Turbulence and the employment experience of older workers

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This paper provides new interpretations of the effects of rising economic turbulence—an increase in the rate of skill depreciation upon job loss—and its interaction with labor market institutions. We have three main results, based on a life-cycle model with labor market frictions and labor force participation decisions. First, rising economic turbulence during the 1970s and 1980s accounts for the decline in employment among older workers in the United States. Second, the interaction between turbulence and institutions explains most of the reduction in labor force participation among older workers in Europe over this period, but ultimately explains little of the rise in unemployment. Third, only a small share of the increase in unemployment can be attributed to the early retirement policies that were implemented in Europe from the 1970s up until the early 1990s. Our analysis indicates that incorporating an operative labor supply choice can pose serious challenges to theories aiming to explain the European unemployment problem.

Keywords. Job search, job loss, turbulence, European unemployment, labor force participation.

JEL classification. E24, J21, J64.

1. Introduction

The outbreak and persistence of high European unemployment since the 1970s compared with the dynamism of the U.S. labor market has sparked a large body of research over the past few decades. In his appraisal of this literature, Blanchard (2006) reached mixed conclusions about the results obtained so far. On the positive side, there are convergent findings pointing to the interaction between shocks and labor market institutions as a key explanation of the transatlantic employment gap. Meanwhile, on the negative side, data accumulated over time highlight the heterogeneity of situations and of trajectories across workers. This poses a challenge to virtually any explanation of the U.S.–Europe employment gap, that it should be simultaneously consistent with the heterogeneous employment patterns found in disaggregated data. The recent literature emphasizes the life cycle as one such major source of heterogeneity (Ljungqvist and Sargent

(2008), Chéron, Hairault, and Langot (2009), Prescott, Rogerson, and Wallenius (2009), and Kitao, Ljungqvist, and Sargent (2017)). A related issue, which has received little attention to date, is that the contributions of unemployment and labor force participation to employment differences change over the life cycle. Hence, in addition to having the correct life-cycle implications for the identities of the nonemployed, a proper account of transatlantic employment experiences should also be consistent with the role played by those different margins of nonemployment.

This paper takes a step in this direction, providing an analysis of the employment experience of older workers on both sides of the Atlantic. We develop a life-cycle model with a frictional labor market and an operative labor supply margin, wherein shocks interact with institutions in ways that deteriorate employment. We use the model to offer new interpretations of the employment effects of shocks and institutions, and the interactions between the two. First, we account for secular changes in the U.S. employment rate of male workers. Usually these changes are overshadowed by the attention to the unemployment rate, which has remained stable in the U.S. in the long run.[1] Second, we study the decline in European employment rates, and in doing so we clarify whether shocks and institutions explain the upward trend in unemployment, the downward trend in labor force participation, or a combination of the two. Third, we draw attention to one specific labor market institution that has changed over time, namely programs aimed at fostering early retirement.[2] These programs have been used in Europe to reduce labor force participation before normal retirement age, often with a "lump-of-labor" view of the relationship between older worker employment and unemployment among younger workers. The model enables us to quantify the implications of this relationship.

Key facts of interest for the paper are depicted in Figure 1. The solid line shows the employment rate of older male workers in the three largest countries in continental Europe (France, Germany, Italy) and the U.S.[3] The dashed line shows an alternative employment rate, which has been calculated by holding the unemployment rate of older workers constant. As can be seen, employment among older workers has fallen secularly, and this decline is predominantly explained by labor force participation, that is, the dashed line closely tracks the solid line. The other salient fact in Figure 1 is that the dynamics of older worker employment are qualitatively similar in the U.S. and Europe and differ only quantitatively. We complement these facts in three ways in Section 2. First, within each country these changes have a sizable impact on the aggregate employment rate. Second, across countries labor force participation accounts for a large fraction of

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[1]This holds for the unemployment rate of men as well as for the unemployment rate of both men and women. Another reason why changes in the employment rate of U.S. men tend to be overlooked is that the aggregate employment-to-population ratio has remained stable as a consequence of the increase in female employment. In this paper, we focus on understanding the specific dynamics of male employment. We think the secular employment experience of women deserves a study in its own right, given the stark contrast with the employment experience of men.

[2]We provide an overview of the main trends in early retirement policies in Section 6 of the paper.

[3]The facts shown in Figure 1 hold true for a larger set of European countries. We present similar time series for Spain, Portugal, Norway, and Sweden and can be found on the journal website: http://qeconomics.org/supp/557/supplement.pdf.
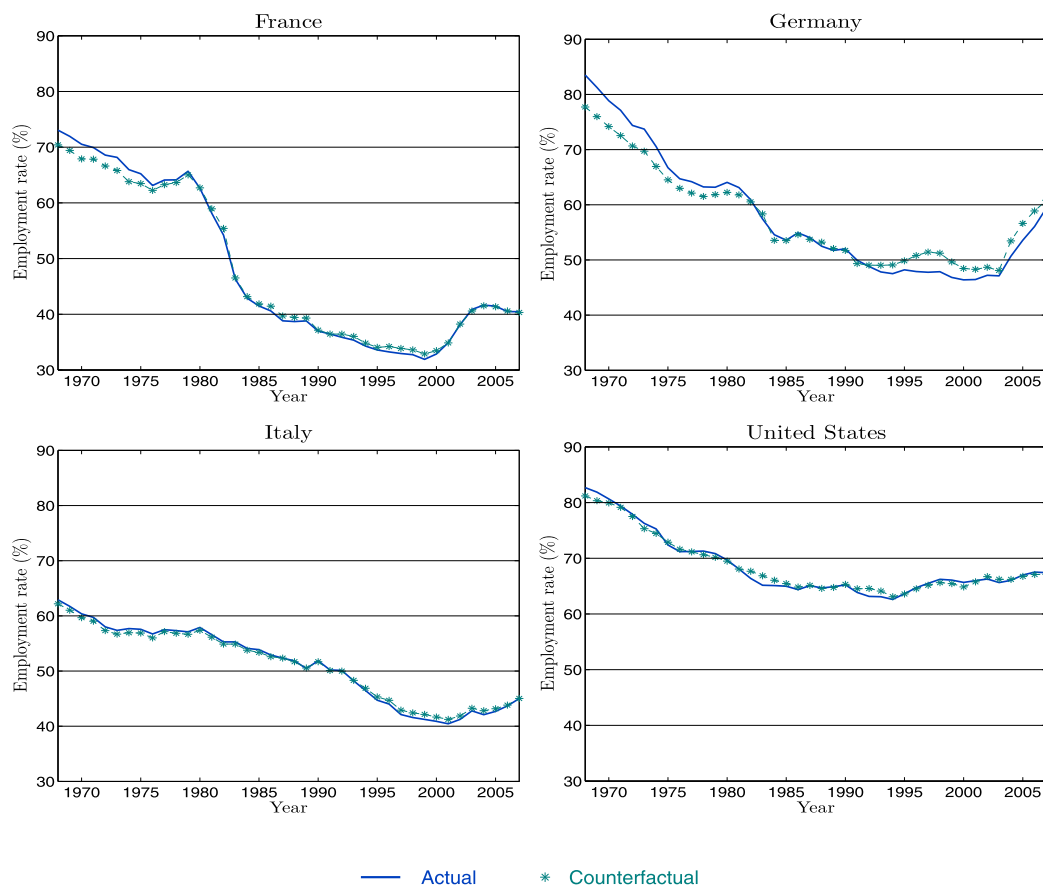
FIGURE 1. Actual and counterfactual employment rates of older male workers. *Notes*: Data from the OECD labor force database for male workers aged 55 to 64; Germany refers to West Germany prior to 1991; see Appendix A.1 for details. In each plot, the solid line is the actual employment rate while the dotted line shows the counterfactual series that holds the unemployment rate fixed to its mean value over the sample period.

the differences in aggregate male employment. Third, the separation between the two nonemployment margins matters because the odds of regaining employment from unemployment rather than from nonparticipation are much higher at older ages.

We draw on various sources to construct a model that relates to the trends shown in Figure 1. The first one of those is the notion of economic turbulence proposed by Ljungqvist and Sargent (1998, 2008). Rising economic turbulence refers to an increase in the rate of skill depreciation upon job loss. This phenomenon captures the microeconomic effects of changes in the macro-environment, such as restructuring from manufacturing to the service industry or new information technologies. Thus it can aptly describe the type of shocks that have the potential to shift the steady-state equilibrium of the labor market. Next, as in the canonical framework of Mortensen and Pissarides (1994) our model features match productivity shocks that generate job destruction. Job creation is also endogenous. There is a single matching function, and hence

firms cannot direct their vacancies toward specific groups of workers, such as, for example, younger workers. But the probability of being hired is not uniform across workers; it varies strongly with their individual characteristics, namely age, human capital, and welfare benefits. Last, the model embodies idiosyncratic, autocorrelated shocks to the value of being out of the labor force. Garibaldi and Wasmer (2005) used a similar assumption to generate endogenous movements in labor force participation, albeit in a much simpler setting. To our knowledge, the model we propose is the first to depart from a two-state abstraction (employment/nonemployment) to discuss the effects of the interaction between shocks and institutions.

The analysis proceeds with a series of numerical experiments based on two calibrated models. Following Ljungqvist and Sargent (1998, 2008), we study the U.S. employment experience through the lens of a laissez-faire economy. We use this economy to *measure* changes in the degree of economic turbulence, by matching the 1970s–1980s increase in U.S. earnings instability highlighted by Gottschalk and Moffitt (1994, 2009). We also use a welfare state economy to describe labor markets in Europe, focusing on changes in policies that provided incentives toward early retirement before the 1990s. Most parameters (e.g., preferences, human capital) are common across the laissez-faire and welfare state economies, and are informed by the behavior of the U.S. labor market at the onset of the 1970s. Two idiosyncratic technology parameters (in addition to the welfare-state policy parameters) capture U.S.–Europe differences in unemployment and labor force participation in the initial steady state. The crux of our analysis is the evolution of equilibrium allocations in the U.S. and Europe, respectively, as we move away from the 1970s up until the 1990s.

The first set of experiments analyzes the effects of the measured change in economic turbulence. We find that this process explains the decline in employment among older workers in the U.S., as it accounts quantitatively for the long-run reduction of their labor force participation. Over this period, we also find that rising economic turbulence explains the European decrease of a twice larger magnitude in labor force participation among older workers. The interaction between shocks and institutions *per se* accounts for about half of this effect.[4] Last, rising economic turbulence explains little of the increase in unemployment that coincided with the aforementioned changes in Europe.

The main economic forces driving these results are as follows. First, workers whose skills depreciate upon job loss have poorer employment prospects. In a laissez-faire economy with only employment and unemployment states, these workers would "bite the bullet" and return to employment at lower wages (Ljungqvist and Sargent (1998, 2008)). The additional option of moving to nonparticipation mitigates this effect in our model, and thereby explains the evolution of *employment* in the U.S. Welfare benefits and stringent employment protection amplify the employability problem of workers

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[4]If we remove the difference in technology parameters between the two economies, we find that the decrease in labor force participation in the laissez-faire economy is almost 50 percent higher than under the baseline. The remaining gap is explained by the interaction between shocks and the labor market policies of the welfare state economy.

whose skills depreciate in Europe. They become detached from the labor market and drop into *nonparticipation* instead of staying in the unemployment pool. Second, older workers are over-represented among workers moving to nonparticipation. Skill depreciation falls more heavily on older workers because they have accumulated more human capital. But a perhaps more fundamental reason is the "horizon effect" analyzed by Chéron, Hairault, and Langot (2009, 2013). From an employer's perspective, the returns to hiring a worker close to retirement are lower because of the expected shorter duration of the match. From a worker's perspective, the returns to staying in the labor force are lower because of the expected shorter duration of job search. These forces coalesce to make older workers choose nonparticipation over the other labor market states.

The second set of experiments considers shifts in early retirement policies as an additional source of employment changes over time.[5] Our welfare-state economy is actually too stylized to model explicitly the numerous policies that provide exit routes to retirement.[6] Meanwhile, the model allows us to explore several polar cases to get a quantitative sense of the nature and magnitude of the effects of those policies. We find, first of all, that the policies considered have a perverse impact on aggregate employment. While leading to an almost one-for-one substitution between nonparticipation and unemployment among older workers, they contribute to unemployment at younger ages. This speaks strongly against the once popular idea that early retirement could be helpful to "make room for the young."[7] Second, in quantitative terms early retirement policies generate little additional unemployment. In particular, although the implementation of these policies coincided with the 1970s–1980s increase in turbulence and continued at least until the early 1990s, this trend cannot reconcile our welfare state economy with the outbreak of high European unemployment.

As noted in the opening sentence, there is a vast literature on employment differences between the U.S. and Europe.[8] Within this body of research our study is more

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[5]Much of the literature considers the interaction between time-varying shocks and time-invariant institutions; see Blanchard and Wolfers (2000). This view is not undisputed, however. Nickell, Nunziata, and Ochel (2005) pointed out that some institutions have evolved in response to shocks in ways that sometimes aggravated the initial impact of the shocks. Early retirement policies seem to fit this description well: in addition to reducing unemployment numbers directly, several reforms were enacted with the objective of releasing jobs for the young in the new era of high unemployment (Ben Salem, Blanchet, Bozio, and Roger 2010).

[6]Consider for instance early retirement benefits and disability insurance benefits—two oft-cited examples of policies toward early retirement. To correctly analyze the effects of financial incentives, we would need a model where agents have a finite intertemporal elasticity of substitution and have access to savings. And to study disability insurance benefits, we would need a model that includes medical expenditures, health status, and health shocks.

[7]Over time, this idea has clearly (albeit slowly) lost ground. Starting in the early 1990s, new reforms were enacted in Europe in an attempt to reverse the trend and increase labor force participation at older ages; see Section 6. Running parallel to this trend, the idea that the efficient policy response is to raise the retirement age has gradually gained support. Hairault (2010) demonstrated this point both empirically and through the lens of a quantitative model.

[8]See, among others, Bertola and Ichino (1995), Marimon and Zilibotti (1999), Mortensen and Pissarides (1999), den Haan, Haefke, and Ramey (2005), Hornstein, Krusell, and Violante (2007), and the contributions by Ljungqvist and Sargent referenced in the paper.

directly related to Ljungqvist and Sargent (2008), Chéron, Hairault, and Langot (2009), and Kitao, Ljungqvist, and Sargent (2017). These papers analyze the age structure of the U.S.–Europe employment-nonemployment gap through the lenses of heterogeneous-agent life-cycle models. We add to this research by explicitly separating unemployment from nonparticipation. We analyze these margins empirically, and then within a quantitative model with endogenous worker transitions between the three labor market states (employment, unemployment, nonparticipation). We set up this model in general equilibrium for two reasons. First, this simplifies the calibration process because more variables are determined endogenously. For instance, wages (and hence the effects of skills on earnings) are endogenous to the model. Second, we use this framework to study the aggregate effects of policies that interact with labor force participation choices. While these policies are targeted at older workers, the effects may spill over on workers in other age groups.

This paper contributes more broadly to research that aims at developing macro-models with labor market frictions and a labor force participation margin. Some examples of this strand of literature include Garibaldi and Wasmer (2005), Pries and Rogerson (2009), Shimer (2013), Krusell, Mukoyama, Rogerson, and Şahin (2011, 2017), and Mankart and Oikonomou (2017). In contrast to these papers, we propose a model with many layers of worker heterogeneity (welfare benefits, skills, taste for leisure, age) so as to study the relationship between economic turbulence and labor market institutions. Our model yields a rich set of implications regarding the relationship between observable characteristics (either aggregate or individual) and worker flows across employment, unemployment, and nonparticipation. Thus, it offers a relevant theoretical framework to analyze why these worker flows are so different across countries (Elsby, Hobijn, and Şahin (2013)), and why they are so volatile over the life cycle (Choi, Janiak, and Villena-Roldán (2015)).

The rest of the paper is organized as follows. Section 2 documents the empirical facts of interest for the paper. Section 3 presents the model economy used to interpret these facts. We calibrate the model in Section 4 and discuss important model-generated outcomes in Section 5. The main results are presented in Section 6: it contains two sets of numerical experiments that study the effects of rising economic turbulence and of the changes in early retirement policies. Section 7 concludes.

2. Some facts

The main facts on U.S.–Europe unemployment differences are well known and thoroughly documented in the literature. In a nutshell, while unemployment in the U.S. has been stable over the past decades, it increased in Europe at the end of the 1970s and has remained persistently high since then as a result of low job-finding rates (Layard, Nickell, and Jackman (2005), Machin and Manning (1999), Blanchard (2006), Rogerson and Shimer (2011)). The goal of this section is to present several additional facts that have, until now, been overshadowed somewhat by the emphasis on studying the unemployment rate. These facts relate to the behavior of labor force participation during the working life cycle and its contribution to aggregate employment differences over time and across countries.

Trends and age heterogeneity

Long-run changes in employment are not uniformly spread across age groups. Instead, they are concentrated both on younger (aged 15 to 24) and older (aged 55 to 64) workers. In particular, in recent decades the aggregate employment rates of male workers in the U.S. and Europe have been dragged down by the decline of employment among older workers.

To make this observation precise, we begin with a simple identity. We let $e_{a,t}^i$, $u_{a,t}^i$, and $p_{a,t}^i$ denote respectively the employment, unemployment, and labor force participation rates of workers of age a in country i at time t. Also, we denote by $\omega_{a,t}^i$ the population share of these workers. The aggregate employment rate, e_t^i, is the following weighted average:

$$e_t^i = \sum_a \omega_{a,t}^i e_{a,t}^i \left(= \sum_a \omega_{a,t}^i (1 - u_{a,t}^i) p_{a,t}^i \right). \tag{1}$$

The first two columns in Table 1 show that the employment rate of older workers is slightly below the aggregate rate in most countries. The second set of columns reports that both rates have decreased since the late 1960s or early 1970s. Aggregate male employment has fallen by 16.4 pp. on average across European countries and by 8.85 per-

TABLE 1. Changes in male employment rates in the U.S. and Europe.

	$e_{t_0}^i$		$e_{t_1}^i - e_{t_0}^i$		
	All	Older	All	Older	$\omega_{a,t_0}^i \dfrac{e_{a,t_0}^i}{e_{t_0}^i}$
France	85.7	73.0	−19.1	−38.8	15.2
				33.5	
Germany	91.6	83.5	−21.2	−36.4	17.5
				33.0	
Italy	82.8	62.9	−16.0	−20.8	14.0
				23.0	
Norway	81.0	83.0	−5.16	−13.7	18.3
				40.6	
Portugal	88.8	81.7	−18.4	−22.6	14.1
				19.9	
Spain	87.2	82.7	−24.0	−33.7	14.9
				21.9	
Sweden	86.0	86.7	−13.7	−22.2	18.7
				27.0	
United States	85.3	82.7	−8.85	−17.5	15.0
				29.4	

Note: Data from the OECD labor force statistics database for male workers; Germany refers to West Germany prior to 1991; see Appendix A.1 for details. $e_{t_0}^i$ (resp. $e_{t_1}^i$) denotes the employment rate at the beginning (resp. end) of the sample period for workers in all age groups (column "All") and for older workers (column "Older") country i. $\omega_{a,t_0}^i \dfrac{e_{a,t_0}^i}{e_{t_0}^i}$ is the beginning-of-period employment share of older workers in country i. The numbers in boldface give the contribution of changes in employment among older workers to changes in aggregate employment. All entries are expressed in percentage points.

centage points in the U.S. As can be seen, the decline has been much larger for older workers: it is about twice the aggregate decrease in several countries, including the U.S. The numbers in boldface give the contribution of those changes to the fall in aggregate employment.[9] On average in Europe, the decrease of older worker employment explains 35.2 percent of the decrease in aggregate employment. The corresponding figure for the U.S. is 29.4 percent. These numbers are substantial because the share of older workers in aggregate employment at the beginning of the sample period (last column in Table 1) is only 18.2 percent in Europe and 15.0 percent in the U.S. In other words, the fall in aggregate employment is disproportionately concentrated on older workers.

Causes of low employment

Lower employment can be caused by higher unemployment, lower labor force participation, or a combination of the two. The counterfactual series in Figure 1 illustrate that, in what concerns employment among older workers, labor force participation plays a predominant role in these dynamics in each country.[10] Here, we add two important observations. First, labor force participation accounts for a substantial part of cross-country differences in aggregate employment. Second, participation among older workers contributes a large share of those cross-country differences.

Consider, again, equation (1) and denote by $\triangle e_t^i$ the difference in aggregate employment between country i and some baseline country j adjusted for demographic differences (using $\varpi_{a,t} \equiv \frac{\omega_{a,t}^i + \omega_{a,t}^j}{2}$). $\triangle e_t^i$ can be decomposed into differences coming from, respectively, unemployment ($\triangle u_t^i$) and labor force participation ($\triangle p_t^i$). That is,

$$
\underbrace{\sum_a (e_{a,t}^j - e_{a,t}^i)\varpi_{a,t}}_{\triangle e_t^i} = \underbrace{\sum_a (u_{a,t}^i - u_{a,t}^j)\frac{p_{a,t}^i + p_{a,t}^j}{2}\varpi_{a,t}}_{\triangle u_t^i}
$$
$$
+ \underbrace{\sum_a (p_{a,t}^j - p_{a,t}^i)\frac{1 - u_{a,t}^i + 1 - u_{a,t}^j}{2}\varpi_{a,t}}_{\triangle p_t^i}.
$$

(2)

Further, we can measure the contribution of each age group a through each of the two nonemployment margins.[11] These contributions are reported in boldface in Table 2,

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[9]Following equation (1), the contribution of age group a is the ratio between $\frac{\omega_{a,t_0}^i + \omega_{a,t_1}^i}{2}(e_{a,t_1}^i - e_{a,t_0}^i)$ and $e_{t_1}^i - e_{t_0}^i$.

[10]To verify this observation, consider decomposing the variations of employment within age group a using: $\mathbb{V}\mathrm{ar}(\log(e_{a,t}^i)) = \mathbb{C}\mathrm{ov}(\log(e_{a,t}^i), \log(1 - u_{a,t}^i)) + \mathbb{C}\mathrm{ov}(\log(e_{a,t}^i), \log(p_{a,t}^i))$. For older workers, the variance contribution of labor force participation is typically between 80 and 95 percent, whereas for prime-age workers there is a more even split between unemployment and labor force participation.

[11]For instance, the numbers reported in boldface in the rightmost column of Table 2 are given by the ratio between $(p_{55-64,t}^j - p_{55-64,t}^i)\frac{1 - u_{55-64,t}^i + 1 - u_{55-64,t}^j}{2}\varpi_{55-64,t}$ and $\triangle e_t^i$.

TABLE 2. Decomposition of differences in male employment between the U.S. and Europe.

	$\triangle e_t^i$	$\triangle u_t^i$		$\triangle p_t^i$	
		All	Older	All	Older
France	10.1	3.60	0.24	6.50	3.96
		33.9	**2.25**	**66.1**	**41.1**
Germany	6.05	3.22	0.86	2.83	2.02
		52.5	**14.2**	**47.5**	**33.6**
Italy	10.3	2.70	0.06	7.55	3.52
		25.1	**0.52**	**74.9**	**35.6**

Note: Data from the OECD labour force statistics database for male workers; see Appendix A.1 for details. $\triangle e_t^i$ denotes the demographic-adjusted differences in aggregate employment between country i and the U.S. $\triangle u_t^i$ and $\triangle p_t^i$ denote differences deriving from unemployment and labor force participation, respectively. The numbers in boldface give their relative contribution to the employment gap $\triangle e_t^i$. The column "All" aggregates over all age groups while the column "Older" refers to older workers. All entries are expressed in percentage points.

which compares the "big three" European countries to the U.S. at the end of the sample period.

The main points are well illustrated by the difference in employment between France and the U.S. The aggregate employment rate in France is lower by 10.1 pp. Unemployment per se leads to a difference in aggregate employment of 3.60 pp., while the corresponding figure for labor force participation is 6.50 pp. Thus, the latter explains two-thirds of the employment gap between France and the U.S. What is more, there is a 3.96 pp. difference in aggregate employment driven by lower labor force participation among older workers. This is higher than the contribution of unemployment aggregated across all age groups, and it explains more than 40 percent of the cross-country difference in employment. The effect of labor force participation among older workers on aggregate employment differences is somewhat smaller, but is still large in Germany and Italy.

Unemployment versus nonparticipation

Beyond the accounting exercise, why does it matter if nonemployed individuals are unemployed or out of the labor force? In our view, the main answer derives from the idea that unemployment and nonparticipation are "behaviorally distinct labor force states," in the words of Flinn and Heckman (1983). Conducting an in-depth investigation of this issue is beyond the scope of our analysis, but we can provide observations that dovetail with this idea. To this end, we use labor force survey micro-data for France, Germany, Italy, and the U.S., and estimate a set of transition probabilities using the protocol described in Appendix A.2. We document in Figure 2 that the odds of moving to employment from unemployment rather than from nonparticipation are greater than one, and that they increase steeply with age. Toward the end of the working life, the odds are about four times higher than at age 20, which indicates a stronger relationship between remaining out of employment and nonparticipation at older ages.
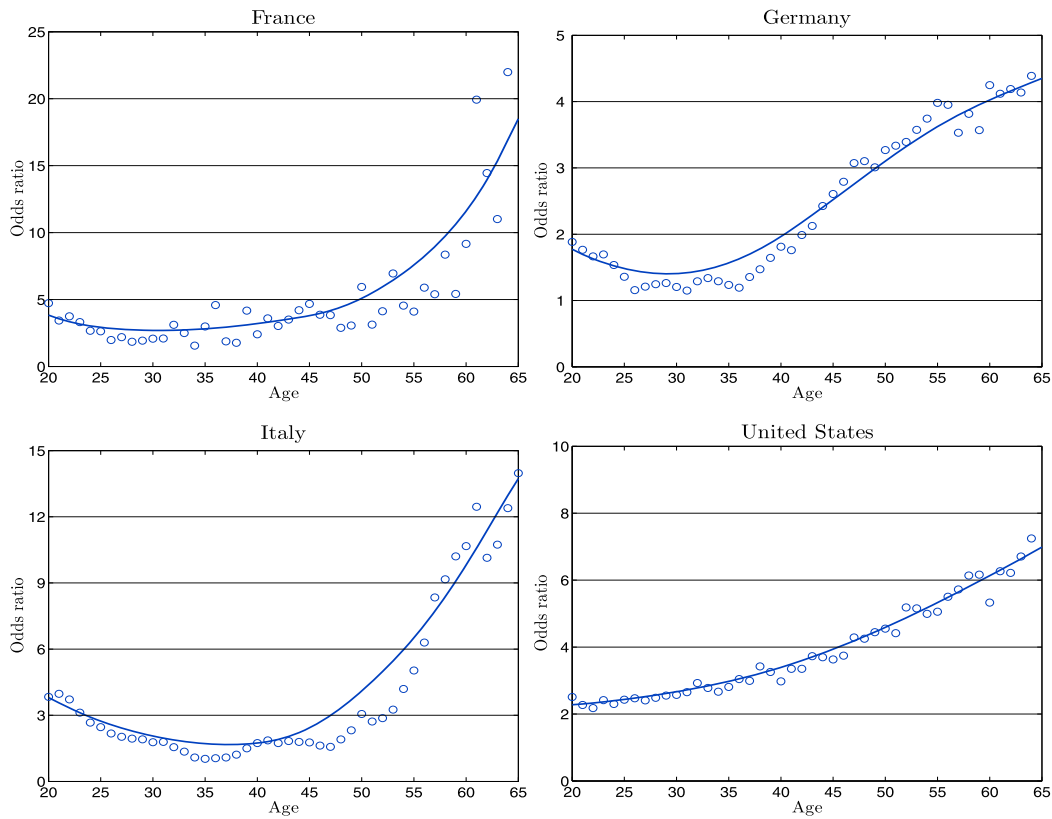
FIGURE 2. Odds ratio of moving to employment from unemployment relative to nonparticipation. *Notes*: Data from the French LFS (France), the GSOEP (Germany), the EU-SILC (Italy), and the CPS (U.S.) for male workers; see Appendix A.2 for details. In each plot, the dots show the ratio between $q_a^{UE}/1 - q_a^{UE}$ and $q_a^{NE}/1 - q_a^{NE}$, where q_a^{UE} (resp. q_a^{NE}) is the life-cycle profile of transition probabilities from unemployment to employment (resp. from nonparticipation to employment).

The model that we develop in the next section can replicate the patterns shown in Figure 2. More crucially, it provides a certain level of structure regarding the differences between unemployment and nonparticipation, and is thus capable of offering a theory explaining these patterns. In the model, workers move into employment from either unemployment or nonparticipation, but they do so less quickly from the latter. One can think, for instance, of different job search behaviors captured by the categories of "unemployment" and "nonparticipation" (e.g., Jones and Riddell (1999, 2006)). Workers self-select themselves into the labor force and choose unemployment over nonparticipation when they have a high probability of being hired conditional on meeting an employer. This selection process increases with age in a manner consistent with Figure 2. There is, in addition, an element of history dependence, which makes the difference between unemployment and nonparticipation even more important. When agents in the model remain out of work, their skills deteriorate and further reduce their employ-

ability. Thus, a nonparticipant faces a higher probability of returning to employment with a lower skill level compared to an otherwise similar unemployed worker. In sum, this formalizes the idea that low labor force participation can be a *cause* of low employment.

3. The model

This section presents the model that we propose in order to analyze the dynamics of unemployment and labor force participation. The model is an extension of the rich McCall (1970) job-search economy developed by Ljungqvist and Sargent (2008). We cast this economy in a general equilibrium setup with endogenous job creation, wage bargaining, and job separations, à la Mortensen and Pissarides (1994). We introduce an idiosyncratic component in workers' valuation of leisure. This component evolves stochastically over time and generates voluntary worker movements in and out of the labor force. To improve the model fit, later on we consider an additional process leading to exogenous transitions out of the labor force. For expositional purposes, we defer this feature to the calibration section of the paper.

3.1 *Economic environment*

Demographics and preferences   One side of the market is populated by a continuum of workers, each of whom belongs to a given age class $a_t \in \{0, \ldots, A\}$. Workers age stochastically and the transition probability from age class a to age class a' is denoted by $\alpha(a, a')$. Aging occurs sequentially: $\alpha(a, a') = 0$ if $a' \neq a + 1$, and workers survive until retirement: $\alpha(a, a) + \alpha(a, a + 1) = 1$ for all $a \in \{0, \ldots, A - 1\}$. Generations overlap and entries equal exits, so that the population measure remains at a constant unit level. Thus, the number of workers entering the economy each period is equal to the share $1 - \alpha(A, A)$ of the number of workers in age class A who retire.

Workers have their momentary utility function defined over consumption and leisure. Consumption c_t equals disposable income in period t. Leisure has several components. The first one is an indicator ℓ_t taking the value of 1 if the individual is out of the labor force and 0 otherwise. Second, there is a stochastic utility component denoted by z_t, which evolves according to a first-order Markov process with transition function $F(z'|z)$, i.e. $F(z'|z) = \Pr\{z_{t+1} < z'|z_t = z\}$. Third and finally, the utility derived from leisure depends on the age of the worker, a_t. There are many possible specifications, and we assume (a nontrivial assumption) that ℓ_t, z_t, a_t enter the valuation of leisure multiplicatively. The goal of this specification is to capture the increase in nonparticipation with age that we observe in the data.[12] Letting β denote the subjective discount factor, work-

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[12]Conditional on z_t the period-utility derived from leisure increases with a_t. Notice that while we describe the bundle $z_t a_t$ as a source of variations in leisure utility, it is also possible to interpret it in terms of entry costs to the labor force. In fact, the model is homothetic to an environment where the costs of re-entering the labor force increase with age; see the discussion in the working paper version of the model (IZA working paper #10061 (2016)).

ers maximize

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \beta^t (c_t + \ell_t z_t a_t), \tag{3}$$

where $\mathbb{E}_0$ indicates mathematical expectation conditional on the information at time 0.

On the other side of the market, there is a continuum of infinitely-lived employers who maximize

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \beta^t (c_t - v_t \eta). \tag{4}$$

v_t denotes vacancies and η is the unit cost of an unfilled job. At any point in time, an employer either has a filled job or a vacant position, and, in the latter case, he or she looks for a potential employee.

Search-matching frictions   Workers can be in one of three distinct labor market states: employment, unemployment, and nonparticipation. There is no on-the-job search: only nonemployed workers (i.e., the unemployed and nonparticipants) can search for jobs, and we refer to them as *job seekers*. The number of contacts per unit of time is given by a standard Cobb–Douglas matching function with constant returns to scale:

$$m(j_t, v_t) = M j_t^\kappa v_t^{1-\kappa}. \tag{5}$$

j_t is the number of job seekers and v_t is the number of vacancies. For future reference, we denote as θ_t labor market tightness, which is the ratio between v_t and j_t. $f(\theta_t) \equiv M\theta_t^{1-\kappa}$ denotes the job-finding probability and $f(\theta_t)/\theta_t = M\theta_t^{-\kappa}$ is the job-filling probability.

The search process distinguishes between unemployed workers and nonpartici-pants.[13] Specifically, the per-period probability that a randomly chosen unemployed worker meets a randomly chosen employer is $f(\theta_t)$, whereas for nonparticipants the corresponding probability is $s_n f(\theta_t)$ with $0 < s_n < 1$. s_n measures the relative matching efficiency faced by nonparticipants: these workers trade a lower matching probability (compared to the unemployed) against the enjoyment derived from leisure in the current period. Accordingly, j_t is given by: $j_t = u_t + s_n n_t$, where u_t denotes the number of unemployed workers and n_t is the number of nonparticipants.

Production   The unit of production is a matched worker-employer pair. Each pair produces a flow quantity y_t and is subject to various shocks. First, a match is dissolved if the worker is hit by the retirement shock (i.e., the worker belongs to age group A and retires, which occurs exogenously with probability $1 - \alpha(A, A)$). Second, there is a per-period probability λ of exogenous job destruction with possible long-term consequences for

---

[13]The model acknowledges the fact that nonparticipants account for a sizable share of transitions into employment. This is not necessarily inconsistent with the official definition of unemployment, according to which only workers who *actively* search for jobs should be classified as unemployed. For instance, Jones and Riddell (1999) found that many job seekers are appropriately classified as nonparticipants as they only use "passive" search methods. Another possible interpretation of the model is that "jobs can bump into people" (Garibaldi and Wasmer (2005)), so that a worker faces a nonzero probability of meeting an employer without exerting any search effort.

workers (details to follow). Third, if none of these events occur, the productivity of the match evolves according to a first-order autoregressive process:

$$y_{t+1} = (1 - \rho)\overline{y}_h + \rho y_t + \varepsilon_{t+1}. \tag{6}$$

$\rho \in (0, 1)$ is the persistence of the process, $\varepsilon \sim N(0, \sigma^2)$ is the innovation and h is the worker's skill level. It is assumed that $\overline{y}_0 < \cdots < \overline{y}_H$, that is, the unconditional mean of the process increases with the skill level of the worker. Hereafter, $G_h(y'|y)$ denotes the transition function for y when the worker's skill level is h, that is, $G_h(y'|y) = \Pr\{y_{t+1} < y'|y_t = y, h_t = h\}$.

The timing of employment is as follows. Upon meeting, an employer and a worker with current skills h draw a productivity y from the distribution $G_{0,h}(y) \equiv G_h(y|\overline{y}_h)$.[14] They decide whether to start producing together or to walk away from one another. In the latter event, they are returned to the pool of unmatched agents. If they choose to stay together, the match becomes subject to the sequence of shocks described in the previous paragraph. So, production stops when the match is hit by an exogenous shock (retirement in age group A or the λ shock) or when the two parties endogenously dissolve the match. Notice that the λ shock and endogenous job destruction can both be followed by a transition to nonparticipation: this occurs if the worker is better off out of the labor force than in the unemployment pool.

Skill dynamics Each individual worker is endowed with a certain amount of skills denoted by h_t, which is distributed on a finite and discrete support $\{0, \ldots, H\}$. A worker who enters the economy starts off with the lowest skill level. Thereafter, his skills (human capital) evolve according to his own idiosyncratic labor market trajectory. This is captured by three Markov processes, with the transition probability from h to h' denoted by $\mu_e(h, h')$ for a worker who retains his job (the subscript e stands for *employment*), $\mu_o(h, h')$ for a worker without a job (o for *out of work*), and $\mu_d(h, h')$ for an exogenously displaced worker (d for *destruction*). Displaced workers are those who get separated from their job by the λ shock.[15]

Accumulation of human capital occurs gradually during employment and depreciation takes place when the worker remains without work. The specification of the two Markov processes governing gradual transitions in skills is as follows:

$$\mu_e(h, h') = \begin{cases} 1 - \mu_e & \text{if } h < H \text{ and } h' = h, \\ \mu_e & \text{if } h < H \text{ and } h' = h + 1, \end{cases} \tag{7a}$$

---

[14]By construction, $G_{0,h'}(y)$ dominates $G_{0,h}(y)$ in a first-order stochastic sense for any $h' \geq h$. Therefore, the model embodies the type of individuals skill dynamics proposed by den Haan, Haefke, and Ramey (2005): matching with more experienced workers yields a higher initial draw of match productivity on average.

[15]We let a quitter retain his current skill level upon leaving his job. den Haan, Haefke, and Ramey (2005) have argued that turbulence and unemployment could be *negatively* related if voluntary quitters face a risk of immediately losing their skills. The insight is that turbulent times could deter workers from leaving their job, and thereby reduce worker flows into unemployment. Our formulation of economic turbulence, which follows Ljungqvist and Sargent (2008), draws on the association between skill loss and disruptive labor market experiences (involuntary job separations). This formulation is robust with respect to changes in calibration and/or modeling choices; see, for example, Ljungqvist and Sargent (2007).

$$\mu_o(h, h') = \begin{cases} \mu_o & \text{if } h > 0 \text{ and } h' = h - 1, \\ 1 - \mu_o & \text{if } h > 0 \text{ and } h' = h \end{cases} \tag{7b}$$

together with: $\mu_e(H, H) = 1$ and $\mu_o(0, 0) = 1$. The third Markov process, $\mu_d(h, h')$, is meant to operationalize the notion of economic turbulence. As in Ljungqvist and Sargent (1998, 2008), turbulence is defined as the risk of instantaneous skill loss when a worker is exogenously separated from his job. We defer the specification of all the $\mu_d(h, h')$'s to Section 4. To fix ideas, throughout the analysis, exogenous job destructions are not followed by an upgrade in skills ($\mu_d(h, h') = 0$ if $h' > h$), and an increase in turbulence lowers the probabilities of retaining current skills ($\mu_d(h, h)$).

In order to understand labor market performances on both sides of the Atlantic, we will study a laissez-faire (henceforth LF) economy and a welfare state (henceforth, WS) economy. The government in the WS economy implements an employment protection scheme and a welfare package, both of which substantially alter the way in which the labor market functions.

Government-mandated programs   Employment protection is a lump-sum tax Ω on job separations paid by the employer. It is assumed that the government does not observe whether these occur for exogenous or endogenous reasons and, therefore, the tax is enforced for both types of job separation.[16] Ω is a sunk cost in that the worker does not receive the proceeds after job separation; as highlighted by Lazear's (1988) seminal study of job security provisions, such transfers would be undone during the process of wage bargaining. Thus, the tax is a deadweight loss for the WS economy. Our preferred interpretation is that Ω encompasses the costs of layoff procedures and regulatory barriers to competition that contribute to the slowing down of labor reallocation in Europe.

The welfare package includes unemployment compensations and subsidized early retirement benefits. The key feature is that these schemes depend on an individual's work experience encoded in his skill level at the time of job separation. An unemployed worker with skill level h at that point is eligible to collect a benefit payment $b \equiv b(h)$.[17] His *current* skills h may change in subsequent periods, but the worker retains his benefit b until finding a new job or leaving the economy. A nonparticipant is also entitled to receive a benefit b but he collects only a share γ_a of that benefit. We let γ_a depend on the age of the worker (a) to analyze the effects of incentives toward early retirement, which have a strong age component. To specify the schedule $b(h)$ in a parsimonious way, we define it as a replacement ratio ϕ times $\overline{y}_h$, the unconditional mean of productivity for

---

[16]We assume that the tax is waived if the match is dissolved because the worker is in age group A and is hit by the exogenous retirement shock. This plays little role in the experiments but avoids having to write an additional Bellman equation for employers who are matched to workers belonging to age group A.

[17]It is assumed that an employed worker who experiences an upgrade in skills from h to h' is directly entitled to the new benefit level $b(h')$. Thus, we do not need an additional state variable indicating whether or not the worker has been working at least one period at the skill level h' to compute his welfare benefits.

workers with skill level h. The social insurance system is financed through a flat-rate tax τ raised on the product of job matches.

Two-tier labor market　It is important to note that government-mandated programs in the WS economy create a two-tier labor market. First, the employment protection tax Ω changes the outside option of the employer when bargaining with an incumbent worker versus when meeting a new worker. Second, on meeting an employer, a worker may be collecting a benefit payment b that differs from the benefit associated to the new job (this occurs if the worker's skill level has changed since his previous job). In both instances, there is an insider-outsider phenomenon at work in the WS economy. We use an index $i \in \{0, +\}$ to capture this phenomenon, with $i = 0$ indicating the initial employment period and $i = +$ for the continuation periods of the job.

3.2 Bellman equations

The behavior of workers and employers who populate the economy can be described by a system of Bellman equations.[18] Denoting by v_n, v_u, v_{e_i}, the value of being in nonparticipation, unemployment, and employment with $i \in \{0, +\}$, respectively, and by $v_o(\cdot) \equiv \max\{v_n(\cdot), v_u(\cdot)\}$ the value of being out of work, workers' decisions are governed by:

$$
v_n(b, h, z, a) = za + \gamma_a b + \beta \sum_{a'} \alpha(a, a') \sum_{h'} \mu_o(h, h')
$$
$$
\times \int \Big[\big(1 - s_n f(\theta)\big) v_o(b, h', z', a') + s_n f(\theta) \tag{8}
$$
$$
\times \int \max\{ v_{e_0}(y', b, h', z', a'), v_o(b, h', z', a') \}\, dG_{0,h'}(y') \Big] dF(z'|z),
$$

$$
v_u(b, h, z, a) = b + \beta \sum_{a'} \alpha(a, a') \sum_{h'} \mu_o(h, h')
$$
$$
\times \int \Big[\big(1 - f(\theta)\big) v_o(b, h', z', a') + f(\theta) \tag{9}
$$
$$
\times \int \max\{ v_{e_0}(y', b, h', z', a'), v_o(b, h', z', a') \}\, dG_{0,h'}(y') \Big] dF(z'|z),
$$

$$
v_{e_0}(y, b, h, z, a) = w_0(y, b, h, z, a) + \beta \sum_{a'} \alpha(a, a')
$$
$$
\times \int \Big[\lambda \sum_{h'} \mu_d(h, h') v_o(b(h), h', z', a') + (1 - \lambda) \sum_{h'} \mu_e(h, h') \tag{10}
$$
$$
\times \int \max\{ v_{e_+}(y', h', z', a'), v_o(b(h'), h', z', a') \}\, dG_{h'}(y'|y) \Big] dF(z'|z),
$$

---

[18]The Bellman equations are written with a summation over h' with the understanding that $h' = 0, \ldots, H$. The summation over a' is written with the understanding that $a' = a, a+1$ and the additional convention that $\alpha(A, A+1) = 0$. In doing so, we are able to write the Bellman equations for all a in $\{0, \ldots, A\}$.

$$v_{e_+}(y, h, z, a) = w_+(y, h, z, a) + \beta \sum_{a'} \alpha(a, a')$$

$$\times \int \left[\lambda \sum_{h'} \mu_d(h, h') v_o(b(h), h', z', a') + (1 - \lambda) \sum_{h'} \mu_e(h, h') \right. \tag{11}$$

$$\left. \times \int \max\{v_{e_+}(y', h', z', a'), v_o(b(h'), h', z', a')\} dG_{h'}(y'|y) \right] dF(z'|z).$$

In equations (10) and (11), $w_0(\cdot)$ and $w_+(\cdot)$ are the wages paid during employment when $i = 0$ and $i = +$, respectively. The wage-setting rule is provided below. Assuming that there is free entry of firms, employers' values of having a filled job v_{f_0} and v_{f_+} are given by:

$$v_{f_0}(y, b, h, z, a) = (1 - \tau)y - w_0(y, b, h, z, a) + \beta \sum_{a'} \alpha(a, a')$$

$$\times \int \left[-\lambda \Omega + (1 - \lambda) \sum_{h'} \mu_e(h, h') \right. \tag{12}$$

$$\left. \times \int \max\{v_{f_+}(y', h', z,'a'), -\Omega\} dG_{h'}(y'|y) \right] dF(z'|z),$$

$$v_{f_+}(y, h, z, a) = (1 - \tau)y - w_+(y, h, z, a)$$

$$+ \beta \sum_{a'} \alpha(a, a') \int \left[-\lambda \Omega + (1 - \lambda) \sum_{h'} \mu_e(h, h') \right. \tag{13}$$

$$\left. \times \int \max\{v_{f_+}(y', h', z', a'), -\Omega\} dG_{h'}(y'|y) \right] dF(z'|z).$$

The decision rules for match formation and match continuation derive from the "max" operator in the Bellman equations above. These decisions are privately efficient from the viewpoint of each worker-employer pair under the assumption that agents bargain over the match surplus.

3.3 *Nash bargaining*

As is standard, wages are set by period-by-period Nash bargaining. $\psi \in [0, 1]$ denotes the bargaining power of workers. The two-tier wage schedule is given by:

$$w_0(y, b, h, z, a)$$
$$= \arg\max_w \{ (v_{e_0}(y, b, h, z, a) - v_o(b, h, z, a))^\psi v_{f_0}(y, b, h, z, a)^{1-\psi} \}, \tag{14}$$

$$w_+(y, h, z, a)$$
$$= \arg\max_w \{ (v_{e_+}(y, h, z, a) - v_o(b(h), h, z, a))^\psi (v_{f_+}(y, h, z, a) + \Omega)^{1-\psi} \}. \tag{15}$$

We can use the first-order conditions associated with (14) and (15) to obtain the decision rules for match formation and match continuation, $\widetilde{y}_0(b, h, z, a)$ and $\widetilde{y}_+(h, z, a)$.

These are pinned down by:

$$v_{f_0}\big(\widetilde{y}_0(b, h, z, a), b, h, z, a\big) = 0, \tag{16}$$

$$v_{f_+}\big(\widetilde{y}_+(h, z, a), h, z, a\big) = -\Omega. \tag{17}$$

3.4 *Participation margin*

Workers' labor force participation choice is subsumed by a threshold $\widetilde{z}(b, h, a)$ which satisfies:

$$v_n\big(b, h, \widetilde{z}(b, h, a), a\big) = v_u\big(b, h, \widetilde{z}(b, h, a), a\big). \tag{18}$$

By combining this definition with equations (8) and (9), it is straightforward to show that at $z = \widetilde{z}(b, h, a)$ the gains and losses of nonparticipation (relative to unemployment) offset each other:

$$\widetilde{z}(b, h, a)a = (1 - \gamma_a)b + (1 - s_n)f(\theta)\beta \sum_{a'} \alpha(a, a') \sum_{h'} \mu_o(h, h')$$

$$\times \int \int \max\{v_{e_0}(y', b, h', z', a') \tag{19}$$

$$- v_o(b, h', z', a'), 0\} \, dG_{0,h'}(y') \, dF(z'|\widetilde{z}(b, h, a)).$$

Equation (19) also highlights how individual participation decisions and aggregate labor market conditions are intertwined. That is, $\widetilde{z}(b, h, a)$ depends on the aggregate job-finding probability $f(\theta)$ only when the worker faces a discounted net present value of employment (measured by the term after $f(\theta)$) that is greater than 0.

3.5 *Aggregate conditions*

Labor market tightness θ and the payroll tax τ are pinned down by aggregate equilibrium conditions. To write these conditions, $n(b, h, z, a)$, $u(b, h, z, a)$, $e_0(y, b, h, z, a)$, and $e_+(y, h, z, a)$ denote the measures of workers in nonparticipation, unemployment, and employment in $i = 0$ and $i = +$.

Free entry Employers create new vacancies until the discounted net present value of doing so is exhausted. Vacancies and job seekers meet by the end of a model period. Therefore, the free entry condition is given by:

$$\eta = \beta \frac{f(\theta)}{\theta} \sum_{b,h,a} \int \int \left[\sum_{a'} \alpha(a, a') \sum_{h'} \mu_o(h, h') \right.$$

$$\left. \times \int \max\{v_{f_0}(y', b, h', z', a'), 0\} \, dG_{0,h'}(y') \right] dF(z'|z) \frac{u(b, h, z, a) + s_n n(b, h, z, a)}{u + s_n n} \, dz, \tag{20}$$

where $u = \sum_{b,h,a} \int u(b, h, z, a) \, dz$ and $n = \sum_{b,h,a} \int n(b, h, z, a) \, dz$. On the right-hand side of the equation, $\frac{u(b,h,z,a)+s_n n(b,h,z,a)}{u+s_n n}$ is the probability of drawing a worker with state variables b, h, z, a from the pool of job seekers.

Balanced budget   Finally, the balanced budget condition is given by:

$$
\tau \sum_{h,a} \int \int y \Big(e_+(y, h, z, a) + \sum_b e_0(y, b, h, z, a) \Big) \, dy \, dz
$$

$$
= \sum_b b \sum_{h,a} \int \big(u(b, h, z, a) + \gamma_a n(b, h, z, a) \big) \, dz. \tag{21}
$$

On the left-hand side of the equation, τ multiplies total output produced by the economy. The right-hand side of the equation links the generosity of social insurance schemes to the population shares of benefit recipients.

3.6 *Equilibrium*

Having described the Bellman equations and aggregate equilibrium conditions, we are in a position to give the following definition.

Definition   An equilibrium is a list of value functions $v_n(b, h, z, a)$, $v_u(b, h, z, a)$, $v_{e_0}(y, b, h, z, a)$, $v_{e_+}(y, h, z, a)$, $v_{f_0}(y, b, h, z, a)$, $v_{f_+}(y, h, z, a)$, a set of decision rules for match formation and match continuation $\widetilde{y}_0(b, h, z, a)$, $\widetilde{y}_+(h, z, a)$ and for labor force participation $\widetilde{z}(b, h, a)$, a list of wage functions $w_0(y, b, h, z, a)$, $w_+(y, h, z, a)$, a distribution of workers across the state space of the economy $n(b, h, z, a)$, $u(b, h, z, a)$, $e_0(y, b, h, z, a)$, $e_+(y, h, z, a)$, and a value for labor market tightness θ and the tax rate τ such that:

1.   Optimal match formation and match continuation decisions: Given θ, τ and the value functions $v_{f_0}(y, b, h, z, a)$, $v_{f_+}(y, h, z, a)$, match formation and match continuation decisions $\widetilde{y}_0(b, h, z, a)$, $\widetilde{y}_+(h, z, a)$ solve equations (16) and (17), respectively.

2.   Optimal labor force participation decisions: Given θ, τ, and the value functions $v_n(b, h, z, a)$, $v_u(b, h, z, a)$, labor force participation decisions $\widetilde{z}(b, h, a)$ solve equation (18).

3.   Nash bargaining: Given θ, τ, and the value functions $v_n(b, h, z, a)$, $v_u(b, h, z, a)$, $v_{e_0}(y, b, h, z, a)$, $v_{e_+}(y, h, z, a)$, $v_{f_0}(y, b, h, z, a)$, $v_{f_+}(y, h, z, a)$, the wage functions $w_0(y, b, h, z, a)$, $w_+(y, h, z, a)$ are given by equations (14) and (15), respectively.

4.   Time-invariant distribution: Given θ, the decision rules $\widetilde{z}(b, h, a)$, $\widetilde{y}_0(b, h, z, a)$, $\widetilde{y}_+(h, z, a)$, and the exogenous laws of motion of y, b, h, z, a, the measures $n(b, h, z, a)$, $u(b, h, z, a)$, $e_0(y, b, h, z, a)$, $e_+(y, h, z, a)$ are time-invariant and their sum adds up to one.

5.   Free entry: Given the measures $n(b, h, z, a)$ and $u(b, h, z, a)$ and the value of match formation $v_{f_0}(y, b, h, z, a)$, labor market tightness θ solves the free entry condition (20).

6.   Balanced budget: Given the measures $n(b, h, z, a)$, $u(b, h, z, a)$, $e_0(y, b, h, z, a)$, $e_+(y, h, z, a)$, τ satisfies the balanced budget condition given by equation (21).

The following assumptions complete the description of condition 4 (time-invariant distribution). New labor market entrants are out of work initially, they are entitled to collect

the lowest level of benefits $b(0)$ and draw a leisure value z from the distribution $F(\cdot|\bar{z})$ ($\bar{z}$ denotes the unconditional mean value of z). The latter assumption is mostly innocuous because workers do not derive any utility from leisure while they belong to age group $a = 0$.

4. Calibration

The calibration process is organized as follows. First, using data moments for the U.S., we specify and calibrate parameters that are *common* to the two setups in Section 4.1. This pins down values for 15 parameters. Second, we set values for parameters that are *specific* to each economy in Section 4.2. These fall into one of two categories: (i) government-mandated programs, which include parameters unique to the WS economy, and (ii) two technology parameters, namely aggregate matching efficiency and the volatility of productivity shocks. Government-mandated programs per se can explain only a part of the differences between the U.S. and Europe observed in the initial period, and so we need (ii) to capture the residual difference in labor market dynamics.

The first two steps of the calibration target the steady state of economies observed in tranquil times. The working assumption is that the parameters that have been set up at this point are invariant across time. Before closing this section, we explain in Section 4.3 how we define economic turbulence and how we measure its changes from tranquil to turbulent times.

4.1 *Common parameters*

In this subsection, we set up the values for 10 out of 15 parameters using external information. We calibrate the remaining five jointly with the parameters discussed in the next subsection. It is useful to note that the five variables are essentially preference parameters, which are held common across the LF and WS economies. Throughout the analysis, one model period is considered to be half a quarter.

Demographics[19]   The working life of individuals is divided into the following periods. While in the age bracket 20–49, workers transit across six consecutive five-year-long age groups. The probability of remaining in each of these is 0.975. The subsequent age bracket, 50–54, consists of five one-year-long age groups; the probability of remaining in these groups is 0.875. By pooling together the age groups of the 50–54 bracket and the last five age groups of the 20–49 bracket, we obtain the model counterpart of the so-called category "prime-age workers." The last age bracket, 55–64, is the direct counterpart of the category "older workers." It contains 20 six-month-long age groups, as the probability of remaining in each of these is 0.750. The obvious role of this partition is to make the policy functions more flexible with respect to age toward the end of the working life.

Discount factor   The discount factor β is 0.9951 to accord with an annual interest rate of 4 percent.

---

[19]For the sake of space, the demographic probabilities (the $\alpha(a, a')$'s) are not reported in Table 3.

TABLE 3. Parameter values (one model period is half a quarter).

Parameter	Description	Value	
	A. Preference parameters	LF	WS
β	Discount factor	0.9951	
ξ_{20-54}	Transitory shocks, prime-age workers*	0.477	
ξ_{55-64}	Transitory shocks, older workers*	0.578	
π	Persistence of leisure utility*	0.700	
$z_{\sup}$	Upper bound for leisure utility*	0.138	
	B. Human capital and match productivity		
μ_e	Probability of upgrading skills	0.033	
μ_o	Probability of losing skills	0.066	
$\bar{y}_0$	Mean of match productivity, lower skill	1.0	
$\bar{y}_H$	Mean of match productivity, higher skill	2.0	
ρ	Persistence of productivity	0.974	
σ	Standard deviation of idiosyncratic shocks*	0.432	0.291
	C. Labor market frictions		
λ	Probability of exogenous job destruction	0.0166	
κ	Elasticity of job filling w.r.t. tightness	0.5	
ψ	Bargaining power of workers	0.5	
η	Vacancy posting cost	3.016	
M	Matching efficiency*	0.495	0.648
s_n	Relative matching efficiency in nonparticipation*	0.240	
	D. Policy schemes	WS	
Ω	Job destruction tax*	6.500	
ϕ	Unemployment benefits replacement ratio*	0.328	
γ_a	Relative generosity of early retirement schemes	$\gamma_{55-59} : 0.0$	
		$\gamma_{60-64} : 0.5$	

Note: Parameters marked with an asterisk (*) are calibrated to match the data moments reported in Table 4. The persistence of leisure utility (Panel A) is calibrated to match the life-cycle profile of the transition probability from nonparticipation to unemployment shown in Figure 3.

Leisure shocks We have assumed that the valuation of leisure begins at 0 and increases with age (see equation (3)). This specification is clearly not designed to explain nonparticipation among younger workers and, to some extent, among prime-age workers.[20] To sidestep this problem and fit the data on labor force participation for prime-age workers, we consider a simple extension of the model. We assume that, in addition to voluntary transitions, there are also involuntary reasons prompting workers to move in and out of the labor force. Specifically, we replace the value of being out of work (formerly defined as $v_o = \max\{v_n(\cdot), v_u(\cdot)\}$) by

$$v_o(b, h, z, a) = \xi_a v_n(b, h, z, a) + (1 - \xi_a) \max\{v_n(b, h, z, a), v_u(b, h, z, a)\}. \tag{22}$$

[20]Our model builds on leisure shocks (or entry costs to the labor market; see footnote 12) to rationalize labor force participation choices. In our view, a model focused on younger workers would need a different driving force and link their labor force participation to schooling investment choices. The earlier version of this paper (IZA working paper #10061 (2016)) provides an informal discussion of some changes of the model along those lines.

ξ_a is the age-dependent probability of a shock that forces a worker to spend one period in nonparticipation. Unlike shocks to the leisure component z, we think of the ξ_a shocks as being transitory. For instance, such shocks could capture relocation to a new city, which would temporarily lower the arrival rate of job offers. We use only two values for ξ_a to maintain parsimony, namely $\xi_a \in \{\xi_{20-54}, \xi_{55-64}\}$.

As just mentioned, z follows a persistent stochastic process. Its Markov transition matrix is constructed as follows: with probability π the value of z remains unchanged, while with probability $1 - \pi$ a new value z' is drawn from the uniform distribution over the support $[0, z_{\sup}]$.

Overall, the different shocks that generate worker transitions in and out of the labor force depend on four parameters: $\xi_{20-54}, \xi_{55-64}, \pi, z_{\sup}$. We target the following data moments, which are meant to capture the state of the U.S. labor market at the onset of the 1970s: (i) the labor force participation rate of prime-age workers is 95 percent, (ii) the participation rate of older workers is 80 percent, (iii) the unemployment rate of older workers is 3.5 percent, (iv) the probability of transitioning from nonparticipation to unemployment falls by 10 percent per year between the ages of 55 and 64. Let us remark on targets (iii) and (iv). Regarding (iii), we target the unemployment rate of older workers, but alternatively we could target their unemployment-to-nonparticipation transition probability. The rationale behind target (iv) is that we need a data moment on the persistence of nonparticipation in order to disentangle the sources of movements in and out of the labor force. The calibration procedure yields $\xi_{20-54} = 0.477$, $\xi_{55-64} = 0.578$, $\pi = 0.700$, $z_{\sup} = 0.138$.[21] The value of π implies that z is resampled on average every 5 months.

Production   The unconditional means of the productivity process, the $\bar{y}_h$'s, are set to evenly partition the $[1, 2]$ interval. Thus, the match productivity of a worker who has reached the top of the skill ladder is, on average and unconditionally, twice higher than that of a new labor market entrant. It turns out that these values imply that wages increase by almost 75 percent from labor market entry to the mid-forties, in tune with the literature. Next, we draw on results from Chang and Kim (2006) to parametrize the persistence of match productivity, ρ. The authors use annual wage data to estimate the parameters of an autoregressive productivity process while controlling for selection into employment. The second panel of Table 1 in Chang and Kim (2006) shows that the annual persistence of idiosyncratic productivity is 0.809 for men. This number implies $\rho = 0.809^{1/8} = 0.974$ since our model period is half a quarter.

Exogenous job destruction   We use data on the labor market history of displaced workers to parametrize λ, the probability of suffering an exogenous job destruction. In Appendix A.3, we document that workers with at least 1 year of employment experience get displaced after spending on average 7.5 years at the same job. Thus, we set λ equal to 0.0166.

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[21]The fact that ξ_{20-54} is lower than ξ_{55-64} might seem counterintuitive. However, this result does not mean that older workers experience more involuntary transitions out of the labor force. If a worker is better off in nonparticipation, then $\max\{v_n(b, h, z, a), v_u(b, h, z, a)\} = v_n(b, h, z, a)$ and, therefore, the ξ_a shock in equation (22) does not affect the worker. By this token, one needs a higher ξ_{55-64} to change labor force participation among older workers.

Skill dynamics   There are five grid points for the support of skills, $\{0, \ldots, H\}$.[22] To construct the law of motion of h, we use the returns to human capital accumulation estimated by Kambourov and Manovskii (2009b).[23] Denoting by x a worker's job tenure, a regression of their estimates against a quadratic polynomial of x yields the following profiles: $-0.0014 + 0.0487x - 0.0017x^2$ for the OLS and $-0.0003 + 0.0287x - 0.0010x^2$ for the IV-GLS estimates. These profiles show that returns to tenure reach their peak after 14 to 15 years. Thus, we set the probability of upgrading skills, μ_e, to 0.033: given the number of grid points H, it takes a worker 15 years on average to move from the lowest skill level to the highest one conditional on being employed continuously.

For the probability of losing skills μ_o, we follow Ljungqvist and Sargent (1998, 2008) in assuming that depreciation of human capital when out of work is stochastically twice as fast as skill accumulation. Existing estimates of skill depreciation are quite disparate across studies, and the literature provides little additional guidance for choosing this parameter. We find, meanwhile, that the results are robust to varying μ_o by an order of magnitude. The main reason for this is that skill depreciation affects workers in the model most acutely when skills are destroyed immediately upon job loss, and less so when their skills deteriorate gradually during a spell of nonemployment.

Matching and bargaining   The elasticity of the job-filling probability with respect to labor market tightness, κ, is set to 0.50 (Petrongolo and Pissarides (2001)). As is usual in the literature, we use the same parameter value for the workers' share of the match surplus, ψ. In the next subsection, we set different aggregate matching efficiencies (M) for the LF and WS economies, but we do use a common value for the relative matching efficiency faced by nonparticipants, s_n.[24] We calibrate it to match the monthly transition rate from nonparticipation to employment of 6.40 percent tabulated by Krusell et al. (2011) (see panel "Men 21–65" in Table 3 of their paper). This yields $s_n = 0.240$.

We follow standard practice to pin down the vacancy posting cost, η. We normalize the value of labor market tightness to 1 in the LF economy in tranquil time and use the free-entry condition to fix the parameter η. This yields $\eta = 3.016$. While this number may appear high, it is important to keep in mind that jobs in this model enable workers to accumulate skills and become more productive. In the steady-state equilibrium of the LF economy, output per worker is 2.367.

4.2 *Economy-specific parameters*

In the WS economy, we can, and do, calibrate the parameters for employment protection and unemployment insurance to match data targets. Due to a lack of good mapping between the model and data, we fix the value of the parameter that governs early retirement incentives, and discuss the effects of changing this value in subsequent sections. Last, we calibrate the remaining technology parameters.

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[22]The results are robust to using a finer grid. We use five grid points to reduce computational costs.

[23]We use Table 2 from Kambourov and Manovskii (2009b). The authors report the returns at 2 years, 5 years, and 8 years of occupational tenure. Their OLS estimates are 0.0891, 0.1995, and 0.2794, respectively. The corresponding numbers based on the IV-GLS estimation are 0.0539, 0.1197, and 0.1680.

[24]One can think of s_n as a preference parameter insofar as s_n could reflect the disutility of making search efforts.

Government-mandated programs   Boeri, Garibaldi, and Moen (2017) compile informa-
tion on judicial discretion over severance payments in OECD countries. Table 1 of their
study indicates that the cost of a fair economic dismissal for a worker with 20 years of
job tenure amount to 10.1 months of wages.[25] Assuming that total dismissal costs are
split in half between direct payments to the worker and payments to third parties,[26] this
yields a target of 5.07 months of wages for the job destruction tax, Ω. We use the average
wage among workers with skill level $h = H$ to proxy the wage of high-tenure workers and
obtain, through calibration, $\Omega = 6.50$.

   Next, we set up a target for the replacement ratio of unemployment insurance ben-
efits, ϕ. Consider unemployment benefits in the U.S., which have a replacement ratio
of 40 percent and last for 6 months. Assuming a 45 percent (semi-quarterly) job-finding
rate, the government would provide unemployed workers with the same expected pay-
ment using a replacement ratio of 31 percent and no time limit on the duration of ben-
efits.[27] Based on similar calculations, one can show that a 71 percent replacement ratio
with infinite duration yields the equivalent of benefits with a replacement ratio of 75
percent and a duration of 36 months.[28] We interpret the gap between 71 and 31 percent
as capturing the difference in generosity of unemployment insurance benefits between
the U.S. and Europe, and calibrate ϕ to match a 40 percent replacement ratio in the WS
economy.

   As previously mentioned, the mapping between the model and data is less clear in
what concerns policies toward early retirement. First, there are multiple programs that
provide these types of incentives, and it is beyond our scope to include them explicitly
in the model. Second, what the model actually captures is the effect of those programs
on the flow cost of nonparticipation (see equation (19)). Thus, our approach is to first
fix the γ_a's to reasonable values, and then study how they affect the results. We focus on
$\gamma_a \in \{\gamma_{20-54}, \gamma_{55-59}, \gamma_{60-64}\}$ and set γ_{20-54} to 0 throughout the analysis. $\gamma_{55-59} = 0.0$ and
$\gamma_{60-64} = 0.5$ is our baseline specification up until Section 6.2.

Other technology parameters   For matching efficiency (M) and the standard deviation
of productivity shocks (σ), we set up the following targets for the LF economy: (i) the un-
employment rate among prime-age workers is 5.5 percent, and (ii) their monthly sepa-
ration rate during employment (i.e., transitions out of employment) is 2.5 percent. Note

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[25]Boeri, Garibaldi, and Moen (2017) report that the costs of a fair economic dismissal for a high-tenure
worker amount to 7.4 months of wages in France, 17 months in Germany, and 6.0 months in Italy. We refer
to the average of these three numbers.

[26]This 50:50 split is a compromise between the high uncertainty of legal procedures described in Boeri,
Garibaldi, and Moen (2017) (which suggests a large deadweight loss) and the estimates of Garibaldi and
Violante (2005) showing that direct payments to workers can account for up to two-thirds of total dismissal
costs.

[27]Let f denote the job-finding rate and denote by q the per-period probability of exhausting benefits.
An unemployed worker faces an expect payment of $\sum_{t=0}^{\infty} \beta^t (1-f)^t (1-q)^t b = \frac{1}{1-\beta(1-f)(1-q)} b$ (we ignore
the life-cycle dimension here, which has a negligible impact on the calculations). With benefits of infinite
duration, denoted as b_∞, that payment becomes $\frac{1}{1-\beta(1-f)} b_\infty$. Plugging $f = 0.45$, $q = 0.25$, $b = 0.40$ into
$b_\infty = \frac{1-\beta(1-f)}{1-\beta(1-f)(1-q)} b$ yields $b_\infty = 0.31$.

[28]To see this, use $f = 0.45$, $q = 0.0417$, $b = 0.75$ in the formula of footnote 27. We use the same value of the
job-finding rate f in these calculations because, as Kitao, Ljungqvist, and Sargent (2017) point out, there
was little difference in unemployment duration between the U.S. and Europe in the 1970s.

that at this stage we have used the unemployment rates of both prime-age workers and older workers in the U.S. as calibration targets. In the WS economy, we search for the parameter values of M and σ that (iii) minimize the unemployment rate and (iv) fit a labor force participation rate of older workers at 65 percent. Again, the data moments we target are representative of the state of the U.S. and Europe in the early 1970s.

We obtain $M = 0.495$ and $\sigma = 0.432$ in the LF economy, and $M = 0.648$ and $\sigma = 0.291$ in the WS economy. Not surprisingly, in the WS economy with its costly government-mandated programs, there are fewer incentives for firms to post vacancies and the model thus needs a higher matching efficiency to rationalize low unemployment rates. This economy attributes the lower separation rates in Europe to a mix of employment protection and a less volatile productivity process.

Table 3 provides a summary of the parametric specification and calibration of the model. In Table 4, the first column reports the nine targeted moments discussed in Sections 4.1 and 4.2. The second column of that table shows that the model performs well at matching the targets. We make additional important connections between the model and data in the next subsection and Section 5.

4.3 *Economic turbulence*

We use Ljungqvist and Sargent's (1998) construct to specify the stochastic process of skill loss when a worker is exogenously separated from his job. For each skill level h, the $\mu_d(h, h')$'s are drawn from the left half of the Normal distribution with mean h, truncated at h and normalized to integrate to 1 over $\{0, \ldots, h\}$. Notice that $\mu_d(h, h') = 0$ for any $h' > h$, and that the probabilities of moving to a lower skill level depend on a single parameter, namely the dispersion of the underlying Normal distribution. A higher degree of economic turbulence refers to an increase of this parameter.

Next, we use the LF economy as a tool to estimate the degree of economic turbulence. Bertola and Ichino (1995), Ljungqvist and Sargent (1998), Kambourov and

TABLE 4. Assessment of the model fit.

Description	Target	Model
A. LF economy		
Unemployment rate, 25–54	5.50	5.45
Transition rate from E to (U, N), 25–54	2.50	2.38
Participation rate, 25–54	95.0	95.1
Unemployment rate, 55–64	3.50	3.84
Participation rate, 55–64	80.0	79.9
Transition rate from N to E, 20–64	6.40	6.83
B. WS economy		
Participation rate, 55–64	65.0	65.9
Job destruction tax	5.07	5.04
Unemployment benefits replacement ratio	40.0	41.0

Note: The following abbreviations are used: E: employment; U: unemployment; N: nonparticipation. All entries are expressed in percentage points. In Panel B, the job destruction tax is expressed as a fraction of the monthly wage of high-tenure workers. The replacement ratio is the ratio between average unemployment benefits and the average wage.

Manovskii (2009a), among others, interpret Gottschalk and Moffitt's (1994) finding of increased U.S. earnings instability between the mid-1970s and mid-1980s as a symptom of more turbulent times. We follow this line of analysis by systematically relating the dispersion of the Normal distribution underlying the $\mu_d(h, h')$'s to the levels of earnings instability at different points in time during this period.[29]

Specifically, our starting point is a standard permanent-transitory decomposition of (the residual of log) annual earnings, namely $\log(w)_{i,t} = \pi_i + \zeta_{i,t}$; see Appendix A.4 for details. For three consecutive windows of time, we compute the transitory component of earnings, which is denoted as $\mathbb{V}\mathrm{ar}(\zeta_i)$ and displayed in Panel A of Table 5. Using the methodology described in the footnote to Table 5, we then search for the degree of turbulence in the LF economy matching earnings instability in the mid-1970s. The first column in Panel B is the steady state of that economy under tranquil times.[30] Next, when economic turbulence increases, the LF economy replicates Gottschalk and Moffitt's (1994) finding of a higher dispersion in the transitory component of earnings after the 1970s. The estimates of turbulent times are shown in the rightmost column of Table 5. Notice that we report the value of $1 - \mu_d(H, H)$ instead of the dispersion of the Normal distribution used to compute the $\mu_d(h, h')$'s, as there is a one-to-one mapping between these two quantities. Finally, we take the lowest and highest values of $1 - \mu_d(H, H)$ displayed in Table 5 to define a 0-to-1 scale of economic turbulence used in the remainder of the analysis. For example, a degree of 0.00 refers to $1 - \mu_d(H, H) = 0.181$, a degree of 0.20 refers to $1 - \mu_d(H, H) = 0.300$ and so on.

5. Model outcomes

Discussing some of the outcomes of the model, this section provides an overview of the main economic forces at work. We consider two sets of outcomes—transition proba-

Table 5. Turbulence and rising earnings instability.

	Time period	1975	1980	1985
A. Data	$\mathbb{V}\mathrm{ar}(\zeta_i)$	0.108	0.129	0.155
	% change	–	19.9	43.2
B. Model	$1 - \mu_d(H, H)$	0.181	0.495	0.776
	$\mathbb{V}\mathrm{ar}(\zeta_i)$	0.104	0.126	0.151
	% change	–	21.1	45.2

Note: Panel A: data from the PSID for prime-age male workers; see Appendix A.4 for details. 1975 refers to the window 1968–1982, 1980 to the window 1973–1987, and 1985 to the window 1978–1992. Panel B: For each "period," the labor market trajectories of 5,000 individuals are simulated over the ages 20 to 54 and their earnings are aggregated to a yearly frequency. The permanent-transitory decomposition uses log-earnings detrended from a quartic polynomial of age.

[29]It is well known (and we verify this finding in our analysis of PSID data) that the increase in earnings instability for men was concentrated in the early 1980s, and that earnings instability remained roughly constant after this decade, at least until the late 1990s; see Figure 1 in Gottschalk and Moffitt (2009). Therefore, we take the mid-1980s as capturing the rate of skill depreciation that characterizes turbulent times.

[30]In other words, there is an outer loop for the calibration of the LF economy: we fix the degree of economic turbulence, follow Sections 4.1 and 4.2 to calibrate the economy, and then update the degree of economic turbulence.

bilities and earnings profiles—which have empirical counterparts. The policy functions behind these outcomes are presented in Appendix B.1.

Worker transition probabilities

There are two worker-level outcomes that play a key role in shaping the profile of transitions across employment, unemployment, and nonparticipation. The first of these is the probability of match formation conditional on meeting an employer. This probability decreases if the worker has a high opportunity cost of labor force participation. That is, his outside option during Nash bargaining is the upper envelope of the values of unemployment and nonparticipation, which leads to a positive relationship between labor costs faced by the employer and the worker's valuation of leisure, z. The probability of match formation also decreases as the worker gets closer to retirement age. A higher a shortens the expected duration of the job match, as well as increases the utility that the worker derives from leisure. Last, a lower skill level h deteriorates match formation at higher ages: the surplus value from employing an older worker is more sensitive to flow profits, and lower values of h are correlated with a lower initial draw for match productivity. To sum up, the probability of match formation is negatively related to both z and a, the cross-derivative term is positive, and a lower h tends to reinforce these effects.

The second key probability is that of moving to nonparticipation following a shock to leisure utility, z. There are again two mechanisms driving the relationship to a, the age of the worker. The probability increases with age because an older worker's decisions respond more to his instantaneous utility, and the positive link between z and a in the utility function amplifies this effect. More importantly, equation (19) highlights an inverted relationship between this probability and that of match formation. When the odds of finding a job match with positive surplus are lower, the returns to searching from the unemployment pool are also lower, meaning the reservation threshold for labor force participation shifts downward (the probability of moving to nonparticipation increases). By the same token and controlling for a worker's age, a lower skill level h increases the probability of choosing nonparticipation over unemployment. These relationships are illustrated by Figures B.1 and B.2 in the Appendix.

In the aggregate, the transition probabilities between labor market states depend on the previously discussed outcomes and on the cross-sectional distribution of the economy. Figure 3 reports these probabilities and compares their *shapes* to those of their empirical counterparts (plotted against a different vertical axis). Although the calibration targets the slope of the transition probability from nonparticipation to unemployment, it is not able to match its level based on the transitory nature of the ξ_a shocks. Also, the calibration targets the level of the nonparticipation-to-employment transition probability; as can be seen, the fit with respect to this data moment (see Panel A in Table 4) masks some discrepancies in the exact profile of the transition probability. Finally, the calibration indirectly targets the level of the unemployment-to-nonparticipation transition probability among older workers (paragraph "Leisure shocks" in Section 4.1). Given the age distribution of unemployment, we find that this probability averages at 22.8 percent among older workers in the LF economy. The corresponding figure in CPS data among workers aged 55 to 64 is 20.8 percent.
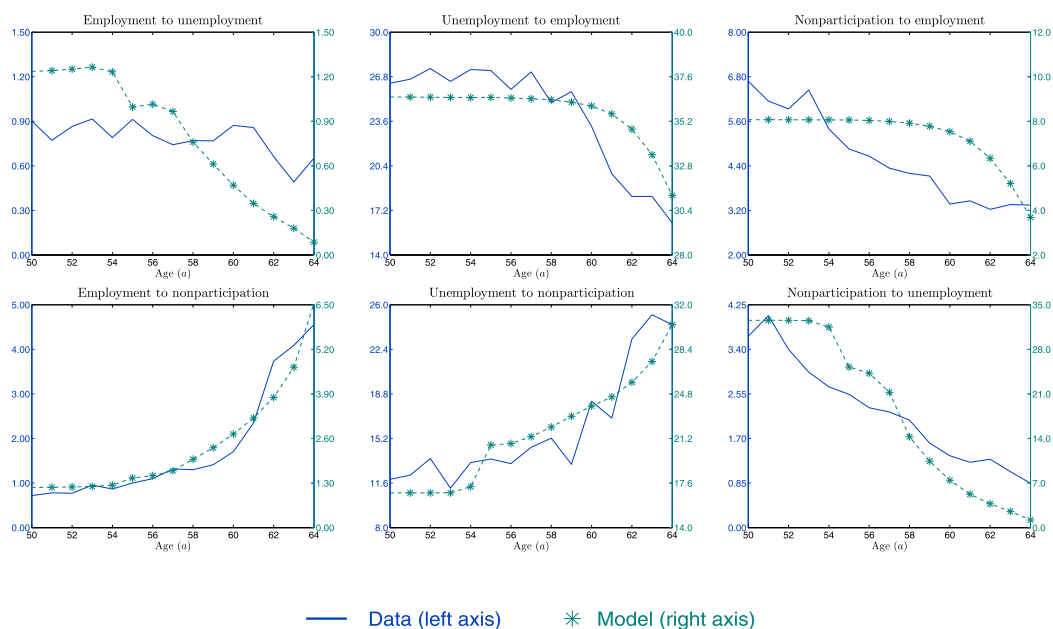
FIGURE 3. Life-cycle profile of transitions across employment, unemployment, and nonpartici-pation. *Notes*: Solid lines (plotted against the left axis): data from the CPS for the years 1976–1979; see Appendix A.2 for details. Dashed lines (plotted against the right axis): transition probabilities in the LF economy under tranquil times.

In the WS economy, the negative relationships between high z, high a, low h, and the probability of match formation are more pronounced. Unemployment insurance and early retirement benefits magnify these effects by raising the values of unemployment and nonparticipation. This holds true if the current benefit of the worker, b, matches his current skill level h (i.e., if $b = b(h)$), but the gradient is stronger if skills have deteriorated since the previous job (i.e., b is higher than the benefits matching the worker's current skill level). In fact, for a nontrivial region of the state space, older workers with depleted skills have a zero probability of drawing a productivity level resulting in positive match surplus; see Figure B.1 in the Appendix. Since age and skills are positively correlated in the cross-section, few workers reside in this region of the state space under tranquil times.

The effects of unemployment benefits on the probability of moving to nonpartici-pation are a priori ambiguous. On the one hand, they increase the flow value of stay-ing in the labor force, which could result in higher unemployment by deterring workers from moving to nonparticipation. This is an interesting property of the WS economy be-cause this labor supply effect of unemployment benefits is absent from standard search-matching models. On the other hand, unemployment benefits raise a worker's reser-vation wage and, therefore, lowers his probability of finding a job with positive match surplus. This provides an incentive to reduce search efforts by moving away from the labor force. Of course, the γ_a's contribute to weakening the ability of unemployment benefits to retain workers in the unemployment pool. In the baseline specification with

$\gamma_{55-59} = 0.0$ and $\gamma_{60-64} = 0.5$, these forces seem to balance one another out (Panel B of Figure B.2 in the Appendix). We show in Section 6.2 that changing the γ_a's can tilt the labor force decision in one direction or the other.

Putting it all together, the odds of returning to employment after being unemployed are higher when compared to returning from nonparticipation, and this pattern grows stronger with age as workers self-select themselves into the labor force. The age gradient is also steeper in the WS economy compared to the LF economy. This is illustrated by Figure B.3 in the Appendix, which is consistent qualitatively and, to some extent, quantitatively with the data shown in Figure 2.[31]

Changes in the wage profile

Section 4.3 relates the instability of earnings found in the data to the increase in economic turbulence. Rising earnings instability in the U.S. has been accompanied by a flattening of the wage-earnings profile of male workers, as documented in Kambourov and Manovskii (2009a), Guvenen and Kuruscu (2010), and Ravikumar and Vandenbroucke (2017). In a nutshell, workers who entered the labor market in the 1980s experienced a flatter wage profile compared to their peers who first started work in the 1960s. Figure 4 reports the wage profiles for the successive cohorts of workers who populate the
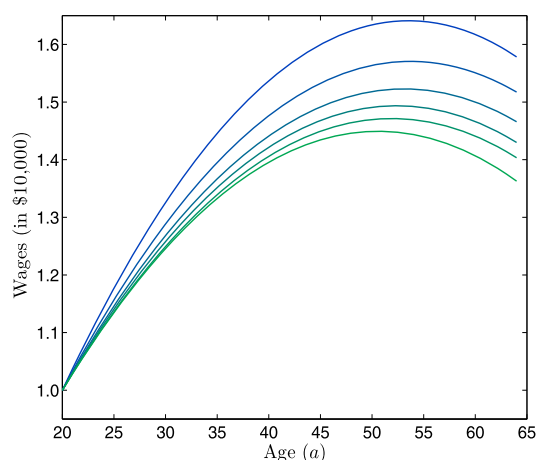

FIGURE 4. Flattening of the life-cycle wage profile. *Notes*: The upper line shows the life-cycle wage profile of a cohort of workers in the LF economy under tranquil times. The lines below show the life-cycle wage profile calculated in the same way in LF economies with an increasing degree of economic turbulence. The cohorts contain 50,000 individuals whose labor market trajectories are simulated for 45 years, and the profiles are computed using a standard mincerian regression model. The coefficients are multiplied by a common factor to normalize the intercept to $10,000 (the real wage of workers aged 20 in 1980).

[31]Due to data availability reasons, Figure 2 is based on recent labor force survey data. We thus draw on the LF and the WS economies under turbulent times to construct the odds ratios displayed in Figure B.3 in the Appendix. The model-generated odds ratios are not, however, very different in tranquil times.

LF economy in times of increasing turbulence.[32] As can be seen, the profiles become flatter with the degree of economic turbulence. This additional validation test suggests that the model is a relevant construct to analyze the consequences of turbulent times.

Earnings effects of skill loss

In the next section, we discuss the effects of higher rates of skill loss on aggregate labor market outcomes. As a preamble to that discussion, in Figure 5 we document the effects of skill loss at the worker level. The figure compares the earnings of two cohorts of workers in the LF economy: job-stayers (solid line) and displaced workers (dashed line).[33] Following Ljungqvist and Sargent (2008), the latter are those workers hit by the λ shock and whose skill loss in period zero exceeds one-third of their skill level h. The model predicts that job displacement leads to a drop in earnings by about 30 percent, with a substantial persistence over the subsequent 5 years. This finding lines up well with the size and persistence of earnings losses documented in the empirical literature following
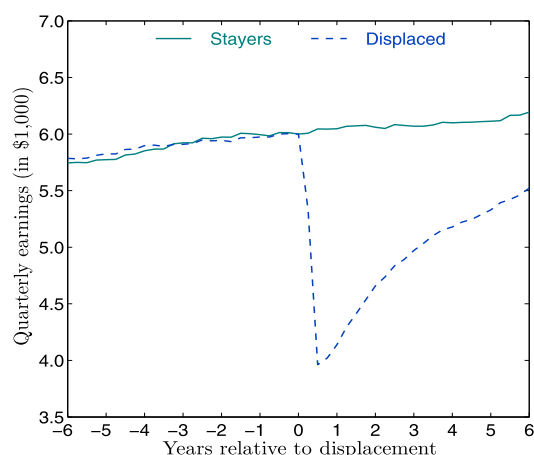

FIGURE 5. Earnings losses of displaced workers. *Notes*: The solid line shows the quarterly earnings of a typical cohort of workers in the LF economy with a degree of turbulence equal to 0.50. The dashed line shows the earnings of a cohort of workers displaced at time zero. Both cohorts contain 5,000 individuals whose labor market trajectories are simulated for 25 years prior to the displacement shock. Quarterly earnings at time zero are normalized to $6,000 to facilitate comparison with the study of Jacobson, LaLonde, and Sullivan (1993).

[32]To make the wage profiles comparable to those reported in the literature, we normalize the intercept to $10,000, which is roughly the average wage of male workers at age 20 in 1980 (expressed in U.S. dollars of that year). In the March CPS, the average wage of men aged 20 in 1980 was $9,345.

[33]This figure draws on the LF economy with a degree of turbulence set to 0.50. Table 5 shows that this degree of turbulence matches well the period centered at 1980, which is the period spanned by the study of Jacobson, LaLonde, and Sullivan (1993). This said, the degree of economic turbulence has almost no effect on the *relative* earnings losses of displaced workers. It increases their skill losses, but it also lowers the effects of human capital on earnings profiles (see Figure 4), and thus lowers the losses when we compare displaced workers to job stayers.

the work of Jacobson, LaLonde, and Sullivan (1993). It gives us confidence in the ability of the model to capture the effects of large, disruptive labor market events.

6. Numerical experiments

This section contains two sets of numerical experiments. In the first one, we study the impact of increasing economic turbulence over time. In these experiments, it is assumed that the policy parameters of the WS economy remain fixed at their baseline level. In the second set of experiments, we analyze the effects of changing the policy parameters that influence early retirement behaviors at a given point in time (i.e., holding the degree of economic turbulence constant).

6.1 *Changing degrees of economic turbulence*

This subsection unfolds as follows. We first analyze the outcomes and main mechanisms at work inside the LF economy and the WS economy. We then compare these results to the data describing the U.S. experience and the average experience of the "big three" countries of continental Europe.

Aggregate outcomes   Panel A of Table 6 allows us to gauge the implications of rising economic turbulence with respect to output, skills, wages, and the tax τ in the WS economy. We display these variables in their raw units of measurement to emphasize two features. First, the average skill level is similar across the two economies. On the one hand, the duration of employment spells is longer in the WS economy because productivity is less volatile and the employment protection tax Ω reduces the layoff rate. This has a positive impact on the skill level. On the other hand, the duration of nonemployment spells in the WS economy is also longer, which lowers the average skill level through skill depreciation. The latter effect becomes stronger in turbulent times. Second, output per worker (and hence net output) is lower in the WS economy. Again, both the volatility of productivity and employment protection contribute to those differences. A less volatile productivity process implies that worker-employer pairs experience positive shocks of a smaller magnitude. A high degree of employment protection entails a less efficient allocation of labor. In turbulent times, we observe a decrease in production, which is driven mostly by a lower average skill level across both economies.

Initially, the employment rate stands at 86.6 percent in the LF economy. The corresponding figure in the WS economy is 84.0 percent. Both decrease in turbulent times to 82.9 and 78.4 percent, respectively. The model therefore predicts a larger decline in employment in the WS economy (by 6.75 versus 4.57 percent in the LF economy). The unemployment rate is initially higher in the LF economy compared to the WS economy (5.10 versus 4.69 percent). Its response to negative shocks is stronger in the WS economy, resulting in roughly the same unemployment rates in the LF and WS economies during turbulent times (6.06 versus 6.07 percent). Finally, these outcomes are the product of a larger deterioration of employment among older workers. Similar results emerge in the employment–nonemployment job-search model of Ljungqvist and Sargent (2008). In the remainder of this subsection, we emphasize some important differences revealed by the addition of a labor supply decision in our framework.

Table 6. LF and WS economies in turbulent times.

		Degree of economic turbulence					
		0.00	0.20	0.40	0.60	0.80	1.00
A. Aggregate outcomes							
Tax rate τ		2.55	2.74	3.04	3.19	3.26	3.29
Net output	LF	1.822	1.757	1.676	1.641	1.626	1.618
	WS	1.539	1.468	1.379	1.340	1.323	1.316
Average skill level	LF	1.671	1.597	1.505	1.465	1.448	1.441
	WS	1.671	1.595	1.502	1.461	1.444	1.436
Average wage	LF	2.031	1.977	1.914	1.888	1.877	1.869
	WS	1.575	1.516	1.447	1.417	1.404	1.398
B. Prime-age workers							
Unemployment rate	LF	5.45	5.69	6.12	6.35	6.45	6.60
	WS	4.90	5.20	5.71	5.98	6.10	6.25
Job-finding rate (U to E)	LF	36.5	35.0	32.7	31.8	31.4	30.7
	WS	27.2	25.4	22.9	21.8	21.4	20.8
Separation rate (E to (U, N))	LF	2.38	2.40	2.45	2.48	2.49	2.51
	WS	1.64	1.64	1.66	1.67	1.67	1.68
Participation rate	LF	95.1	94.9	94.6	94.4	94.3	94.2
	WS	95.6	95.3	94.8	94.6	94.5	94.3
C. Older workers							
Unemployment rate	LF	3.84	3.87	3.90	3.91	3.89	3.90
	WS	3.79	4.03	4.46	4.74	4.86	5.04
Job-finding rate (U to E)	LF	35.6	34.0	31.6	30.6	30.2	29.6
	WS	19.0	16.0	12.0	10.3	9.60	8.67
Separation rate (E to (U, N))	LF	3.36	3.46	3.61	3.68	3.71	3.75
	WS	2.35	2.36	2.38	2.39	2.40	2.40
Participation rate	LF	79.9	77.6	74.0	72.3	71.6	70.6
	WS	65.9	61.9	56.0	53.4	52.2	50.8
Transition to nonparticipation (N)							
From employment (E)	LF	2.76	2.89	3.09	3.18	3.23	4.18
	WS	2.00	2.04	2.10	2.13	2.15	2.17
From unemployment (U)	LF	22.8	23.9	25.8	26.6	26.9	27.5
	WS	34.7	37.3	41.0	42.7	43.4	44.3

Note: The following abbreviations are used: E: employment; U: unemployment; N: nonparticipation. The tax rates in Panel A and the entries in Panels B and C are expressed in percentage points. Job-finding, separation rates (Panel B) and transitions to nonparticipation (Panel C) are monthly transition probabilities.

Age-specific outcomes　　Panels B and C of Table 6 report the consequences of turbulent times on employment among prime-age and older workers, respectively. More details are provided in Panel C in order to explain changes in the labor force participation rates of older workers.

Prime-age workers experience a slight decrease in employment, by 2.15 percent in the LF economy and 2.76 percent in the WS economy. As can be seen in Panel B, the rates of labor force participation remain almost unchanged, so that the bulk of employment

changes is driven by an increase in unemployment. The job-finding rate is the main variable explaining changes in the unemployment rate of prime-age workers. Notice that job-finding rates depend on three elements: labor market tightness, the decision rule for match formation, and the cross-sectional distribution of workers. It can be shown that the decrease in vacancies (and thus labor market tightness) accounts for the behavior of the job-finding rate among prime-age workers; see Appendix B.1. Conversely, shifts in the cross-sectional distribution lead to a compositional change that explain the increase in separation rates (employed workers have lower skills), but this plays little role in the dynamics of unemployment in Panel B.

The employment impact of turbulence is much more significant for older workers. Panel C indicates that their employment rates decreases by 11.7 percent in the LF economy, from 76.8 to 67.8 percent. The effect is twice as large in the WS economy: older worker employment rate decreases by 23.9 percent, from 63.4 to 48.2 percent. Their unemployment rate remains almost unchanged in the LF economy, while it increases by one-third in the WS economy. But the main effect is the decrease in labor force participation across the two economies. We highlight below that those changes (namely, -11.6 percent in the LF economy and -22.9 percent in the WS economy) are quantitatively consistent with the data. There are two mechanisms driving this effect. First, as shown by equation (19), the decrease in labor market tightness lowers the opportunity costs of being in nonparticipation relative to unemployment. Second, the cross-sectional distribution of the economy shifts toward older workers with a lower conditional probability of match formation, leading to a higher probability of moving to nonparticipation. The last rows of Panel C confirm that participation decreases because both employed and unemployed workers drop from the labor force earlier.

Older workers face a severe employability problem for two reasons. First, the process of building up human capital implies that age is correlated with a higher skill level (meaning relatively larger skill losses in turbulent times) and more generous welfare benefits. Second, the "horizon effect" (Chéron, Hairault, and Langot (2009, 2013)) implies that the returns to hiring older workers are lower.

More on the mechanisms   In turbulent times, labor force attachment among *employed* workers decreases. The model enables us to formalize this idea and quantify its implications. That is, we can use it to compute the share of employed workers who would choose nonparticipation over unemployment if they were not employed. We find that the workers account for 44.4 percent of employment at age 60 in the LF economy under tranquil times, and that this number rises to 56.0 percent in turbulent times. In the WS economy, the corresponding figure for workers aged 60 in tranquil times is 74.4 percent. This figure is so large that it increases "only" to 78.7 percent in turbulent times. Put differently, in the WS economy workers become less attached to the labor force at younger ages. For instance, 54.3 percent of employed workers would prefer nonparticipation over unemployment at age 58 in turbulent times. A direct implication of these observations is that wages should be less responsive to aggregate economic conditions at older ages.[34]

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[34]Hairault, Langot, and Zylberberg (2015) proposed a life-cycle employment model where older workers may prefer retirement over unemployment conditional on being out of work. The authors show that, if this

We can also use our model to ask how labor force attachment among *nonemployed* workers contributes and responds to aggregate outcomes. In experiments not reported here, we addressed two such questions. First, by self-selecting themselves out of the labor force, do workers contribute significant improvements to the quality of the pool of job seekers? The answer is a clear "no." Holding the surplus value of firms $v_{f_0}(y, b, h, z, a)$ fixed to its initial value while using the distributions $n(b, h, z, a)$ and $u(b, h, z, a)$ from turbulent times to calculate the returns to posting a vacancy, we found that labor market tightness (θ) was only marginally lower than in the equilibrium under tranquil times. The second question is: how much of the decline in labor force participation is driven by aggregate conditions measured by $f(\theta)$? To answer this, we performed a partial-equilibrium exercise, shifting the job-finding probability from its value in tranquil times to its value in turbulent times. Labor force participation among older workers decreased by only 1 to 2 pp. in the LF economy and around 3 pp. in the WS economy. In sum, the bulk of changes in labor force participation in Panel C of Table 6 comes from shifts in the cross section of workers, rather than shifts in the policy functions.

Taking stock　　We now examine the levels and trends observed in the data through the lens of the model. In Table 7, the set of rows titled "data" reports the relevant empirical moments measured at the beginning and end of the period considered, followed by their change measured in percentage terms. Panel A refers to the U.S. and Panel B displays the average of France, Germany, and Italy.

The first remarks concern the ability of the model to accurately describe labor force participation and explain its evolution from the early 1970s to the late 1980s. The LF economy matches the U.S. levels well, and effectively links the bulk of changes in labor force participation among older workers to the increase in economic turbulence. It predicts a decrease of 11.6 percent while the actual decrease is 13.5 percent. So, the model explains the decline in employment among older workers in the U.S. as the main driving force behind this dynamic is the change in their labor force participation. Similarly, the WS economy provides a good quantitative account of the behavior of labor force participation among older workers in Europe. The table shows that, through the lens of this economy, the increase in turbulence leads to a fall in participation by 22.9 percent versus 24.1 percent in the data. Meanwhile, as we discuss below, it cannot rationalize the important changes that accompanied this dynamic.

The explanatory power of the model is lower along the other dimensions. In line with the U.S. data, the LF economy exhibits little change in labor force participation among prime-age workers, but it predicts little change in the unemployment rates of

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so happens, then the search externality vanishes for older employed workers because their Nash-bargained wage is independent of labor market tightness. The "unattached employed workers" in our model are in similar, but not identical, positions. While they prefer nonparticipation over unemployment given their current state variables, they may still experience a negative shock to leisure utility (z) or positive productivity shocks (y or h) that reverse this ordering.

TABLE 7. Employment changes: LF and WS economies versus data.

		Early 1970s	Late 1980s	% Change
A. United States				
Unemployment rate, 25–54	Data	3.59	5.53	+54.1
	LF	5.45	6.60	+21.1
Participation rate, 25–54	Data	94.9	93.5	−1.50
	LF	95.1	94.2	−0.95
Unemployment rate, 55–64	Data	3.10	4.35	+40.5
	LF	3.84	3.90	+1.56
Participation rate, 55–64	Data	78.0	67.5	−13.5
	LF	79.9	70.6	−11.6
B. Europe				
Unemployment rate, 25–54	Data	1.51	4.74	+213
	WS	4.90	6.25	+27.6
Participation rate, 25–54	Data	97.0	93.9	−3.20
	WS	95.6	94.3	−1.36
Unemployment rate, 55–64	Data	2.55	5.64	+121
	WS	3.79	5.04	+33.0
Participation rate, 55–64	Data	67.7	51.4	−24.1
	WS	65.9	50.8	−22.9

Note: Panels A and B: data from the OECD labor force database for male workers; see Appendix A.1 for details. The early 1970s (resp. late 1980s) refer to the mean value over the years 1970–1974 (resp. 1986–1990). In Panel B, Europe refers to the (unweighted) average of statistics for France, Germany, and Italy. All entries in both panels are expressed in percentage points.

prime-age and older workers.[35] The fit of the WS economy with respect to European unemployment rates is also less satisfactory. This is not surprising for the levels of unemployment in the early 1970s since the calibration of the WS economy does not target these moments.[36] But the model does miss by a significant margin the outbreak of high European unemployment that occurred at the end of the 1970s. It predicts only between 10 and 30 percent of those changes, depending on the demographic group considered. In light of these results, it seems that rising economic turbulence cannot explain high unemployment if one accounts for the endogenous labor supply decisions of workers.

Here, we make two additional comments. First, we have thus far analyzed the consequences of rising economic turbulence in two economies which differ with respect

[35]The data moments in the first column of Table 7 are calculated over the years 1970 to 1974. Thus, they are slightly different from the data moments of the calibration, which capture the state of the U.S. labor market at the onset of the 1970s (see Panel A of Table 4). In particular, the unemployment rates in Table 7 are lower because of the recovery period after the 1970 U.S. recession. Note that this makes the relative change (last column of Table 7) in unemployment from the early 1970s to the late 1980s look larger in the data.

[36]The calibration minimizes unemployment while targeting the rate of labor force participation. A higher value of the matching efficiency parameter (M) lowers unemployment but it increases the incentives to participate in the labor force. The standard deviation of productivity shocks (σ) helps strike a balance to obtain lower unemployment rates among older workers relative to unemployment among prime-age workers.

to both labor market institutions and some technology parameters. To measure the effects of the *interaction* between economic turbulence and institutions, we would need to remove the difference in technology parameters. We did so in experiments not reported here: we studied a laissez-faire economy with the parameters M and σ of the baseline WS economy. Subtracting technological differences closed almost half of the gap in labor market outcomes between the LF and WS economies. For instance, labor force participation among older workers decreases by 16.2 percent from tranquil to turbulent times in the reparametrized LF economy (versus 11.6 percent in the baseline). We conclude that per se the interaction between turbulence and institutions explains at least 50 percent of the differences between the two economies.

The other comment relates to the timing of employment changes analyzed in this section. On the one hand, the increase in turbulence as measured by the transitory component of earnings ends during the late 1980s (footnote 29), which is also the period when labor force participation among older workers stabilizes in the U.S. On the other hand, in Europe, the downward trend in labor force participation continues after this period (see Figure 1). It is conceivable that the adoption of new information technologies and the induced changes in organizations and work practices occurred later in Europe than in the U.S. Yet a perhaps more promising explanation is that there were also changes in labor market institutions that impacted labor force participation among older workers in Europe. The next subsection presents results that substantiate this explanation.

6.2 *Changing labor market institutions*

In this subsection, we begin by briefly describing the relevant changes in a specific labor market institution—early retirement schemes—during the period from the 1970s to the 1990s. Then we use our model to analyze the nature and magnitude of the employment effects of those changes.[37]

Summary of the evidence   The chapters collected in Gruber and Wise (2010) document a trend toward policies that incentivized older workers to withdraw from the labor market, followed by a reversal starting in the 1990s. Here, we summarize the salient facts for France, Germany, and Italy.[38]

France developed several early retirement schemes targeted at workers aged 60 to 65 in the 1970s. The most important of these was the so-called *Guarantie de ressources*,

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[37]Existing evaluations of the employment effects of early retirement policies are mostly based on reduced-form analyses. For instance, one regresses the unemployment rate for the younger on the labor force participation rate of older workers, while exploiting some policy discontinuities or controlling for variables that may lead to spurious correlation. In this section, we study the equilibrium response of the labor market following a change in the parameters of early retirement policies. We use the variations of labor force participation among older workers prompted by the policy change to calculate the employment and unemployment elasticities reported in Table 9.

[38]Our summary for France is based on the chapter written by Ben Salem et al. (2010); for Germany on the chapter by Börsch-Supan and Schnabel (2010); and for Italy on the chapter by Brugiavini (2010). The book by Gruber and Wise (2010) contains specific chapters for five other European countries, namely Belgium, the Netherlands, Spain, Sweden, and the U.K.

which was introduced in 1972 for laid-off workers and extended in 1977 to those who voluntarily quit their jobs. An additional phase of early retirement schemes targeted at workers aged over 55 years was implemented in the 1980s (in addition to lowering the normal retirement age from 65 to 60). These schemes worked through an unemployment insurance route: they exempted older workers from searching for a job, and provided them with benefits until they become entitled to a full-rate pension. The 1993 Balladur reform of the pension system marks the end of the trend toward promoting early retirement.

In (West) Germany, initially the only option for men to retire before the age of 65 was to prove a disability. A first reform was passed in 1972 with the stated goal of "providing more leisure to the workers" (Börsch-Supan and Schnabel (2010, p. 152)). The most important changes took place in the 1980s, when more generous unemployment benefits for workers aged 55 to 59 were introduced in order to create a "bridge to retirement." These benefits were not means tested, and in addition workers were exempted from the need to meet job-search requirements. The reversal of trend was initiated by the 1992 reform leading to (quasi-)actuarial adjustments to the benefit system. The new phase of policy changes includes the 2001 Riester reform and some elements of the Hartz reforms.

In what regards early retirement benefits in Italy, "after World War II, acts of Parliament enacted piecemeal changes that went almost invariably in the direction of increasing generosity, with no concern about the long-term effects of these amendments" (Brugiavini (2010, p. 195)). The first attempts to cut the incentives for workers to withdraw from the labor force long before retirement age were made in 1984. The government introduced a minimum eligibility level for yearly earnings that counted as full for social security tax payments. It also tightened the eligibility criteria for, and limited their duration of, disability insurance benefits. But the trend really came to an end with the 1992 Amato reform and the 1995 Dini reform of the social security system.

The WS economy can speak to the effects of changing policies toward early retirement. True, it does not contain an explicit model of the policies, but it can at least capture their effects on the incentives (in terms of flow value) of remaining in the labor force instead of dropping out into early retirement programs. For workers aged 55 to 64, this additional incentive is given by $(1 - \gamma_a)b$. Our approach is to explore the range of values between two extreme benchmarks: we do this by varying the parameter γ_a from zero to 100 percent to measure the effects of eliminating the flow value of participating in the labor force. Noting that early retirement policies were implemented as early as the 1970s and were seldom repealed before the 1990s, we also explore two extreme cases in terms of economic context: namely, we study their effects in both tranquil times and turbulent times.

In what follows, it is important to note that the WS economy is slightly different from that studied in Section 6.1 in that we recalibrate the WS economy in line with changes made to the parameter γ_a. The calibration procedure and parameter values are provided in Appendix B.2.

Employment effects Table 8 reports the effects of changing early retirement incentives on unemployment and labor force participation among older workers. To do so, our main instrument is the parameter γ_{60-64}, which crucially affects the incentives offered to workers aged 60 to 64. In keeping with out approach of exploring extreme benchmarks, we consider two alternatives for the other parameter, γ_{55-59}: we keep it either fixed to zero or we set it equal to γ_{60-64}.

The first remark is that early retirement incentives are very effective in reducing labor force participation among older workers. In the various environments considered, we find that changing the parameters governing the generosity of those schemes can decrease participation by about 40 to 45 percent. There is substitution with unemployment: the unemployment rate of older workers decreases by roughly one pp. in tranquil times and two pp. in turbulent times. Again, this effect revolves around reducing the relative losses of nonparticipation shown in equation (19). Note that the effect on unemployment is not always linear. An increase in γ_a can increase the value of employment (the worker will bargain for a higher wage at older ages) while having little impact on the probability of match formation. This channel implies a higher opportunity cost of nonparticipation, and thus explains the slight increase in unemployment at lower values of γ_a.

Table B.1 in the Appendix is the analogue for prime-age workers of Table 8. In that table, we report that labor force participation among workers aged 25 to 54 is very insensitive to early retirement policies, but that their unemployment rates are somewhat more responsive. There are two macro-channels that could be driving this result, and which may interact with one another. First, early retirement schemes improve the bargaining position of workers and thereby lead to lower returns to job creation. Second, increasing the generosity of these schemes leads to an increase in the tax rate τ to meet the government budget constraint. We find that the unemployment effects are mostly driven by the negative impact on job creation.

TABLE 8. Effects of early retirement incentives on employment among older workers.

		Generosity of incentives γ_{60-64}				
		0.00	0.25	0.50	0.75	1.00
A. Tranquil times						
Unemployment rate	$\gamma_{55-59}=0$	3.97	4.08	4.07	3.81	3.24
	$\gamma_{55-59}=\gamma_{60-64}$	3.71	3.84	3.87	3.51	2.64
Participation rate	$\gamma_{55-59}=0$	77.2	71.5	64.9	58.3	52.7
	$\gamma_{55-59}=\gamma_{60-64}$	78.1	71.6	63.4	54.4	45.7
B. Turbulent times						
Unemployment rate	$\gamma_{55-59}=0$	5.81	5.96	5.76	4.94	3.94
	$\gamma_{55-59}=\gamma_{60-64}$	5.56	5.73	5.57	4.79	3.83
Participation rate	$\gamma_{55-59}=0$	59.8	53.3	46.3	39.3	33.0
	$\gamma_{55-59}=\gamma_{60-64}$	60.5	54.0	46.9	39.9	33.5

Note: Results for older workers: calculations are based on the parameter values reported in Table 3 and the recalibrated parameter values reported in Appendix B.2. All entries are expressed in percentage points.

Quantitative appraisal   Next, we synthesize the impact of early retirement programs by evaluating several employment and unemployment elasticities. As already mentioned, the goal is to get a sense of the nature and magnitude of the main effects, using the variations of labor force participation among older workers triggered by policy changes. We let ω_a denote the population share of age group a ($a = 25$–54 for prime-age workers and $a = 55$–64 for older workers), and denote by e_a, u_a, p_a the employment, unemployment, and labor force participation rates, respectively. Also, we use ϵ_k to denote the elasticity of $k \in \{e_a, u_a, p_a\}$ with respect to participation among older workers. The main accounting equation is:

$$\epsilon_e = \omega_{25-54} \frac{e_{25-54}}{e} \epsilon_{e,25-54} + \omega_{55-64} \frac{e_{55-64}}{e} \epsilon_{e,55-64}. \tag{23}$$

This equation decomposes the effects of older worker participation rates on the aggregate employment rate through two channels: directly through employment in this age group ($\frac{e_{55-64}}{e} \epsilon_{e,55-64}$) and indirectly through employment among younger workers ($\frac{e_{25-54}}{e} \epsilon_{e,25-54}$).

Table 9 reports the employment elasticities that enter equation (23) and two unemployment elasticities, $\epsilon_{u,25-54}$ and $\epsilon_{u,55-64}$. Consider first the employment effects among older workers. The relevant elasticities are linked by: $\epsilon_{e,55-64} = 1 - \frac{u_{55-64}}{1-u_{55-64}} \epsilon_{u,55-64}$. Thus, the calculations verify that nonparticipation among older workers is essentially a substitute for unemployment ($\epsilon_{u,55-64}$ is positive), which leads to an employment elasticity of around 1 minus the unemployment rate in all instances. Turning to the effects on prime-age workers, we see that $\epsilon_{u,25-54}$ is *negative*, showing that older worker nonparticipation is complemented by unemployment among younger workers. The effects on the employment rate of prime-age workers is inherently more modest. Here, the relevant accounting equation is: $\epsilon_{e,25-54} = \epsilon_{p,25-54} - \frac{u_{25-54}}{1-u_{25-54}} \epsilon_{u,25-54}$, which yields smaller absolute values since $\epsilon_{p,25-54} \approx 0$.

The last column of Table 9 displays the results based on equation (23). We draw two main conclusions. First, the complementarity between older worker nonparticipation and unemployment at younger ages has a nonnegligible impact on aggregate employ-

TABLE 9. Adding up the employment effects of early retirement incentives.

	Elasticities by Age Groups				
	$\epsilon_{u,25-54}$	$\epsilon_{e,25-54}$	$\epsilon_{u,55-64}$	$\epsilon_{e,55-64}$	Total ϵ_e
A. Tranquil times					
$\gamma_{55-59} = 0$	-0.236	0.022	0.396	0.983	0.201
$\gamma_{55-59} = \gamma_{60-64}$	-0.242	0.022	0.374	0.985	0.197
B. Turbulent times					
$\gamma_{55-59} = 0$	-0.144	0.024	0.587	0.965	0.158
$\gamma_{55-59} = \gamma_{60-64}$	-0.164	0.025	0.574	0.967	0.159

Note: Calculations are based on the parameter values reported in Table 3 and the recalibrated parameter values reported in Appendix B.2.

ment. A simple calculation illustrates this. $\epsilon_{e,55-64}$ is close to 1, the population share of older workers (among workers aged 25 to 64) ω_{55-64} is 0.25, and their relative employment rate, e_{55-64}/e, is about 70 percent in tranquil times and 55 percent in turbulent times. As a result, $\omega_{55-64}\frac{e_{55-64}}{e}\epsilon_{e,55-64}$ is roughly one-quarter of 70 percent (0.175) in tranquil times, and one-quarter of 55 percent (0.138) in turbulent times. But due to the negative value of $\epsilon_{u,25-54}$, the elasticity of aggregate employment is 15 percent *higher* than this number. Second, and somewhat conversely, the magnitude of the elasticity $\epsilon_{u,25-54}$ is too small to trigger large unemployment responses. Thus, although in Section 6.1 we ignored potential changes in retirement policies over time, these cannot explain the discrepancy between the WS economy and the outbreak of high European unemployment.

7. Conclusion

We provide a novel assessment of the effects of rising economic turbulence and its interaction with labor market institutions. To this end, we develop a rich life-cycle model featuring two sources of nonemployment: there are frictions in the labor market and agents face a nondegenerate labor supply problem. Our first result is that rising economic turbulence consistently explains the lower labor force participation of older workers, and how it has contributed to the decline in aggregate male employment in the U.S. Thus, turbulence is not just an account of the steady U.S. unemployment rate. Second, economic turbulence and institutions explain the much larger decrease in labor force participation among older workers in Europe. However, neither of these factors offer much in terms of explaining the increase in unemployment, which is somewhat in contrast with the standard interpretation of the effects of those shocks. Finally, we find that the early retirement policies of the 1970s–1990s period, although detrimental to employment, cannot bring the model closer to explaining the era of high unemployment in Europe.

Our model generates worker transition probabilities across employment, unemployment, and nonparticipation, with some success in explaining how these probabilities change over the life cycle. It would be interesting for future work to develop a version of the model that fits these transition probabilities from labor market entry to labor market exit—in all likelihood, this would be achieved by removing some layers of worker heterogeneity that were relevant for this paper. This model could shed light on the structural determinants (e.g., preferences, technology) of the large life-cycle variations of worker flows observed in the data. It would also be useful to develop cross-country empirical evidence on the life-cycle profile of transition probabilities between the three labor market states. The model, or a modified version of it, could serve as a structural tool to analyze the discrepancies and relate them to cross-country differences in labor market institutions. On a related note, the model could help understand why the effects of certain labor market policies (e.g., minimum wage, employment protection) are so heterogeneous over the life cycle.

Appendix A: Data Appendix

A.1 *Cross-country time series*

Our analysis of cross-country time series is mostly based on data from the Organisation for Economic Co-operation and Development (OECD) labor force database (http://stats.oecd.org/). The OECD provides employment and labor force participation statistics harmonized for the purpose of developing cross-country comparisons. These data are available at the country level but also at a finer level, namely gender and different age groups. The disaggregated data are not census-based, however: they are taken from labor force surveys, which usually span a shorter period of time. Therefore, we complement our analysis of OECD data as follows:

• For France, the OECD data coverage begins in 1983. We compute the time series prior to 1983 directly from the French Labor Force Survey. The 1968–1982 waves of the survey are obtained from the repository of the *Réseau Quetelet* (http://www.reseau-quetelet.cnrs.fr/).

• For Germany, the OECD database before 1991 covers West Germany only. There is no ideal method to address this data issue. Meanwhile, the OECD West German data is available up until 1998, meaning we can conduct sensitivity checks using these data. In results available upon request, we find that the stylized facts of Section 2 are also borne out by the West German data.

• For Italy, several time series from the OECD database exhibit large discontinuities in 1982 and 1993. We remove the breaks in the OECD data by aligning those time series to their respective counterparts provided by the Italian National Institute of Statistics (http://dati.istat.it/).

• For Spain and Norway, the OECD data coverage begins in 1972. For Portugal, the data coverage begins in 1974. We make no attempt to expand these data before the first period of observation. No adjustment is required for Sweden, as the OECD Swedish data begin as early as 1963.

A.2 *Life-cycle profile of transition probabilities*

In order to study transition probabilities, we use microdata that allow us to link respondents longitudinally over time. The data come from the French Labor Force Survey (LFS), the German Socio-Economic Panel (GSOEP), the Italian sample of the European Union Statistics on Income and Living Conditions (EU-SILC), and the monthly Current Population Survey (CPS). The latter data are available as of 1976, so that we can construct transition probabilities for the U.S. even before the 1980s (see Figure 3). In Figure 2, we use CPS data from the years 2005–2015 to match the time period spanned by the other datasets.

Using the linked data, we compute the transition probability of moving across labor market states (employment, unemployment, nonparticipation) for each group of individuals of age a observed during period t. Let q^{ij} denote the transition probability of

moving from i to j (where i and j denote a labor market state). We estimate the following regression model:

$$q_{a,t}^{ij} = \vartheta_a \mathbf{D}_a + \vartheta_t \mathbf{D}_t + \varsigma_{a,t}, \tag{24}$$

where $\mathbf{D}_a$ (resp. $\mathbf{D}_t$) is a full set of age (resp. time) dummies and $\varsigma_{a,t}$ is the residual of the regression. The coefficients ϑ_a on the age dummies is the life-cycle profile of the transition probability q^{ij}.

A.3 *Displacement and job tenure*

We use data from the biennial Displaced Worker supplements of the CPS to pin down a value for λ, the probability of job displacement.[39] We supplement these data with a measurement of declining occupations, which we compute from the March CPS (see the notes to Table A.1 for details). We think of declining occupations as a proxy for the loss of human capital triggered by the λ shock.[40]

Table A.1 reports the average job tenure of displaced workers stratified in various ways. Our preferred estimates are displayed in the second row of the table, which focuses on workers with at least 1 year of job tenure prior to displacement. As can be seen, for those who report that their previous plant or company was closed down or that their position was abolished, job tenure is 7.4 years on average. The figure is slightly lower at 6.9 years when we include workers who lost their job because of insufficient work, while it increases to over 8.1 years for workers previously employed in declining occupations. The average of these two numbers is 7.5, which we use to parametrize λ.

TABLE A.1. Years of job tenure prior to displacement.

	Reason for Job Loss		Declining Occupations		
	Any	(i) and (ii)	Top 25	Top 10	Top 5
All workers	5.10	5.93	5.92	6.14	6.96
At least 1 year of tenure	6.88	7.41	8.05	8.17	9.11

Note: Data from the Displaced Worker supplements of the CPS for male workers aged 30 to 54. The reported reasons for job loss are: (i) "Plant or company closed down or moved," (ii) "Plant or company is still operating but the job was lost because the position or shift was abolished," (iii) "Plant or company is still operating but the job was lost because of insufficient work." The ranking of occupations is constructed as follows: we regress the employment share of each 2-digit occupation against a linear time trend (the data come from the March CPS and cover the past 40 years), and use the OLS coefficient on the time trend to rank occupations from the top declining to top expanding ones.

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[39]The Displaced Worker supplements provide information on the reason for losing the previous job, the length of time worked at this job and numerous job characteristics. We restrict the analysis of these data to workers aged 30 and above because a very large number of workers under age 30 report zero years of work experience at the lost job.

[40]Returns to tenure indicate that human capital is predominantly occupation specific (Kambourov and Manovskii (2009b)). Suppose a worker gets displaced from his job and his previous occupation of employment has shrunk, so that his probability of reemployment in that occupation is small. This situation is very much akin to: $\mu_d(h, h) < 1$.

A.4 *Transitory variance of earnings*

The analysis of earnings instability is based on data from the Panel Study of Income Dynamics (PSID). Our sample includes male heads of household aged 20 to 54, who are neither self-employed, dual-employed or working for the government. As is standard, we first retrieve the residual part of wages that is not explained by life-cycle effects and/or by education. We do so by running the OLS regression: $\log(w)_{i,t} = \mathbf{x_{i,t}}\delta_t + v_{i,t}$ year by year, where $\log(w)_{i,t}$ is the log of annual earnings and $\mathbf{x_{i,t}}$ includes a quartic polynomial of age and its interaction with educational dummies. Thus, the earnings variable we study is: $\widehat{v}_{i,t} = \log(w)_{i,t} - \mathbf{x_{i,t}}\hat{\delta}_t$.

Following Gottschalk and Moffitt (1994, 2009), we select a fixed calendar window to estimate the permanent and transitory components of earnings. We use a 15-year window to compute the permanent component, which is estimated by $\overline{\widehat{v}_{i,t}}$ (the top bar denotes the average with respect to calendar time). The transitory variance is then estimated using:

$$\widehat{\mathbb{V}(\zeta_i)} = \frac{1}{N} \sum_{i=1}^{N} \left[\frac{1}{T_i - 1} \sum_{t=1}^{T_i} (\widehat{v}_{i,t} - \overline{\widehat{v}_{i,t}})^2 \right]. \tag{25}$$

We refer to a time window by taking the middle year of the time window, that is, 1975 denotes the time window 1968–1982. We note that there is a difference in *levels* between the transitory variances in Panel A of Table 5 and those reported by Gottschalk and Moffitt (1994, 2009): ours are closer to Kambourov and Manovskii (2009a) due to sample dispositions and the length of the time window used to compute $\widehat{v}_{i,t}$. The *trend* in earnings instability shown in Table 5 is in line with both set of studies.

Appendix B: Model Appendix

B.1 *Policy functions*

Panels A and B in Figure B.1 show the probability of match formation conditional on meeting an employer in the LF economy and the WS economy, respectively.[41] This probability is given by $1 - G_{0,h}(\widetilde{y}_0(b, h, z, a))$. It depends on welfare benefits b (in Panel B), current skills h, leisure utility z and age a. In both panels, the plots show the probability conditional on a value of z: z_{25} is the first quartile of the grid points for z, z_{50} is the median, and z_{75} the third quartile.[42] We interpolate the probability with respect to the skill level h to improve legibility.

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[41]We focus on the match formation probabilities because they are more directly interpretable. Consider for instance the relationship between the policy function $\widetilde{y}_0(b, h, z, a)$ and the worker's skill level, h. A higher skill level allows agents to draw a match productivity level from a better probability distribution (in the sense of first-order stochastic dominance). Thus, the reservation value $\widetilde{y}_0(b, h, z, a)$ tends to *increase* with h, but in general this does not mean that the probability of match formation *decreases* with h. To fix ideas, in the computations, the interval where y resides for a worker with skill level h is: $[\overline{y}_h - \frac{2\sigma}{\sqrt{1-\rho^2}}, \overline{y}_h + \frac{2\sigma}{\sqrt{1-\rho^2}}]$.

[42]By construction of the stochastic process for z, and because newborn workers sample z uniformly, the cross-sectional distribution of workers with respect to this variable is uniform over $[0, z_{\sup}]$. Therefore, one-quarter of the population has z below z_{25}, another quarter has z between z_{25} and z_{50} and so on.

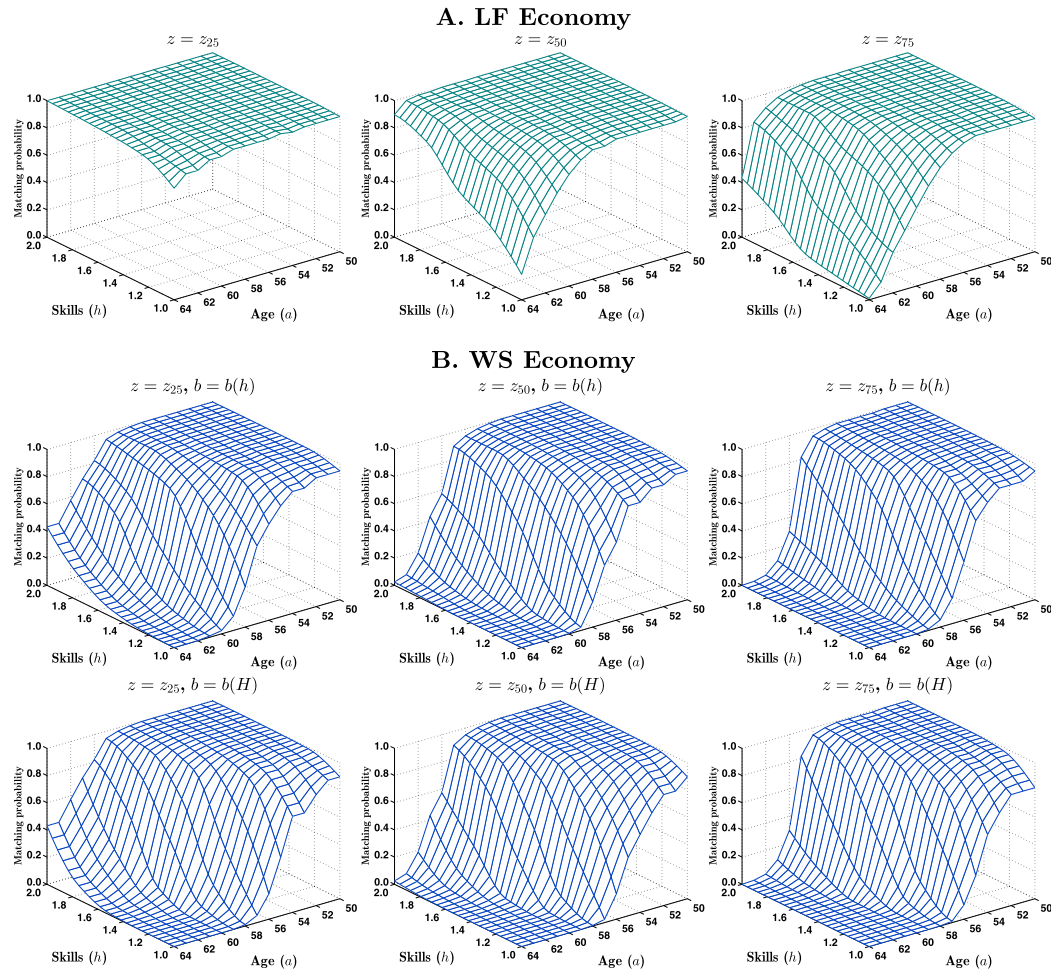**A. LF Economy**

B. WS Economy

FIGURE B.1. Conditional probability of match formation, $1 - G_{0,h}(\widetilde{y}_0(b, h, z, a))$. *Notes*: The plots show the matching probabilities (probability of match formation conditional on meeting an employer) in the LF economy (Panel A) and in the WS economy (Panel B). In Panel B, the upper set of graphs shows the probability for workers whose welfare benefit amount, b, matches their current skill level, h. The lower set of graphs shows the probability for workers with the highest level of welfare benefits, $b(H)$.

In the LF economy, when an nonemployed worker and a vacancy meet (Panel A), they almost always match with probability 1.[43] The probability decreases at the end of the working life (high a), and especially so if the worker's valuation of leisure (z) is high. In the WS economy (Panel B), we report two sets of plots of the probability $1 - G_{0,h}(\widetilde{y}_0(b, h, z, a))$. In the upper set of plots, a worker's benefit b matches his cur-

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[43]Since $G_{0,h}(y) = G_h(y|\overline{y}_h)$ and the interval for y conditional on h is centered at $\overline{y}_h$, there is very little mass in the tails of the probability distribution $G_{0,h}$. Therefore, the matching probability can be very close to 1 even if the productivity threshold $\widetilde{y}_0(b, h, z, a)$ is strictly above the lower bound of the support.

rent skill level ($b = b(h)$). In the lower set of plots, the matching probability is that faced by workers who are entitled to the highest level of benefits ($b = b(H)$). Thus, in these plots except for $h = H$ on the horizontal axis, a worker who accepts a job in this period must forego his high unemployment benefit and faces the risk of receiving $b(h) < b(H)$ if the job is destroyed shortly after. This results in a slight flattening of the match formation probabilities, while preserving the negative relationships with respect to low h, high z, and high a.

For the sake of space, we do not report a plot illustrating the differences in decision rules between match formation ($\widetilde{y}_0(b, h, z, a)$) and match continuation ($\widetilde{y}_+(h, z, a)$).[44] It is straightforward to describe how these policy functions differ. The match surplus is an increasing function with respect to idiosyncratic match productivity, y. Hence, by inspecting equations (16) and (17), we see that the employment protection tax Ω shifts the thresholds for match continuation downwards (*ceteris paribus*, i.e., if we compare $\widetilde{y}_+(h, z, a)$ with $\widetilde{y}_0(b(h), h, z, a)$). In other words, Ω makes employers retain their incumbent workers at lower values of y relative to selection at the entry level.

Figure B.2 plots the probability of moving to nonparticipation following a shock to leisure utility, z. Again, we "plug" the policy function into the relevant probability distribution to facilitate interpretation. Let us denote by F_0 the uniform distribution over the support $[0, z_{\text{sup}}]$, and recall that when leisure switches from z to z', the new value z' is drawn from F_0 independently of z. Therefore, the conditional probability of moving to nonparticipation is given by $1 - F_0(\widetilde{z}(b, h, a)) = 1 - \widetilde{z}(b, h, a)/z_{\text{sup}}$. Panels A refers to the LF economy and Panel B refers to the WS economy with either $b = b(h)$ or $b = b(H)$. The relevant properties of the probability $1 - F_0(\widetilde{z}(b, h, a))$ are discussed in Section 5.

B.2 *Alternative calibrations*

To calibrate the WS economies used to discuss the effects of changing incentives toward early retirement, we proceed in the following way. Consider the first alternative where γ_{55-59} remains set at 0. We explore values of the parameter γ_{60-64} ranging from 0 to 1, so we first apply the calibration procedure presented in Section 4 to these polar cases and obtain two sets of values for the calibrated parameters M, σ, ϕ, Ω. Then we take the average of these values to parametrize the WS economy. The values we obtain are: $M = 0.688$, $\sigma = 0.290$, $\Omega = 6.540$, $\phi = 0.372$. We proceed in the same way for the other alternative when γ_{60-64} is changed from 0 to 1, namely the WS economy with $\gamma_{55-59} = \gamma_{60-64}$. The calibration procedure yields: $M = 0.761$, $\sigma = 0.283$, $\Omega = 6.497$, $\phi = 0.371$.

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[44]Note that the match continuation policy function $\widetilde{y}_+(h, z, a)$ cannot be easily represented by plugging it into a probability distribution (unlike the policy function $\widetilde{y}_0(b, h, z, a)$). Consider for instance the probability of endogenous job destruction in a match with current state variables y, h, z, a. That probability is given by $G_h(\widetilde{y}_+(h, z, a)|y)$, which is a four-dimensional object. The "y" dimension makes it especially inconvenient to represent $G_h(\widetilde{y}_+(h, z, a)|y)$ graphically since y and h are correlated: the correlation makes it unclear how to fix y in order to compare the job destruction probability at two different values of h.
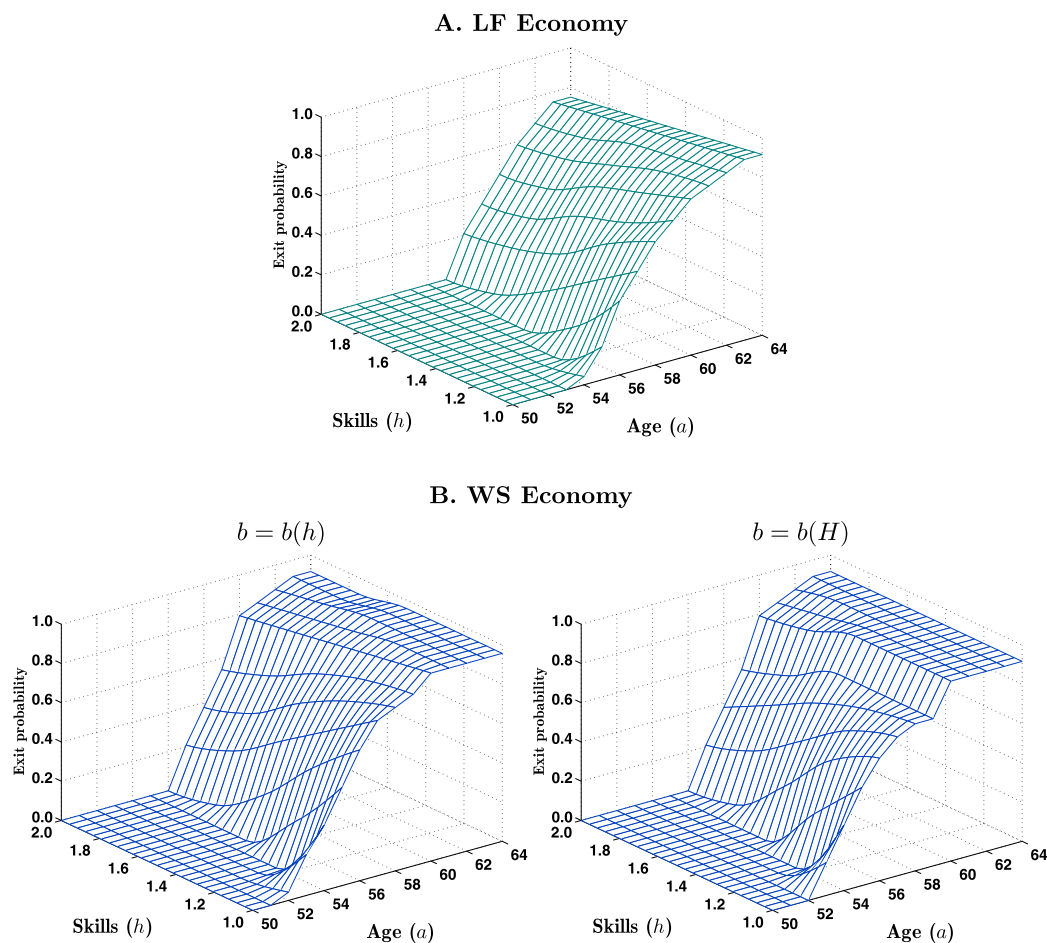
A. LF Economy

B. WS Economy

$b = b(h)$ $b = b(H)$

FIGURE B.2. Conditional probability of moving to nonparticipation, $1 - F_0(\widetilde{z}(b, h, a))$. *Notes*: The plots show the exit probabilities (probability of leaving the labor force conditional on drawing a new value of leisure utility z) in the LF economy (Panel A) and in the WS economy (Panel B). In Panel B, the left graph shows the probability for workers whose welfare benefit amount, b, matches their current skill level, h. The right graph shows the probability for workers with the highest level of welfare benefits, $b(H)$.

B.3 *Additional figure and table*

Figure B.3 shows the odds ratios of moving to employment from unemployment relative to nonparticipation in the two model economies. These odds ratios are discussed in Section 5. Table B.1 is the analogue for prime-age workers of Table 8 in the paper: the table reports the effects on employment among these workers of changing the incentives toward early retirement. We discuss the results in Section 6.2.
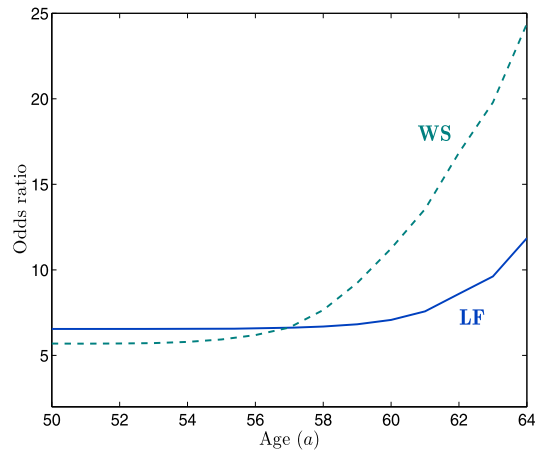
FIGURE B.3. Odds ratio of moving to employment from unemployment relative to nonpartici-pation. *Notes*: The lines show the ratio between $q_a^{UE}/1 - q_a^{UE}$ and $q_a^{NE}/1 - q_a^{NE}$ where q_a^{UE} (resp. q_a^{NE}) is the life-cycle profile of transition probabilities from unemployment to employment (resp. from nonparticipation to employment). The solid (resp. dashed) line denotes the LF economy (resp. WS economy). In each economy, the odds ratio are computed in the equilibrium under turbulent times.

TABLE B.1. Effects of early retirement incentives on employment among prime-age workers.

		Generosity of Incentives γ_{60-64}				
		0.00	0.25	0.50	0.75	1.00
A. Tranquil times						
Unemployment rate	$\gamma_{55-59} = 0$	4.59	4.69	4.81	4.92	5.01
	$\gamma_{55-59} = \gamma_{60-64}$	4.30	4.40	4.54	4.70	4.83
Participation rate	$\gamma_{55-59} = 0$	95.9	95.8	95.7	95.6	95.5
	$\gamma_{55-59} = \gamma_{60-64}$	96.1	96.0	95.9	95.8	95.6
B. Turbulent times						
Unemployment rate	$\gamma_{55-59} = 0$	6.01	6.12	6.26	6.42	6.61
	$\gamma_{55-59} = \gamma_{60-64}$	5.64	5.74	5.88	6.02	6.20
Participation rate	$\gamma_{55-59} = 0$	94.6	94.4	94.2	94.0	93.7
	$\gamma_{55-59} = \gamma_{60-64}$	94.9	94.7	94.6	94.3	94.0

Note: Results for prime-age workers: calculations are based on the parameter values reported in Table 3 and the recali-brated parameter values reported in Appendix B.2. All entries are expressed in percentage points.

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