is difficult get a clear answer to this question as the increases in minimum wages corresponded to a recession that also had disproportionate adverse effects on youth employment. Using the model to predict the effect of the new higher minimum wage generates that the higher minimum wage would increase unemployment for 15-24 year olds by 2%. That implies that the increase in minimum wages accounted for 22.5% of the increase in youth unemployment between 2006 and 2009.

Figure 2 shows the unemployment rate by age group for the US and France in 2000. The model predicts that if the US changed minimum wages and payroll taxes to the levels found in France that unemployment for young workers would be even higher than observed in France. This implies that large changes in minimum wage policies can have large effects. Exploring why the model predicts such high levels of unemployment at French minimum wages is informative. First, calibrating the model to the United State implies high levels of job separation rates that make it difficult for young workers to gain experience and avoid

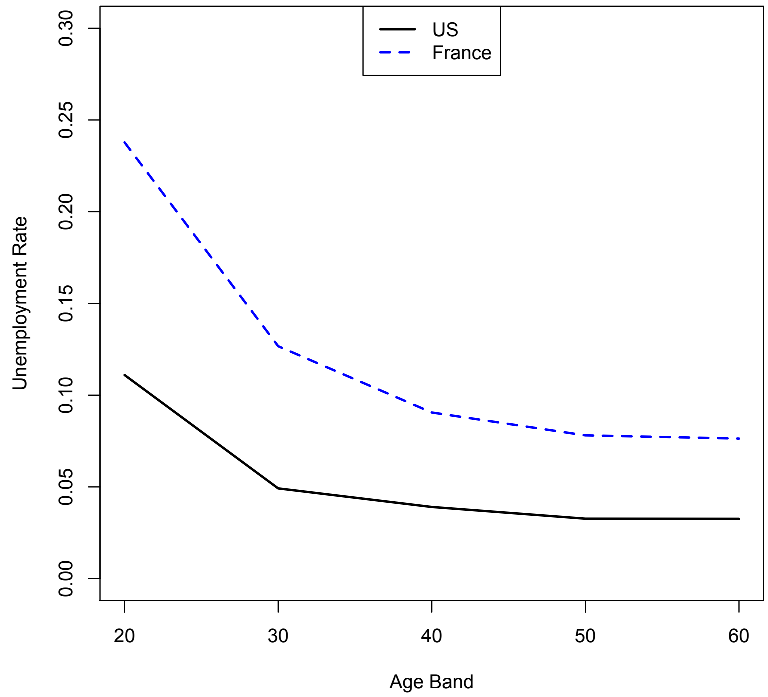

Figure 2: *Average unemployment rate by age group for the US and France in 2000.*

the effects of minimum wages. The lower job separation rates in France help to mitigate these effects. Second, the model has no mechanism to exit the labor force while high levels of minimum wages could cause differences in labor force participation across countries. While minimum wages can play an important role in explaining labor market outcomes for young workers, future work to understand why transition rates differ by such large amounts across countries and to understand patterns in labor force participation are important to make detailed cross country comparisons.

Section 2 discusses the related literature. The model is presented in section 3. Section 4 calibrates the model to match the age patterns of employment found in the US. Section 5 documents the predictions from the model and section 6 uses the model to quantitatively assess the effects of minimum wage changes. Section 7 concludes.

2 Related Literature

This paper relates to two major literatures. First, is the literature that assesses the impact of minimum wages on labor market outcomes. Second, it complements the literature that attempts to explain employment differences between the US and Europe. While both of these literatures are too large to fully review here, this section discusses how this paper relates to important past results.

The nearest literature studies the interaction between human capital accumulation and minimum wages. Rosen (1972) was one of the first to characterize the market for workers skills gained through job experience. He argues that in a competitive labor market workers can be paid a lower wage if their job provides them with learning opportunities and he recognized that a minimum wage could have the effect of lowering the potential opportunities for learning. Mincer and Leighton (1980) and Hashimoto (1982) formally study the effects of minimum wages on job training and find modest support for minimum wages reducing training. More recently, Acemoglu and Pischke (1999) formulate a model where minimum wages can possibly increase training in a non-competitive labor market and provide new empirical evidence that minimum wage changes have no effect on training. While not treating investment as a decision, inexperienced workers are willing to accept lower wages in order to gain the skills that experience provides. The additional skills gained through experience has important interactions with minimum wages for young workers whose job acceptance decisions are influenced by the presence of minimum wages.

The search model in this paper is closely related to recent literature that studies the effects of minimum wages in such models. Flinn (2006) studies the effects of minimum wages in a Mortensen-Pissarides equilibrium search environment. Rocheteau and Tasci (2008) study the effects of minimum wages in a variety of equilibrium search models. Minimum wages are introduced in this paper in the same way as in Flinn (2006) who considers the efficiency of minimum wages for different bargaining environments. Unlike Flinn (2006), this paper assumes that the Hosios (1990) condition applies, so that the equilibrium is efficient. This paper extends the simple search framework to include human capital accumulation to allow the minimum wage to only impact inexperienced workers and applies the framework to explore the cross-country implications of minimum wages on employment outcomes for young workers.

Finally, there is a large literature on the effects of minimum wages on worker outcomes. Card and Krueger (1994) stimulated interest in research on minimum wage by arguing that a minimum wage increase in Pennsylvania had no adverse impact on employment. Since then, many empirical papers have sought to evaluate the effects of the minimum wage on employment outcomes. For a recent survey of the literature see Neumark and Wascher (2007). While there is no consensus on the overall effect of minimum wages, most studies conclude that minimum wages have slightly negative employment effects, though often the effects are not statistically significant. While not a comprehensive review, this section uses the model to help reconcile the major results from this literature.

Even without a general consensus on the effect of minimum wages on overall employment, there are studies that find that minimum wages adversely effect employment of youth. Despite not finding general evidence that minimum wages hurt employment Dolado et al. (1996) find that minimum wages effect young workers. Using longitudinal data Abowd et al. (1997) find that young men employed at the minimum wage in both France and the United States experience a significant decline in their probability of employment after an increase in the minimum wage. Differences in total size of employment effects could be a function of the portion of the population paid the minimum wage, which is higher in France. Looking over 17 OECD countries Neumark and Wascher (2004) find that in general minimum wages cause decreased employment among young workers. The declines are less severe in countries that have special provisions whereby youth are hired at wages below the minimum. Moreover, Wessels (2005) finds that minimum wages significantly decrease teenage labor force participation.

Empirical studies have also focused on France where minimum wages are especially high. Bazen and Skourias (1997) find a negative effect of minimum wages on youth employment in France despite finding no significant effects for other groups. Fougere et al. (2000) study the effects of various youth employment policies in France. They find that subsidies that reduce the labor costs of hiring young workers have strong positive effects on increasing employment. The model is broadly consistent with these empirical findings. It reveals a mechanism where youth employment outcomes are hurt by increases in the minimum wage while other segments of the population suffer no adverse employment effect.

This paper provides theoretical support for findings in the empirical literature about the effects of minimum wages on employment outcomes. It explains why the effects of minimum wages are only found among young workers. Moreover, the impact of minimum wages on employment is non-linear; low levels of minimum wages have little effect where high minimum wages yield much higher youth unemployment rates. This reconciles the literature that finds small effects of minimum wage laws in the United States where minimum wages are low with the literature that finds larger effects in Europe.

Finally, this paper compliments a research agenda to quantitatively assess the impact of various labor market institutions on employment outcomes as in Rogerson (2006). While previous work focuses on explaining employment differences between the US and Europe, this paper studies factors that explain why the differences are concentrated among young workers. Prescott (2004) and Ljungqvist and Sargent (1998) argue that the differences in employment between the United States and Europe can be accounted for by taxes and differences in unemployment benefits coupled with loss of human capital when unemployed respectively. While potentially accounting for large differences in unemployment neither of these explanations account specifically for employment differences among young workers. This paper makes progress by explicitly modeling outcomes for young workers and exploring one policy that could have large effects on observed differences.

3 Model

This section describes the search and matching model that can mimic the age patterns found in employment. The model extends the matching models of Mortensen and Pissarides (1994) and Pissarides (1985) by allowing employed workers to become experienced. Experienced workers are less likely to become separated from their jobs. This feature enables the model to generate differences in employment outcomes between young and older workers. While experience makes jobs last longer, experienced and inexperienced workers still draw job offers from the same fixed underlying productivity distribution $F(y)$. Although equilibrium in this environment will entail a stationary distribution of experienced and inexperienced workers, the model can be simulated to generate hypothetical employment histories for individual workers that can be compared to data on employment outcomes.

3.1 Agents

There is a unit mass of workers who exit the labor market at rate δ. A new cohort of size δ enter the labor force at each date to replace the workers who have left. Hence, there is a constant number of workers alive at any given time. New workers enter the labor market inexperienced and unemployed. Workers have preferences:

$$\int_0^\infty e^{-(r+\delta)t} c_t dt$$

where c_t is consumption. Agents supply labor to the market inelastically when they are employed.

Additionally, there is a continuum of infinitely lived agents that will be called firms with preferences:

$$\int_0^\infty e^{rt} c_t dt$$

Firms search separately for inexperienced and experienced workers and can post any number of vacancies, $v_t \in \mathbb{N}_0$, at a flow cost of k_i consumption units for an open vacancy of type $i \in \{e, n\}$ where e denotes experienced and n denotes inexperienced workers.

3.2 Production

Production occurs when a worker is paired with a firm. Experienced and inexperienced workers have separate constant returns to scale matching functions: $m_e(v_e, u_e)$ and $m_n(v_n, u_n)$[2]. A worker of type $i \in \{e, n\}$ meets a vacant job at rate $\lambda_i = m_i/u_i$. Symmetrically, an open vacancy of type i meets a worker at rate $q_i = m_i/v_i$.

When a worker and vacancy of either type meet, the pair draw a match specific productivity y from distribution $F(y)$. Both workers and firms immediately observe the productivity draw. Given the productivity y both parties agree on whether to form a match and use Nash-bargaining to split the surplus. As is standard in the matching literature, the solution to this problem consists of a reservation productivity level for each type of worker. These reservation productivities are denoted by y_e^* and y_n^* for experienced and inexperienced workers. If a match is formed, wages are determined by Nash bargaining with weight θ given to the workers. This will result in wage functions $w_e(y)$ and $w_n(y)$ that depend on the type of worker in the match.

3.3 Equilibrium

Workers in the model can be in any one of four possible states. The value functions for unemployed inexperienced, unemployed experienced, employed inexperienced and employed experienced workers are as follows:

$$(r + \delta)U_n = \lambda_n \int \max\{E_n(y) - U_n, 0\}\, dF(y) \tag{1}$$

$$(r + \delta)U_e = \lambda_e \int \max\{E_e(y) - U_e, 0\}\, dF(y) \tag{2}$$

[2] Alternately, both experienced and inexperienced workers could draw jobs from the same matching function. The baseline version of the model calibrates the matching rate to be identical between the two types of workers. Two matching functions allow changes in minimum wages to alter the job offer rates for different types of workers as experienced workers become more profitable. This allows another potential channel whereby labor market policies can affect employment outcomes. While similar results can be generated by calibrating a model with a single matching function, such models generate a potential multiplicity of equilibria.

$$(r+\delta)E_n(y) = w_n(y) + p\left[\max\left\{E_e(y), U_e\right\} - E_n(y)\right] + s_n\left[U_n - E_n(y)\right] \tag{3}$$

$$(r+\delta)E_e(y) = w_e(y) + s_e\left[U_e - E_e(y)\right] \tag{4}$$

Unemployed workers are matched with firms at rate λ_i depending on their type $i \in \{e, n\}$. When matched they get a draw from the productivity distribution $F(y)$ and either become employed with productivity y or remain unemployed. Employed inexperienced workers are paid a wage $w_n(y)$ based on their productivity y. Additionally, they separate from their job and become unemployed inexperienced at exogenous rate s_n and become experienced at rate p. When employed inexperienced workers becomes experienced they can choose either to become employed experienced with productivity y or they can quit and become unemployed experienced to search for a higher productivity match. Finally, employed experienced workers get paid $w_c(y)$ and become unemployed experienced at rate $s_e < s_n$. Note that becoming experienced is an absorbing state: experienced workers remain so until they leave the labor force.

Next, firms can choose to open vacancies for either experienced or inexperienced workers. Their value functions for inexperienced and experienced vacancies and filled jobs are as follows:

$$rV_n = -k_n + q_n \int \max\{J_n(y) - V_n, 0\} dF(y) \tag{5}$$

$$rV_e = -k_e + q_e \int \max\{J_e(y) - V_e, 0\} dF(y) \tag{6}$$

$$(r+\delta)J_n(y) = y - (1+\tau)w_n(y) + s_n[V_n - J_n(y)] + p[\mathbb{I}_{Stay}(J_e(y) - J_n(y)) + (1 - \mathbb{I}_{Stay})(V_n - J_n(y))] \tag{7}$$

$$(r+\delta)J_e(y) = y - (1+\tau)w_e(y) + s_e[V_e - J_e(y)] \tag{8}$$

If a firm posts a vacancy for an inexperienced worker, it pays a flow cost k_n for having the open vacancy and meets a worker with probability q_n. When the match occurs the firm decides to establish a job or remain as a vacancy depending on the realization of the productivity draw. Experienced vacancies are identical except that they pay flow cost k_e.

The flow costs of vacancies may differ in the two markets either due to the type of work requiring more capital to be ready for an individual to start work or higher costs in seeking a more specific type of employee. The firm with an inexperienced worker gets the output from the match y less the wage and payroll taxes paid to employ the worker $(1+\tau)w_n(y)$. The match dissolves at rate s_n. At rate p the worker becomes experienced. If the worker keeps her job the match becomes experienced, otherwise the firm and worker separate. Finally, a firm with a experienced worker gets the output y and pays wage and payroll taxes $(1+\tau)w_e(y)$. The firm and worker separate at rate s_e. Note that filled jobs are discounted at rate $r+\delta$ because when the worker dies the match ends.

To complete the notation for the model let the masses of unemployed inexperienced workers, unemployed experienced workers, inexperienced matches, experienced matches, inexperienced vacancies, and experienced vacancies be denoted by u_n, u_e, e_n, e_e, v_n, and v_e respectively. We can now define a steady state competitive equilibrium of the model:

Definition 1 *A steady state equilibrium consists of the value functions for the worker, U_n, U_e, $E_n(y)$, and $E_e(y)$, the value functions of the firm, V_n, V_e, $J_n(y)$, $J_e(y)$, the aggregate state variables, u_n, u_e, e_n, e_e, v_n, and v_e, the wages, $w_n(y)$ and $w_e(y)$, and the reservation productivity levels for each type of worker, y_n^* and y_e^* such that:*

1. *Value functions are satisfied: Given $w_n(y)$, $w_e(y)$, u_n, u_e, v_n, and v_e, U_n, U_e, $E_n(y)$, $E_e(y)$, V_n, V_e, $J_n(y)$, and $J_e(y)$ satisfy equations (1)–(8).*

2. *Match Formation: Given $w_n(y)$, $w_e(y)$, u_n, u_e, v_n, and v_e, the reservation productivity levels y_n^* and y_e^* are optimal decision rules.*

3. *Free Entry: Given $w_n(y)$ and $w_e(y)$, u_n, u_e, v_n, and v_e, the value of vacancies must be $V_n = V_e = 0$.*

4. *Bargaining: $w_n(y)$ and $w_e(y)$ satisfy the Nash bargaining equations:*

$$E_n(y) - U_n = \theta[J_n(y) + E_n(y) - V_n - U_n] \tag{9}$$

$$E_e(y) - U_e = \theta[J_e(y) + E_e(y) - V_e - U_e] \tag{10}$$

5. *Steady State: The following four equations hold:*

$$u_n + u_e + e_n + e_e = 1$$

$$(1-\gamma)pe_n + s_e e_e = \lambda_e(1 - F(y_e^*))u_e + \delta u_e$$

$$\lambda_e(1 - F(y_e^*))u_e + p\gamma e_n = (s_e + \delta)e_c$$

$$\lambda_n(1 - F(y_n^*))u_n = (s_n + p + \delta)e_n$$

Where $\gamma = \min\{\frac{1-F(y_e^*)}{1-F(y_n^*)}, 1\}$ *is the percentage of inexperienced workers who remain employed when they become experienced.*

3.4 Characterizing the Solution

The solution to the model involves solving for the reservation productivity level for each type of worker. By continuity of the value functions $E_n(y)$ and $E_e(y)$, the reservation productivities are defined by the indifference point between unemployment and being employed at the reservation productivity level. That is, $U_n = E_n(y_n^*)$ and $U_e = E_e(y_e^*)$.

Lemma 1 *Wages for experienced and inexperienced workers are given by:*

$$(1 + \theta\tau)w_e(y) = \theta y + (1-\theta)w_e(y_e^*)$$

$$(1 + \theta\tau)w_n(y) = \theta y + (1-\theta)w_n(y_n^*) + p(1-\theta)\mathbb{I}_{y_n^* \geq y_e^*} \frac{\frac{\theta}{1+\theta\tau}(y_n^* - y_e^*)}{r + \delta + s_e}$$

Proof. See Appendix. ■

Lemma (1) derives the wage equations for the model that have the following properties. First, as long as both inexperienced and experienced workers remain employed at a given productivity y the difference between their wages is a constant and the slope of each wage with respect to experience is $w_i'(y) = \frac{\theta}{1+\theta\tau}$ for $i \in \{e, n\}$. Moreover, wages will be higher for experienced workers if they have a higher reservation wage and vice versa. Finally, wages at the reservation level for each type of worker are given by $w_e(y_e^*) = \frac{y_e^*}{1+\tau}$ and $w_n(y_n^*) = \frac{y_n^*}{1+\tau} + \frac{p(1-\theta)}{1+\tau}\mathbb{I}_{y_n^* \geq y_e^*}\frac{\frac{\theta}{1+\theta\tau}(y_n^* - y_e^*)}{r+\delta+s_e}$.

Next, the conditions for which $y_e^* > y_n^*$ are documented in the following proposition:

Proposition 1 *If* $\frac{\lambda_e}{r+\delta+s_e+p} > \frac{\lambda_n}{r+\delta+s_n+p}$, *the reservation productivity level of an inexperienced worker is less than a experienced worker. That is:* $y_n^* < y_e^*$.

Proof. See Appendix. ■

Lower job separation rate for experienced workers is the key factor that generates differences in employment outcomes between young and old workers. However, the differences in separation rates are filtered through the worker's search decisions to generate employment outcomes. Because their jobs are expected to last longer, experienced workers take longer on average to find new jobs. The job finding rate for each type of worker, $i \in \{e, n\}$, is given by $\lambda_i(1 - F(y_i^*))$. Proposition 1 gives general conditions for $y_n^* < y_e^*$. As an important special case it implies that $y_n^* < y_e^*$ when either $s_n > s_e$ or $\lambda_e > \lambda_n$. If one of the two inequalities hold the ordering of reservation values can still be upheld as long as the other variables are close enough across types. When $y_n^* < y_e^*$, the reservations property can be used to find equations that define the values or y_n^* and y_e^*. For experienced workers, the reservation productivity solves the following equation:

$$\frac{y_e^*}{1+\tau} = \frac{\lambda_e\theta}{(r+\delta+s_e)(1+\theta\tau)}\int_{y_e^*}^{\infty}(y - y_e^*)dF(y)$$

For inexperienced workers, differentiating equation (3) gives an equation for $E_n'(y)$. Since employed workers quit their jobs when they become experienced unless their productivity is above y_e^*, the differentiation is done in two parts. When $y \geq y_e^*$:

$$E_n'(y) = \frac{w_n'(y) + p\frac{w_e'(y)}{r+\delta+s_e}}{r+\delta+p+s_n}$$

When $y < y_e^*$:

$$E_n'(y) = \frac{w_n'(y)}{r + \delta + p + s_n}$$

Since $w_e'(y) = w_n'(y) = \frac{\theta}{1+\theta\tau}$, a closed form expression for $E_n'(y)$ is obtained. Note that for each segment $E_n'(y)$ is a constant. Hence, assuming that $y_n^* < y_e^*$, equation (1) is used to solve for y_n^*:

$$\frac{r+\delta}{(r+\delta+p)(1+\tau)}[y_n^* + \frac{p}{r+\delta}y_e^*] = \lambda_n \int_{y_n^*}^{\infty} E_n(y) - U_n dF(y)$$

$$= \frac{\lambda_n \theta}{(r+\delta+s_n+p)(1+\theta\tau)} \left[\int_{y_n^*}^{y_e^*} (y - y_n^*) dF(y) \right.$$
$$\left. + \int_{y_e^*}^{\infty} (y - y_n^*) + \frac{p}{r+\delta+s_e}(y - y_e^*) dF(y)\right]$$

3.5 Model with Minimum Wages

This section introduces minimum wages to the model. Minimum wages are introduced as a binding wage floor in the model, $\bar{w}$. For a match to form, the wage paid must be equal to or exceed this minimum level. As in Flinn (2006), the minimum wage will create a side condition on the Nash bargaining problem in the model. This changes the equilibrium concept that was previous described. In the original model, workers and firms agreed on match formation. With a wage floor, a worker may want to work at the minimum wage, $\bar{w}$, while the firm is unwilling to form a match at this wage. To get around this problem, the firm now unilaterally chooses whether to form a match when a firm and worker meet. Hence, the worker no longer makes a maximization decision. Firms solve the same problem as before.

A second difference in the model with minimum wages concerns Nash bargaining. We continue to assume Nash bargaining with the added constraint that $w_i(y) \geq \bar{w}$. This implies that $E_i(y) - U_i \geq \theta[J_i(y) + E_i(y) - V - U_i]$ for $i \in \{e, n\}$. The equation holds with equality if $w_i(y) > \bar{w}$. Under this setup, workers get share θ of the surplus when $w_i(y) \geq \bar{w}$, but receive

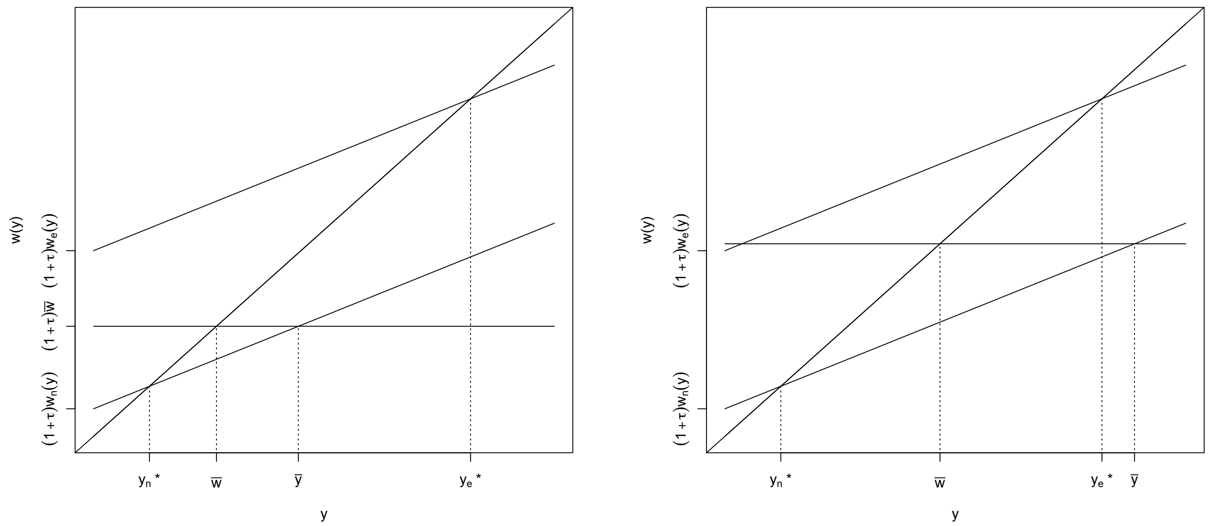

Figure 3: *Graphical depiction of Nash bargaining solution. Left panel for* $\bar{y}_n < y_e^*$ *right panel for* $\bar{y}_n > y_e^*$.

a higher share when the minimum wage binds. Since firms unilaterally make the choice of when to accept a match, for a minimum wage above the original reservation productivity level of inexperienced workers there is positive surplus from the match as long as $y \geq (1+\tau)\bar{w}$. For the firm to be willing to hire a worker at the minimum wage, the worker must be productive enough to cover the costs of the wage and payroll taxes. Define $\bar{y}_n$ as the productivity level where the original wage function crosses the minimum wage; that is $w_n(\bar{y}_n) = \bar{w}$. Workers with productivity between $(1+\tau)\bar{w}$ and $\bar{y}_n$ earn the minimum wage so all extra output produced during this range goes to the firms. For productivity above $\bar{y}_n$ workers and firms split surplus according to the previous wage equation. As in Flinn (2006) the model delivers a positive mass of workers who earn the minimum wage.

Figure 3 depicts the Nash bargaining solution for two two levels of minimum wages. In the left panel the minimum wage is such that $\bar{y}_n < y_e^*$ and in the right panel a higher level of minimum wages such that $\bar{y}_n > y_e^*$. In both cases, the reservation productivities y_n^* and y_e^* are determined by the point where the wage functions $(1+\tau)w_n(y)$ and $(1+\tau)w_e(y)$

cross the 45-degree line. This is the threshold where workers productivity is just able to compensate firms for the cost of paying their wages and payroll taxes. These plots are helpful for constructing limits of integration when solving the problems of inexperienced workers and firms in the model with minimum wages.

It is worth emphasizing that under a minimum wage the equilibrium productivity thresholds where workers would accept employment y_n^* and y_e^* are different than in the model without minimum wages. There are three different effects that cause the thresholds to vary. First, the minimum wage implies that that some jobs that were previously available to workers are no longer available. This decreases the value of being unemployed and hence y_n^*. Second, for a positive mass of productivity levels the workers will get paid the minimum wage which is above the unconstrained wage function. This pushes y_n^* in the opposite direction. Finally, there is a general equilibrium effect that arises as firms find it less profitable to post vacancies for workers as they both have a lower match rate and have to pay a wage premium. This lowers y_n^* even further.

Using $\bar{y}_n$ the value functions for vacancies and unemployed workers can be defined in order to solve for y_n^*. With a binding minimum wage for inexperienced workers, their value function is:

$$(r+\delta)U_n = \lambda_n \int_{(1+\tau)\bar{w}}^{\infty} \left[E_n(y) - U_n\right] dF(y)$$

Assuming $\bar{y}_n < y_e^*$ the equation can be solved as:

$$\frac{r+\delta}{(1+\tau)(r+\delta+p)}\left(y_n + p\frac{y_e}{1+\tau}\right) = \frac{\lambda_n}{r+\delta+p+s_n}\left[\int_{(1+\tau)\bar{w}}^{\bar{y}_n} \bar{w} - \frac{y_n^*}{1+\tau} dF(y)\right.$$

$$\left.\int_{\bar{y}_n}^{y_e^*} \frac{\theta}{1+\theta\tau}(y-y_n^*)dF(y) + \int_{y_e^*}^{\infty} \frac{\theta}{1+\theta\tau}(y-y_n^*) + \frac{p\theta}{(r+\delta+s_e)(1+\theta\tau)}(y-y_e^*)dF(y)\right]$$

Alternately, if the minimum wage is higher so that $y_e^* < \bar{y}_n$ then the equation becomes:

$$\frac{r+\delta}{(1+\tau)(r+\delta+p)}\left(y_n + p\frac{y_e}{1+\tau}\right) = \frac{\lambda_n}{r+\delta+p+s_n}\left[\int_{(1+\tau)\bar{w}}^{y_e^*} \bar{w} - \frac{y_n^*}{1+\tau} dF(y)\right.$$

$$\int_{y_e^*}^{\bar{y}_n} \bar{w} - \frac{y_n^*}{1+\tau} + \frac{p\theta}{(r+\delta+s_e)(1+\theta\tau)}(y - y_e^*)dF(y)$$

$$+ \int_{\bar{y}_n}^{\infty} \frac{\theta}{1+\theta\tau}(y - y_n^*) + \frac{p\theta}{(r+\delta+s_e)(1+\theta\tau)}(y - y_e^*)dF(y) \Bigg]$$

An important feature to note is that both of these equations show that payroll taxes have an interaction with the level of the minimum wages as discussed in Pries and Rogerson (2005). Higher payroll taxes increase the effective minimum productivity level that a worker must possess to be hired under any given minimum wage restriction.

To complete the model, the free entry condition for firms in the inexperienced sector is derived by rewriting equation (5). In the case where $\bar{y}_n < y_e^*$ the equation becomes:

$$k_n = \frac{q_n}{r+\delta+s_n+p} \left[\int_{(1+\tau)\bar{w}}^{\bar{y}_n} \left[y - (1+\tau)\bar{w} \right] dF(y) \right.$$

$$\left. + \int_{\bar{y}_n}^{y_e^*} \left[y - (1+\tau)w_n(y) \right] dF(y) + \int_{y_e^*}^{\infty} \left[y - (1+\tau)w_n(y) + p\frac{y - (1+\tau)w_c(y)}{r+\delta+s_c} \right] dF(y) \right]$$

Alternately, when $y_e^* < \bar{y}_n$ then the equation becomes:

$$k_n = \frac{q_n}{r+\delta+s_n+p} \left[\int_{(1+\tau)\bar{w}}^{y_e^*} \left[y - (1+\tau)\bar{w} \right] dF(y) \right.$$

$$+ \int_{y_e^*}^{\bar{y}_n} \left[y - (1+\tau)\bar{w} + p\frac{y - (1+\tau)w_c(y)}{r+\delta+s_c} \right] dF(y)$$

$$\left. + \int_{\bar{y}_n}^{\infty} \left[y - (1+\tau)w_n(y) + p\frac{y - (1+\tau)w_c(y)}{r+\delta+s_c} \right] dF(y) \right]$$

If worker productivity is $y \in [(1+\tau)\bar{w}, \bar{y}_n]$ the wage paid to the worker is the minimum $\bar{w}$. For values above $\bar{y}_n$ the worker is paid the wage given by unconstrained Nash bargaining. These changes mean that a minimum wage has both a direct effect on which jobs will be available for the worker and an equilibrium effect on the profitability of vacancies in the economy. The probability that any given contact with a firm will result in a job will go down. With these changes the model can be solved for employment dynamics given a specified level of the minimum wage.

4 Calibration

The model is calibrated to match key features of employment and job separation in the United States. A period in the model corresponds to one month. δ determines the rate at which individuals exit the labor force. Assuming that workers stay an average of 40 years, δ is set to $\frac{1}{480}$. The discount rate is set using $r + \delta = 0.003$, which is equivalent to a 4% annual interest rate. Finally, labor market policies of minimum wages and taxes are set to the levels in the United States in the year 2000. Using data from the OECD Minimum Wage database the minimum wage is set to 36% of the median wage. For taxes, the minimum wage is interacted with the level of payroll taxes at the minimum wage level. OECD (2006) reports the payroll tax in the United States at the minimum wage where $\tau = 0.082$ in 2000. Finally, workers enter the model at age 18. They are inexperienced and have an unemployment rate equal to the steady state level of unemployment for inexperienced workers.

The separation rates for experienced and inexperienced workers are calibrated to match those in the US data for individuals at age 18 and 50 respectively. Figure 4 shows separation rates in the US[3]. Separation rates decline dramatically with age. For inexperienced workers, the separation rate is set to $s_n = 0.14$, which is between the level of separations for 18 and 19 year olds in the US. For experienced workers the separation rate is set to $s_e = 0.015$ which is about the average level observed for individuals at age 50.

The rate at which inexperienced employed workers become experienced, p, is set so that the decline in separation rates match the US economy. The rate at which employed workers become experienced is set to $p = \frac{1}{36}$. An employed worker, on average, becomes experienced after working for three years. Higher values of p imply that workers become experienced at a faster rate and hence the employment effects of higher minimum wages have less persistence than for lower values of p. Little difference exists in the magnitudes of employment effects implied by different values of p. The profile of separation rates from simulations of the

[3]This data was constructed by Robert Shimer using CPS monthly microdata from 1976 to 2005. The procedure used follows Shimer (2005) to create a time-series of separation rates for each age. The reported values are the average of this time series. For additional details, please see Shimer (2005) and his webpage http://sites.google.com/site/robertshimer/research/flows.

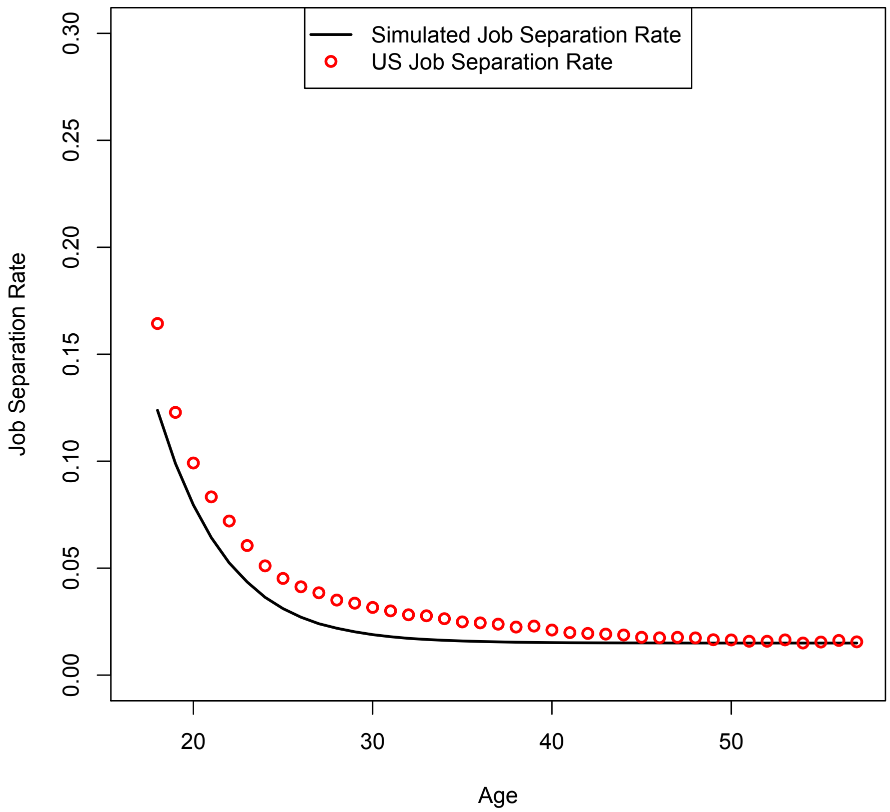

Figure 4: *Job separation rates in the United States by age and separation rates simulated from the model.*

model under this parameterization are plotted against the US data in Figure 4. The profile is similar to that found in the US with a sharp decline in the initial years after entering the labor force and a flat profile later in life.

Matching functions take the standard Cobb-Douglas form, $m_i(u_i, v_i) = u_i^{\eta} v_i^{1-\eta}$ for $i \in \{e, n\}$. η is the same in both value functions. η is set to 0.5. This value is within the range of estimates found in Petrongolo and Pissarides (2001) and is comparable with the calibration found in Pries and Rogerson (2005). The Nash bargaining parameter is $\theta = 0.5$. The choice of $\theta = \eta$ insures that the Hosios (1990) condition applies. This contrasts from Flinn (2006)

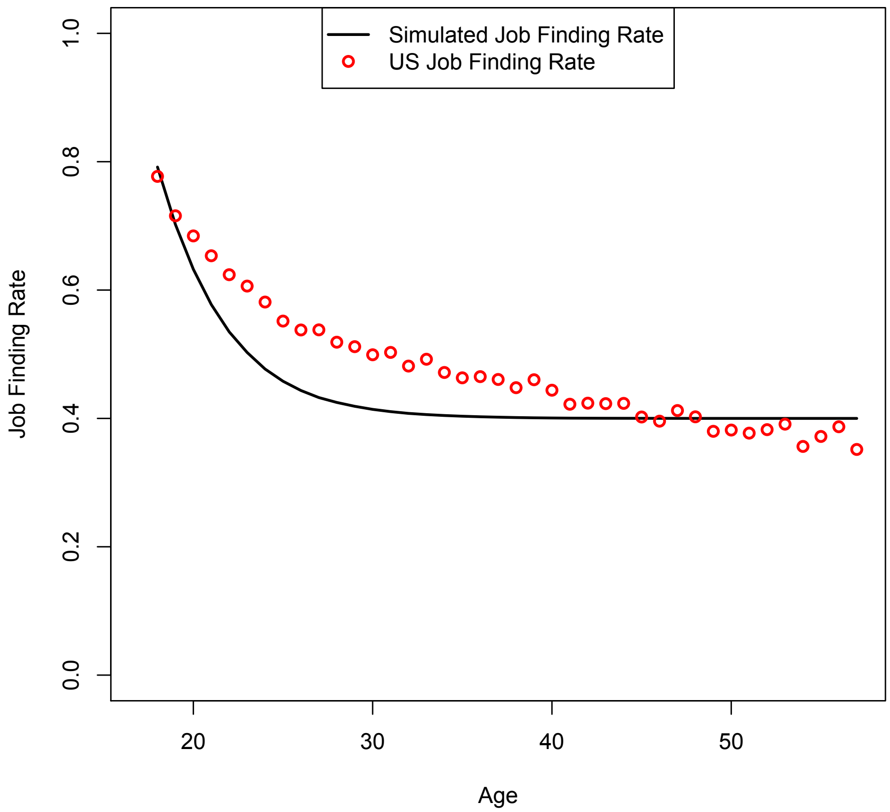

Figure 5: *Average job finding rates in the United States by age and finding rates simulated from the model.*

who varies the Nash-bargaining parameter to generate potential efficiency gains from higher levels of minimum wages.

The productivity distribution is assumed to be log normal ($\log y \sim N(\mu, \sigma^2)$). As a normalization, the median of the productivity distribution is set to one. This implies $\mu = 0$. The value of σ determines the dispersion of productivity and hence wages in the model. For levels of the minimum wage considered, higher values of dispersion imply that the minimum wage has a greater effect. σ and the flow costs for inexperienced and experienced vacancies k_n and k_c are calibrated by targeting values for the job offer rate for inexperienced workers

λ_n and the job finding rates for inexperienced and experienced workers $\lambda_n(1 - F(y_n^*))$ and $\lambda_e(1 - F(y_e^*)$. The targets for λ_n and $\lambda_n(1 - F(y_n^*))$ jointly determine σ and k_n while the target for $\lambda_e(1-F(y_e^*)$ determines k_e. The job finding rates are chosen to match observed job finding rates in the US. $\lambda_n(1-F(y_n^*)) = .85$ matches job finding rates for 17 year old workers and $\lambda_e(1 - F(y_e^*) = .4$ is close to the average for workers between the ages of 45 and 50. Finally, $\lambda_n = .87$. The only restriction is that λ_n must be greater than $\lambda_n(1-F(y_n^*))$. Larger values imply that σ must be larger to push have young workers reject a larger fraction of jobs. These targets yield parameter values of $\sigma = 0.23$, $k_n = 1.76$, and $k_e = 0.001$. Figure 5 plots the average job finding rate by age in the United States and the job finding rate by age simulated from the model. The decline in job finding rates is more rapid in the model as the rate of connections is used to match the decline in separations. However, the magnitude of the decline closely matches the data. Interestingly, these parameters are consistent with a model of training as in Rosen (1972). The flow cost to hiring an experienced worker is nearly zero where the high flow cost in hiring an inexperienced worker can be interpreted as a training cost. These high flow costs drive down the opportunity for inexperienced workers to find employment and get training since they can always quit and bring their skills to a different job. Continuing with this interpretation, conditional on meeting experienced workers are much less likely to be hired as their skills may not match the firm that they meet while inexperienced workers are willing to take almost any job.

A summary of the parameter values chosen is presented in Table 1.

5 Model Predictions

The calibrated model with minimum wage is consistent with many observed patterns of employment by age. This section describes the predictions of the model for job finding rates and effects of the minimum wage on employment. The model provides a theoretical explanation for a variety of empirical findings in the literature.

Parameter	Value	Target
μ	0	Normalization
σ	0.23	$\lambda_n = .87$
δ	1/480	40 year working life
r	0.003-δ	Annual Interest rate of 4%
s_n	0.14	16-Year-Old Separation Rate
s_e	0.015	50-Year-Old Separation Rate
p	1/36	Curvature of Separation Rate by Age
η	0.5	Petrongolo & Pissarides (2001)
θ	0.5	Hosios (1990)
k_n	1.76	$\lambda_n(1 - F(y_n^*)) = .85$
k_e	0.001	$\lambda_e(1 - F(y_e^*) = .4$

Table 1: *Calibrated values of the model parameters.*

5.1 Youth Employment

As an examination of the effects of these parameter choices, the steady state number of individuals in each state $\{u_n, u_e, e_n, e_e\}$ are presented in Table 2. In the model, 5.1% of people are unemployed, which is similar to the aggregate unemployment rate in the US. Also, the table shows that in the stationary distribution of employment outcomes 8.3% of workers are inexperienced.

State	Quantity
u_n	0.014
u_e	0.037
e_n	0.069
e_e	0.880

Table 2: *Steady state results for share of population in each state in the economy.*

The mechanism for high youth unemployment in the model is that inexperienced workers face high separation rates from their jobs and hence are unemployed a higher percentage of time. As workers age they are more likely to be experienced and have stable employment. To see the added effects of this new channel on youth employment outcomes, Figure 6 compares the simulated unemployment rates by age from the calibrated model with simulated

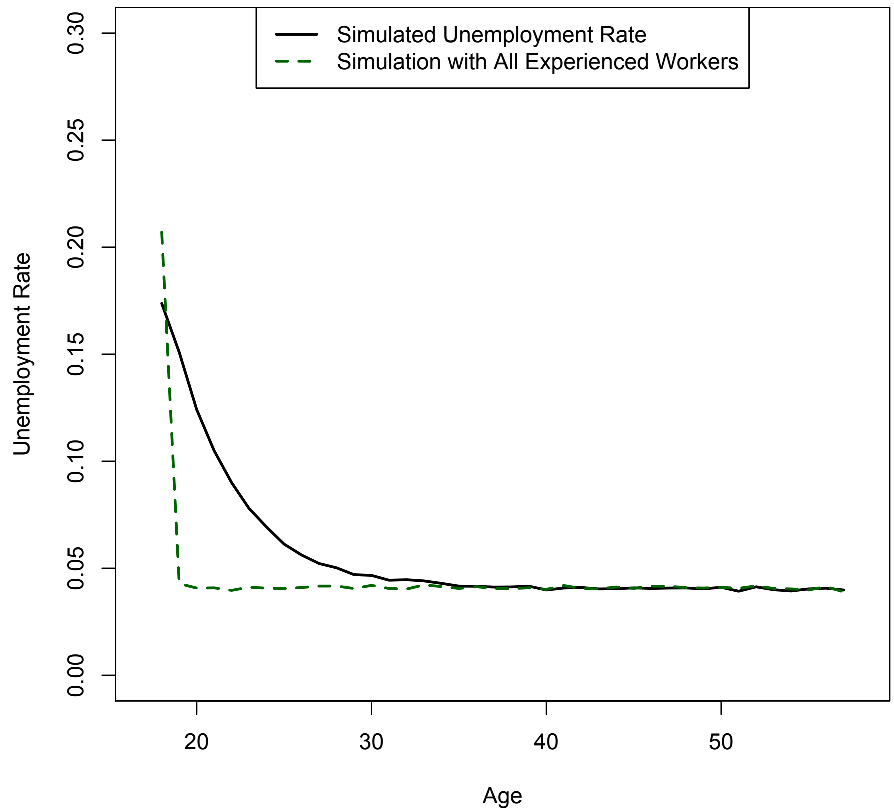

Figure 6: *Average unemployment rates by age from simulated model.*

outcomes from a model where all workers start off unemployed and experienced. The figure show that a model without the experience channel where all workers have to start off unemployed captures an initially high rate of unemployment for entering workers but is unable to propagate the high levels of unemployment as workers reach steady state levels of unemployment within their first to years of work. Including the additional decline in separation rates as workers gain experience provides a mechanism where the model can generate persistently high unemployment observed for young workers.

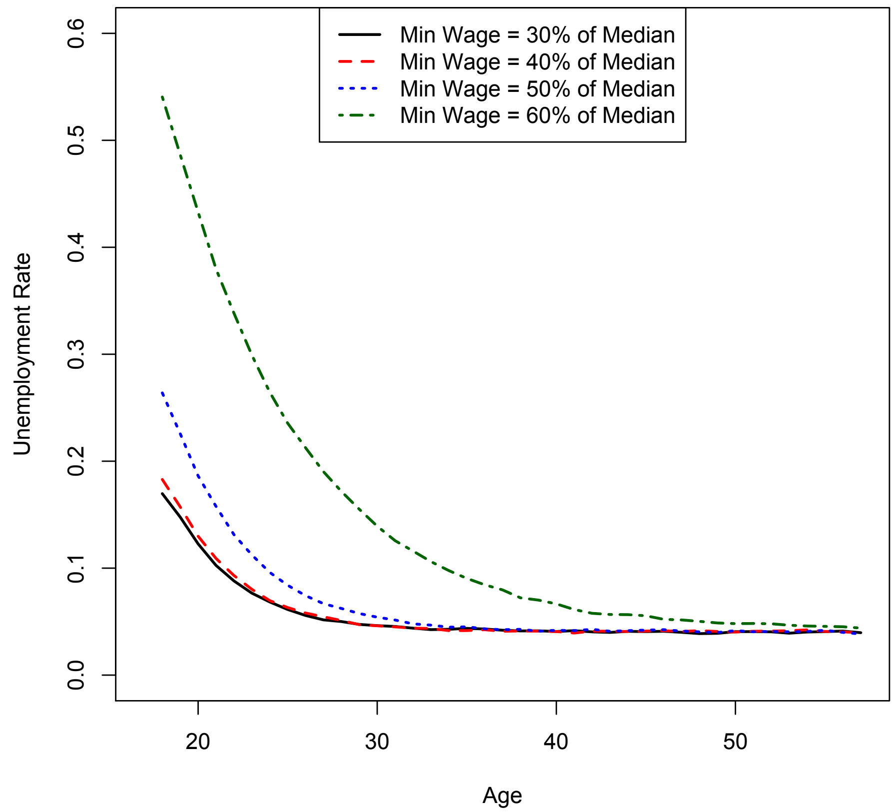

Figure 7: *Average unemployment rate by age in model by minimum wage level.*

5.2 Employment Effects of Minimum Wages

The empirical literature on minimum wages and employment dynamics has looked at direct employment effects and implications for the wage distribution and future earnings of individuals who face high minimum wages. The model is consistent with empirical findings that minimum wages disproportionately harm young workers employment outcomes.

Figure 7 shows the unemployment effects of minimum wages simulated from the model. It shows the average employment to population ratio by age for four different values of the minimum wage. Minimum wages are calibrated as a percentage of the median wage. The figure shows that the effects of minimum wages are non-linear. As minimum wages rise, the unemployment increases among young workers become more dramatic. The solid line depicts the average employment rate in the model with minimum wages at 30% of the median. Raising the minimum wage to 40% of the median has almost no effect on employment outcomes while subsequent increases to 50 and 60% have large effects. Moreover, Figure 7 shows that the effects of a minimum wage are initially large and die out over time as workers gain experience. Higher levels of the minimum wage generate greater persistence as it harder for young workers to find their first job and become experienced.

The model helps explain the failure of some papers to find significant effects of minimum wage on employment such as Card and Krueger's (1994) failure to find any negative effects of the minimum wage on employment in the United States. Since minimum wages are relatively low in the United States and minimum wages have a non-linear effect on employment, it is unsurprising that small changes in the minimum wage might have insignificant effects on employment.

Figure 8 shows how the results of the model vary for different values of τ. The figure shows payroll taxes shift the entire unemployment profile up and down. However, these tax changes do not have large effects on their own. However, it is important to control for the interaction between payroll taxes and minimum wages as higher payroll taxes directly influence the costs paid by a firm that hires a worker at the minimum wage.

5.3 Long-Run Effects

Neumark and Nizalova (2004) document that exposure to high minimum wages at young ages has long-run effects for employment outcomes. They show that exposure to high minimum wages implies that workers both work and earn less even into their late 20's. Moreover, Keane and Wolpin (1997) show that human capital accumulation while on the job is important to understanding worker's labor market decisions and outcomes. Missing skill accumulation early in life has long run implications for wage growth if the agent is unable to make up for the lack of skill accumulation while waiting for employment.

The model can account for differences in wage outcomes as experienced workers have a

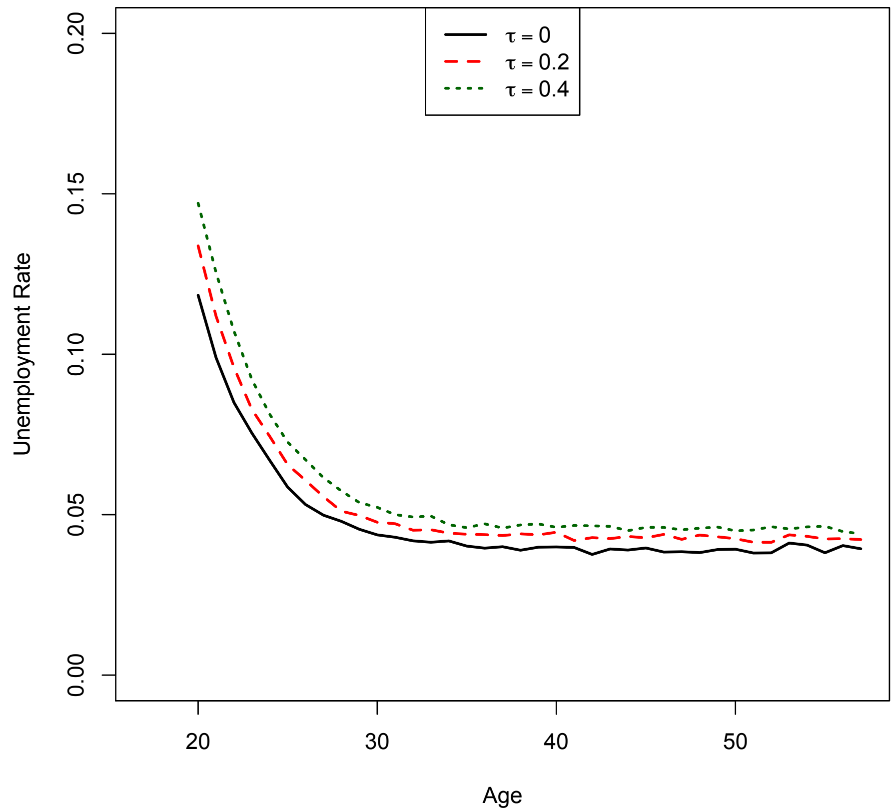

Figure 8: *Average unemployment by age in model for various levels of payroll taxes.*

higher reservation productivity level and earn much higher wages than inexperienced workers. Workers who are exposed to high minimum wages early in life will have a much lower probability of becoming employed and experienced. Figure 9 presents the percentage of people who are experienced by age from the model calibrated with US and French policy parameters. It shows that under a higher minimum wage a worker is less likely to be experienced and that these effects can persist for many years. The lower rate of experience will show up as lower rates of employment and wages later in life.

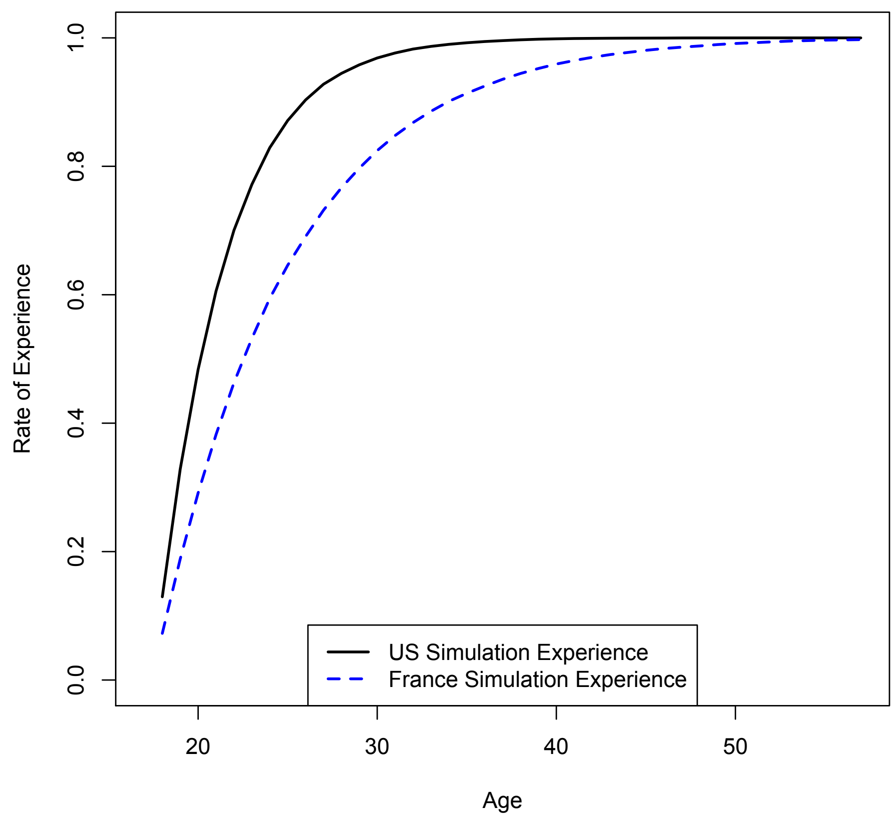

Figure 9: *Percent of population with experience by age for the model simulated with US and French parameters.*

6 Minimum Wage Changes

This section uses the model to evaluate the effects of changes in the minimum wage. First, the model is used to assess the effects of the Fair Minimum Wage Act of 2007 that increased minimum wages from \$5.15 an hour to \$7.25 an hour in the United States between 2007 and 2009. Second, the model will be used to answer the counterfactual question of how much higher unemployment would be in the United States if it adopted the level of minimum wages and payroll taxes in France.

The model can be used to calculate how much of observed differences in youth unemployment outcomes are explained by differences in minimum wages by simulating employment outcomes for each set of policy variables. For each specification the the model is solved to generate job finding rates for inexperienced and experienced workers and the probability that a worker quits when she becomes experienced. These three numbers along with the calibrated separation rates for inexperienced and experienced workers are used to simulate the model in continuous time. From the continuous time simulation, the worker's employment status and experience are recorded at the end of each model period. This corresponds to monthly employment data that can be aggregated into annual statistics and average unemployment rates for various age groups. The simulations are run to record employment outcomes for the first 40 years in each worker's career. For each specification, the model simulated for 50,000 individual outcomes. These data are then aggregated into yearly data by age to be comparable with OECD statistics.

The labor data used in this paper are obtained from the OECD Corporate Data Environment Labor Market Statistics Database. Using the Labor Force Statistics (LFS) by Sex and Age, series of unemployment rates are constructed for males in each age group. The data are broken down into five different age groups: 15-24, 25-34, 35-44, 45-54, and 55-64.

6.1 Fair Minimum Wage Act

The Fair Minimum Wage act of 2007 raised the minimum wage in the United States from \$5.15 an hour to \$7.25 an hour with three equally sized increases in ending in July 2009. Over this time the minimum wage went from 35% to 45% of the median wage. While this large change in the minimum wage could have provided empirical evidence on the effects of minimum wage changes on unemployment, the recession and financial crisis that occurred over the same time period make it difficult to isolate the effects of the minimum wage. Between 2006 and 2009, the male unemployment rate reported by the OECD for workers aged 15-24 went from 11.2 to 20.1% while the overall unemployment rate for workers age 15 to 64 went from 5.1 to 10.5%. During the recession had a disproportionate effect on youth employment outcomes.

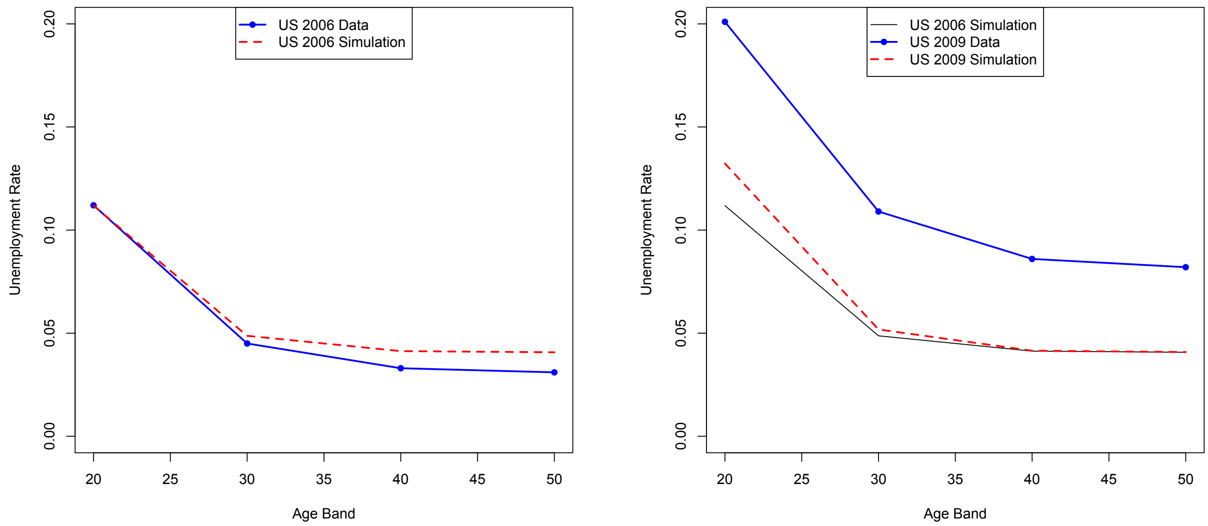

Figure 10: *Simulated results for the US and France compared to the data.*

This section uses the model to compare predicted unemployment for the minimum wage level in 2006 with that in 2009. Using simulated data the model is able to answer the question of how much of the increase in youth unemployment can be attributed to the change in minimum wages. The model predicts that as a result of the minimum wage increase the unemployment rate for 15-24 year old workers should increase from 11.2 to 13.2%. The 2% increase from the model says that the increase in minimum wages accounts for 22.5% of the 8.9% increase in unemployment observed in the US data between 2006 and 2009.

The simulation results are compared with actual unemployment outcomes in Figure 10. The left panel of Figure 10 shows unemployment rates in the US for four age groups compared with predicted unemployment rates from the model with the same minimum wages in 2006. As the economic environment is similar to the calibrated year of 2000, the model prediction is very close to the observed data. The right panel shows the model prediction with the higher minimum wage found in 2009. The model predicts that the increase in minimum wages causes an increase in unemployment among 15-24 year old workers and a slight increase for

25-34 year olds, but almost no effect on older workers.

6.2 France vs. United States

This section quantitatively assesses the impact of changing minimum wage and payroll tax levels to those found in France. Significant attention has been paid to explaining large differences in unemployment between the US and Europe. These observed differences are largest between the US and France while France has the highest levels of minimum wages observed of any European country. Table 3 shows the average unemployment rate by age group of France and the United States in 2000. Unemployment rates in both countries are highest among young workers at 23.8% for France and 11.1% for the US. While both countries show large declines in unemployment rates as workers age, about 8% of prime aged males in France are still unemployed compared with about 3.5% in the US. Measures of minimum wages and payroll taxes for France and the US are presented in Table 4. The table shows the hourly minimum wage in 2006 prices along with the ratio of the minimum wage to the median wage. To calibrate the model, the ratio of the minimum wage to the median is used. to control for differences in wage levels. This can help to account for how binding the minimum wage levels are in each country. Countries that have high productivity and pay high wages can sustain higher absolute levels of the minimum before the minimum wage policy will cut into the distribution of accepted jobs. These large differences make French policies an ideal experiment to evaluate the effects of the minimum wage. This section will use the model to predict what would happen to employment in the US if it adopted French levels of minimum wages and payroll taxes.

Country	15-24	25-34	35-44	45-54	55-64
France	23.8	12.7	9.1	7.8	7.6
US	11.1	4.9	3.9	3.3	3.3

Table 3: *Average unemployment rate by age band in 2000 taken from HP-filtered time series with smoothing parameter of 100.*

Country	Hourly Min Wage	Ratio of Min to Median	Payroll Tax Rate
France	\$8.80	0.60	23%
US	\$6.08	0.36	8.2%

Table 4: *Hourly minimum wages in 2000 in US dollars at 2006 prices, ratio of the minimum wage to the median wage in 2000.*

The model is used to simulate employment outcomes for policy variables corresponding to the US and France in 2000. The left panel of Figure 11 shows the simulated results for the US plotted against the unemployment age bands. It shows that the calibrated model matches the US level of youth unemployment and the transition into prime aged employment levels. The right panel of Figure 11 compares the simulation for France with the US simulation and French Data. France simulation 1 is the model prediction for US unemployment if it adopted the minimum wages and payroll tax rates observed in France. The model predicts that if the US adopted French policies the unemployment rates for workers aged 15-24 would be *even higher* than the rates observed in France. 15-24 year old workers are predicted to have an unemployment rate of about 40% compared to 23.8% in the French data.

The difference in the model's prediction compared with the French data can be broken into two components. First, the model generates a large initial unemployment effect for young workers than observed in the data. Second, the model predicts that as workers age the worker's unemployment outcomes converge to the level found in the US while France has persistently higher unemployment even for younger workers. The first can be thought of as an issue of the size and persistence of minimum wages while the second can be interpreted as a level difference in unemployment between the US and France that is not captured by the model. Explaining these differences helps to understand the model predictions about minimum wages and the causes of high rates of European employment.

The model makes two key assumptions that derive the prediction of high youth unemployment for minimum wages at the French level. First, the separation rates that are used to calibrate the model for the US are held constant in the simulation for France. Since France has much lower average job separation rates than the US, the simulation would not be ex-

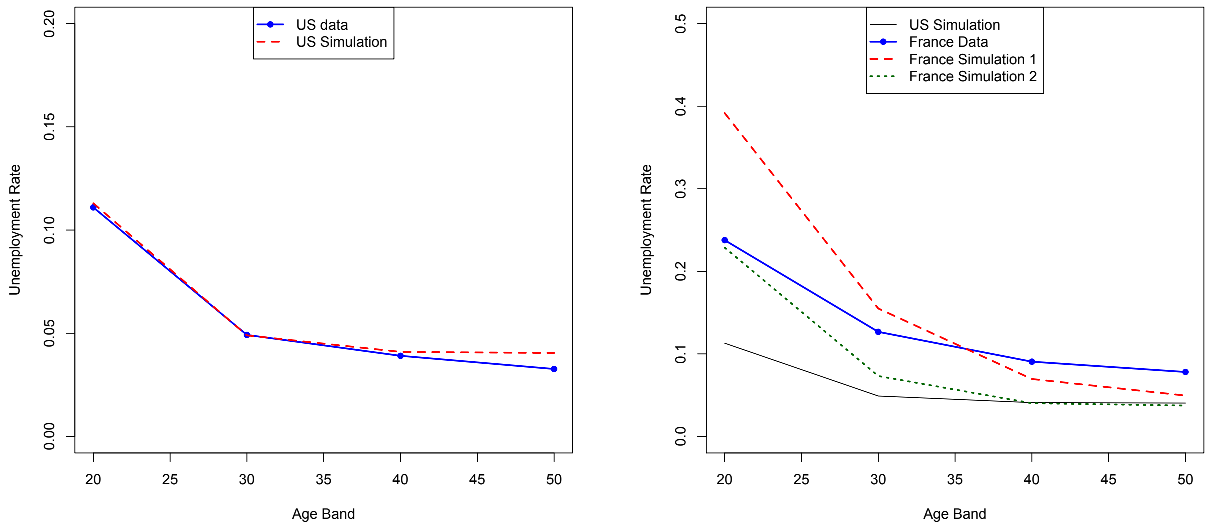

Figure 11: *Simulated results for the US and France compared to the data.*

pected to replicate the employment outcomes for France. Indeed, simulation 2 in the right panel of Figure 11 shows the predicted unemployment rates for the model with $s_n = 0.05$ and $s_e = 0.005$. These values are about one-third the size of the calibrated values for the US. This slightly understates the difference as Elsby et al. (2008) finds an average monthly job separation rate of 3.6% in the US compared with 0.8% in France. With lower levels of job separation rates, simulation 2 shows that youth unemployment rates are much lower[4]. This highlights a key feature of the model that minimum wages interact with job experience to generate employment outcomes. In an environment where inexperienced workers face high turnover they will have more difficulty gaining the experience needed. A related concern is that the rate of separation could be endogenous to changes in the minimum wage. However, in models with endogenous separations such as Jovanovic (1979) and Gorry (2010) minimum wages increase the separation threshold and hence increase job separations for new workers.

[4]The second simulation can also be thought of as a reduced form way of modeling additional firing costs. While this is not the best model to approach such a question as there is no reason for endogenous separations in the model, higher firing costs in the model would influence the outcomes for both experienced and inexperienced workers so should not have a amplification effect on the unemployment of young workers.

Hence, the simulations in this paper should understate potential effects of the minimum wage.

Additionally, for high levels of the minimum wage, the model may overstate the true unemployment effects on minimum wage as workers may respond to low probabilities of finding a job by exiting the labor market. When conditions for finding jobs become poor enough, young workers may find it more advantageous to either quit looking for work or pursue other activities such as continuing education. Indeed, Neumark and Wascher (2003) empirically evaluate the effect of minimum wage in a model with labor force participation and school enrollment decisions and find evidence of workers exiting the labor market as a result of higher minimum wages. Figure 12 plots the labor force participation rates for the US and France in 2000. The figure shows that there are large differences in participation between the US and France in 2000. While minimum wages could potentially explain some of these differences the labor participation decision is beyond the scope of this model.

The second area where both model simulations differ from French data is in employment outcomes for older workers. French workers seem to face a level difference of higher unemployment outcomes at all wages in addition to the disproportionately high levels of youth employment. Here, minimum wages can be a complimentary explanation to other factors that help to explain unemployment differences across countries such as unemployment benefits, taxes, structural change, and firing costs. Ljungqvist and Sargent (1998) show that loss of human capital combined with high levels of human capital can generate long unemployment durations as found in many European countries. Prescott (2004) shows that higher levels of taxes decrease aggregate hours worked while Rogerson (2008) attributes many of the differences to structural changes in employment across sectors. Finally, higher firing costs reduce both the rate of separation and hiring (see for example Pries and Rogerson (2005)). While all of these policies are able go generate level effects on unemployment, this paper contributes to the literature on European employment by showing that minimum wages can be an important factor to generate the larger unemployment differences among young workers.

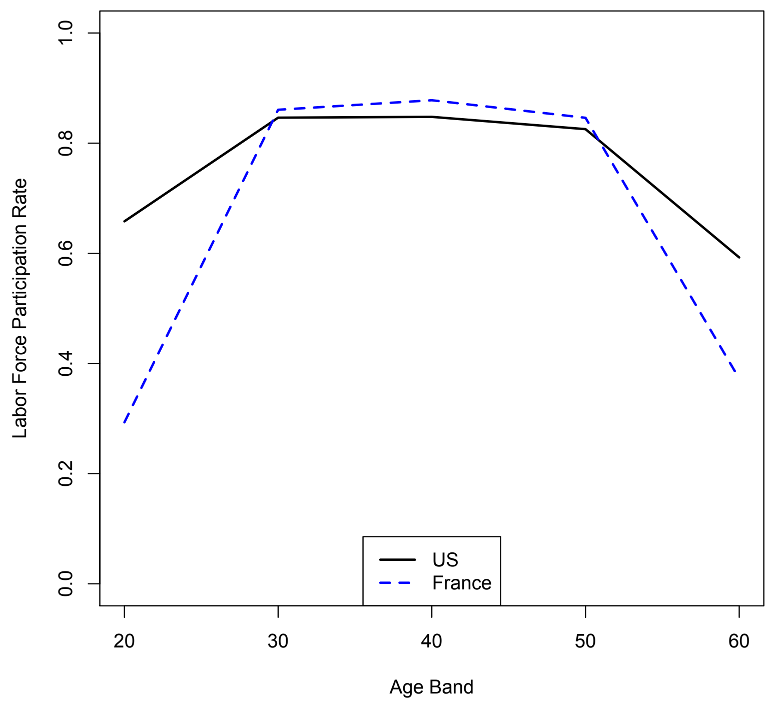

Figure 12: *Average labor force participation rate by age group for the US and France in 2000.*

7 Conclusion

Much of the macro labor literature has focused on representative agent models that abstract from differences in labor market decisions over an individual's life cycle. This paper extends standard search models to feature a worker's experience in the labor market. Experience gives workers a lower rate of job separations. This model allows differences in employment outcomes to be considered by age, since older workers are more likely to be experienced.

Examining the model with minimum wages provides a theoretical foundation for empirical findings on the effects of minimum wages and an ability to evaluate the effects of minimum wages on youth employment outcomes. The model is consistent with many of the empirical findings on the effects of minimum wages. Minimum wages decrease youth employment while having a small effect on prime aged employment outcomes. Also, the model predicts minimum wages to have non-linear effects on employment, which helps explain why empirical studies have found very small effects of minimum wages in the US but greater effects in other countries.

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Appendix

A Proofs

A.1 Proof of Lemma 1

Since being experienced is an absorbing state, equations (4), (8), and (10) along with the free entry condition can be used to solve for $w_e(y)$, U_e, $E_e(y)$, and $J_e(y)$. The reservation property implies that:

$$(r+\delta)U_e = w_e(y_e^*)$$

Imposing free entry, the value function for an entrepreneur matched with an experienced worker becomes:

$$J_e(y) = \frac{y-(1+\tau)w_e(y)}{r+\delta+s_e}$$

$E_e(y)$ is given by:

$$E_e(y) = \frac{w_e(y)+s_e\frac{w_e(y_e^*)}{r+\delta}}{r+\delta+s_e}$$

Finally, plugging these into equation (10) gives:

$$(1+\theta\tau)w_e(y) = \theta y + (1-\theta)w_e(y_e^*)$$

Next, for an inexperienced worker the reservation property implies:

$$w_n(y_n^*) = (r+\delta+p)U_n - p\max\{E_e(y_n^*), U_e\}$$

Solving for U_n gives:

$$U_n = \frac{w_n(y_n^*)+p[U_e+\mathbb{I}_{y_n^*\geq y_e^*}(E_e(y_n^*)-U_e)]}{r+\delta+p}$$

Imposing free entry the value functions for an entrepreneur matched with an inexperienced worker and for an employed inexperienced worker are:

$$J_n(y) = \frac{y-(1+\tau)w_n(y)+p\mathbb{I}_{y\geq y_e^*}J_e(y)}{r+\delta+s_n+p}$$

$$E_n(y) = \frac{w_n(y)+s_nU_n+p\max\{E_e(y),U_e\}}{r+\delta+s_n+p}$$

Substituting into equation (9) gives:

$$(1-\theta)\left[w_n(y)+p\max\{E_e(y),U_e\}-(r+\delta+p)U_n\right] = \theta[y-(1+\tau)w_n(y)+p\mathbb{I}_{y\geq y_e^*}J_e(y)]$$

$$(1+\theta\tau)w_n(y)+p(1-\theta)\left[\max\{E_e(y),U_e\}-U_e-\mathbb{I}_{y_n^*\geq y_e^*}(E_e(y_n^*)-U_e)\right]$$

$$= \theta y + (1-\theta) w_n(y_n^*) + p\theta[\mathbb{I}_{y \geq y_e^*} J_e(y)]$$

Substituting in equation (10) simplifies the equation to:

$$(1+\theta\tau) w_n(y) = \theta y + (1-\theta) w_n(y_n^*) + p(1-\theta)\mathbb{I}_{y_n^* \geq y_e^*}(E_e(y_n^*) - U_e)$$

$$(1+\theta\tau) w_n(y) = \theta y + (1-\theta) w_n(y_n^*) + p(1-\theta)\mathbb{I}_{y_n^* \geq y_e^*} \frac{\frac{\theta}{1+\theta\tau}(y_n^* - y_e^*)}{r+\delta+s_e}$$

A.2 Proof of Proposition 1

Suppose by contradiction that $y_n* > y_e^*$ while $\frac{\lambda_e}{r+\delta+s_e+p} \geq \frac{\lambda_n}{r+\delta+s_n+p}$. Then from lemma (1) we have that $w_n(y) > w_e(y)$ for any $y \geq y_n^*$.

Then the reservation properties for experienced and inexperienced workers give the following equations:

$$(r+\delta)U_e = w_e(y_e^*)$$

$$(r+\delta)U_n = w_n(y_n^*) + pE_e(y_n^*) - pU_n$$

Subtracting the two equations we get:

$$(r+\delta)(U_e - U_n) = w_e(y_e^*) - w_n(y_n^*) - (pE_e(y_n^*) - U_n) < 0$$

Therefore $U_e < U_n$.

Using $w_e(y_e^*) = \frac{y_e^*}{1+\tau}$ and equation (2), the reservation productivity for experienced workers y_e^* solves the following equation:

$$(r+\delta)U_e = \frac{y_e^*}{1+\tau} = \frac{\lambda_e \theta}{r+\delta+s_e} \int_{y_e^*}^{\infty} \frac{y - y_e^*}{1+\theta\tau} dF(y)$$

Now for $y \geq y_n^*$ equation (3) and the reservation property gives:

$$(r+\delta+s_n)(E_n(y) - U_n) = w_n(y) - w_n(y_n^*) + p(E_e(y) - E_n(y)) - p(E_e(y_n^*) - U_n)$$

$$= w_n(y) - w_n(y_n^*) + p(E_e(y) - E_e(y_n^*)) - p(E_n(y) - U_n)$$

Which gives:

$$(r+\delta+s_n+p)(E_n(y) - U_n) = w_n(y) - w_n(y_n^*) + p(E_e(y) - E_e(y_n^*))$$

Then we can use equation (1) to get:

$$(r+\delta)U_n = \lambda_n \int_{y_n^*}^{\infty} E_n(y) - U_n dF(y)$$

$$= \frac{\lambda_n}{r+\delta+s_n+p} \int_{y_n^*}^{\infty} w_n(y) - w_n(y_n^*) + p(E_e(y) - E_e(y_n^*)) dF(y)$$

$$= \frac{\lambda_n}{r+\delta+s_n+p} \int_{y_n^*}^{\infty} w_n(y) - w_n(y_n^*) + \frac{p(w_e(y) - w_e(y_n^*))}{r+\delta+s_e} dF(y)$$

Using the wage equations we have $w_i(y) - w_i(y_n^*) = \frac{\theta(y-y_n^*)}{1+\theta\tau}$ for $i \in \{e, n\}$. Substituting this in gives:

$$(r+\delta)U_n = \frac{\lambda_n}{r+\delta+s_n+p} \frac{r+\delta+s_e+p}{r+\delta+s_e} \int_{y_n^*}^{\infty} \frac{\theta(y-y_n^*)}{1+\theta\tau} dF(y)$$

Given $y_n^* > y_e^*$:

$$(r+\delta)U_n < \frac{\lambda_n}{r+\delta+s_n+p} \frac{r+\delta+s_e+p}{r+\delta+s_e} \int_{y_e^*}^{\infty} \frac{\theta(y-y_e^*)}{1+\theta\tau} dF(y)$$

Finally, $\frac{\lambda_e}{r+\delta+s_e+p} > \frac{\lambda_n}{r+\delta+s_n+p}$ implies $\lambda_e > \frac{\lambda_n(r+\delta+s_e+p)}{r+\delta+s_n+p}$. Therefore,

$$(r+\delta)U_n < \frac{\lambda_e}{r+\delta+s_e} \int_{y_e^*}^{\infty} \frac{\theta(y-y_e^*)}{1+\theta\tau} dF(y) = (r+\delta)U_e$$

A contradiction.