Turbulence and the Employment Experience of Older Workers

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ABSTRACT

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This paper provides a unified account of the trends in unemployment and labor force participation pertaining to the employment experience of older male workers during the past half-century. We build an equilibrium life-cycle model with labor-market frictions and an operative labor supply margin, wherein economic turbulence à la Ljungqvist and Sargent (1998) interact with institutions in ways that deteriorate employment. The model explains simultaneously: (i) the fall in labor force participation in the United States, (ii) the similar but more pronounced decline in Europe alongside rising unemployment rates and (iii) differences across European countries in the role played respectively by unemployment and labor force participation. The model also shows that policies that fostered early retirement may have exacerbated the deterioration of European labor markets: raising early retirement incentives to reduce unemployment among older workers tends to increase unemployment at younger ages, especially in turbulent economic times and under stringent employment protection legislation.

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1 Introduction

The outbreak and persistence of high European unemployment since the 1970s compared with the dynamism of the U.S. labor market have sparked a large body of research over the past decades. In his appraisal of this literature, Blanchard (2006) reached mixed conclusions about the results so far obtained. On the positive side, there are convergent findings pointing to the interaction between shocks and institutions as a key explanation of the transatlantic employment gap; this is often referred to as the 'shocks-and-institutions' hypothesis, following Blanchard and Wolfers (2000).[1] Meanwhile on the negative side, data accumulated over time reveal a large heterogeneity of situations across workers and across countries as well. This poses a challenge to virtually any explanation of the transatlantic employment gap, that it should be simultaneously consistent with the heterogeneous employment patterns found in disaggregated data. The recent literature has focused on the life cycle as one such major source of heterogeneity; see Ljungqvist and Sargent (2008), Chéron et al. (2009), Prescott et al. (2009) and Kitao et al. (2016). A related issue, which has received little attention to date, is that differences in employment over the life cycle originate from different margins – unemployment, labor force participation – depending on the demographic group considered and/or the country under study. 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 by analyzing the secular employment experience of older workers on the two sides of the Atlantic. We make two related contributions. First, 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. So doing, we provide a novel evaluation of the shocks-and-institutions hypothesis: we assess whether it explains quantitatively the role played respectively by unemployment and labor force participation in altering the employment rates of older workers. Second, we employ the model to study the aggregate employment effects of programs aimed at fostering early retirement. Such programs treat nonparticipation typically as a *substitute* to unemployment for older workers, and therefore they are often used with a view of reducing unemployment numbers. We analyze the conditions under which they become *complement* with unemployment among workers at younger ages.

The facts of interest for the paper are depicted on Figure 1.[2] We focus on the employment experience of older male workers because it displays significant variations as to the importance of each nonemployment margin, and exhibits interesting dynamics both in the U.S. and in Europe. Indeed, (i) labor force participation of older male workers fell during the past decades in the U.S., (ii) there was a more pronounced decline accompanied by rising unemployment rates in European countries and (iii) unemployment and participation played a different role across countries in reducing the employment rate. We complement these facts in two ways in Section 2. First, we show that changes in labor force

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[1]A complementary explanation is that some labor market institutions have evolved in response to shocks in ways that sometimes aggravated the initial impact of those shocks; see, e.g., Nickell et al. (2005).

[2]Figure 1 reports the Hodrick-Prescott trend component instead of the raw time-series to highlight long-run changes. For Europe, we focus on the three largest countries in continental Europe: France, Germany and Italy. In Appendix C.2, we show that the labor market facts in Figure 1 are borne out by data for a larger set of European countries.
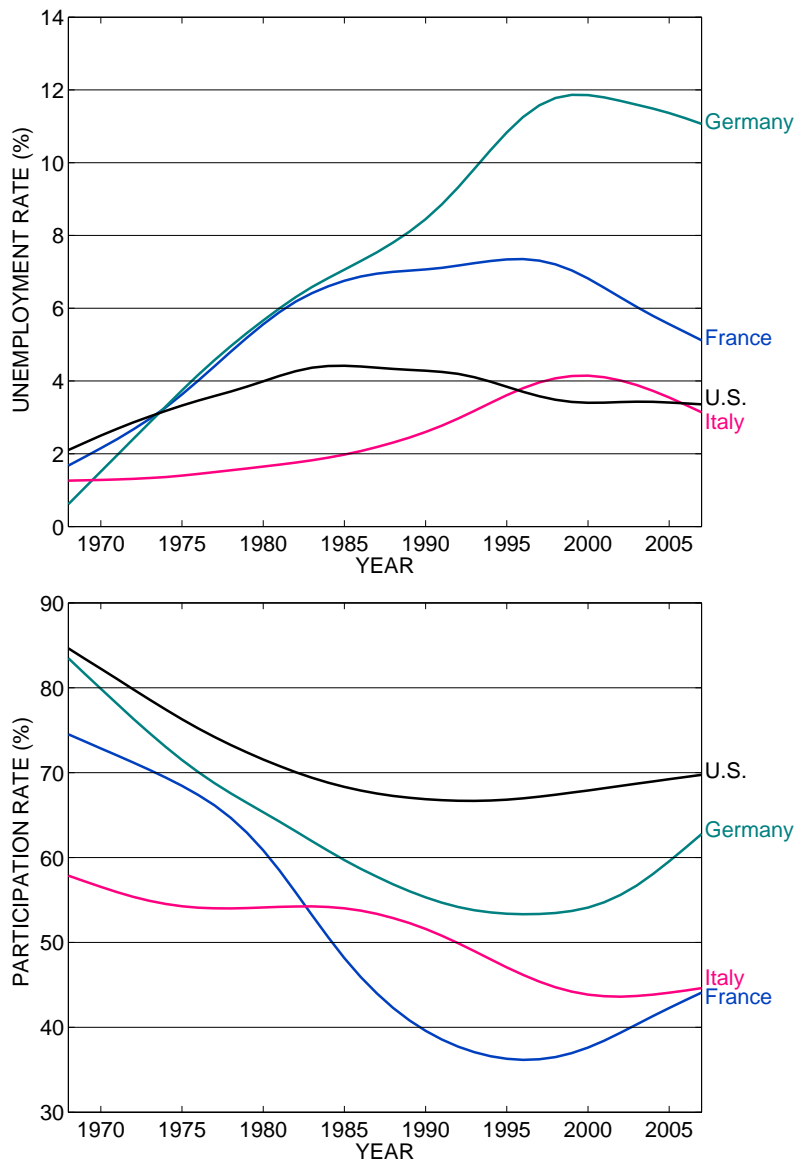
Figure 1. Unemployment and labor force participation among older male workers

participation are quantitatively more important than changes in unemployment to explain employment among older workers. Second, that the separation between the two nonemployment margins is especially relevant for older workers 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 speaks to the trends shown in Figure 1. Firstly, we use the formulation of the shocks-and-institutions hypothesis proposed by Ljungqvist and Sargent (1998, 2008). We choose this formulation because of its greater ability to relate economic turbulence at the micro level to the macro-performance of labor markets. Next, as in the canonical framework of Mortensen and Pissarides (1994), our model features search-matching frictions, idiosyncratic match productivity shocks and Nash-bargained wages. The model also includes a life-cycle structure, human capital accumulation, different levels of welfare benefits, so that workers are (ex post) heterogeneous along several dimensions. There is a single matching function, and hence

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firms cannot direct their vacancies towards specific groups of workers, such as, e.g., younger workers. This assumption does not mean that the hiring probability is uniform across workers; for instance, as we highlight below, this probability is highly age differentiated. It implies nonetheless that the individual participation decisions of older workers have a limited impact on the vacancy posting decisions of firms. Last, the model embodies idiosyncratic, autocorrelated shocks to the value of being out of the labor force. A similar assumption is used by Garibaldi and Wasmer (2005) to create endogenous movements along the labor force participation margin, albeit in a much simpler setting. To our best knowledge, the model we propose is the first to depart from a two-state abstraction (employment/nonemployment) to discuss the shocks-and-institutions hypothesis.

The analysis proceeds with a series of numerical experiments based on a calibrated model. We specialize shocks to the value of being out of the workforce in ways that imply that movements in and out of the labor market are concentrated among older workers. At the margin, the opportunity cost of participating in the labor market equates the expected returns to receiving a job offer which, in line with data for older workers, occurs only in the unemployment pool. Hence unemployment and labor force participation at older ages are essentially substitutes: when a worker faces a lower employment probability (for reasons idiosyncratic to the worker, or because the aggregate job-finding rate is low), he often moves into nonparticipation. We mention these features here to highlight the role of the 'horizon effect' in the analysis. This effect, which has been thoroughly discussed in the studies of Chéron et al. (2009, 2011, 2013), refers to the fact that older workers are closer to the horizon of retirement. It has two implications, *ceteris paribus*, in the frictional labor markets that we consider. First, from an employer's perspective, the returns to hiring an older worker are lower because of the expected shorter duration of the match. Second, from a worker's perspective, the returns to staying in the labor force are lower because of the expected shorter duration of job search.

Following Ljungqvist and Sargent (1998, 2008), a Laissez-faire economy and a Welfare state economy embody, respectively, the labor markets of U.S. and Europe. In the quantitative analysis, there is a common set of parameters that govern labor dynamics which we anchor to U.S. data, and a set of parameters for government-mandated programs that are specific to the Welfare-state economy.[3] At a given point in time, these programs are responsible for differences in equilibrium allocations between the two economies. Across time, equilibrium allocations evolve in response to changes in economic turbulence. We calibrate the latter to make the Laissez-faire economy replicate the increase in U.S. earnings instability, that we measure in ways similar to Gottschalk and Moffitt (1994, 2009).[4] The *interaction* with labor market institutions amplifies the effects of economic turbulence in the Welfare-state economy. Last, in that economy, we introduce some variations in labor market institutions in order to address differences between the trajectories of specific European countries.

The first set of experiments shows that the shocks-and-institutions hypothesis can explain quanti-

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[3]In addition, there is a fixed cost of job creation that is specific to each economy. Following common practices, we pin down this parameter by normalizing the value of labor-market tightness for a given set of parameter values that characterize 'tranquil times'. The job creation cost is held constant throughout the numerical experiments.

[4]In Ljungqvist and Sargent (1998)'s language, 'economic turbulence' are the microeconomic counterpart of changes in the macro-environment, such as restructuring from manufacturing to the service industry or new information technologies. The micro-evidence on earnings volatility at the individual level yields a practical way to quantify changes in the degree of economic turbulence. In the model, these changes are materialized by a change in the rate of skill loss.

tatively the bulk of the patterns displayed in Figure 1. The United States avoided high unemployment rates because the lack of generous unemployment insurance programs avoids deterring job creation and, in addition, avoids retaining workers in the labor force. In turbulent times, workers with depleted skills are more numerous and, facing a low probability of employment, they endogenously drop from the labor force. Older workers are over-represented among these workers because skill accumulation is a time-consuming process, so that obsolescence falls more heavily on older workers. In Europe, generous social insurance benefits and high separation costs exacerbate the employability problem of those workers whose skills have depreciated. Thereby they generate the larger decreases in the *employment* rates of older workers. The Welfare state economy attributes the relative importance of unemployment and labor force participation in this dynamics to the generosity of welfare programs that incentivize early retirement. Quantitatively, it also explains why the largest increases in unemployment are felt in those countries with a higher labor force participation rate.

The second set of experiments builds on the good performance of the model at explaining non-participation among older workers. Specifically, it examines the labor market effects of changing the incentives provided by early retirement pathways.[5] Our framework is actually too stylized to model explicitly the various policies that play this role, such as, e.g., early retirement benefits and disability benefits.[6] Instead, it allows us to examine changes in the generosity of these programs relative to that of unemployment insurance benefits. Motivated by the evidence showing that the employment of older workers is especially hampered by skill obsolescence (e.g. Aubert et al. (2006)) and costly lay-off procedures (e.g. Behaghel et al. (2008)), we assess the effects of early retirement incentives under two sets of conditions: different degrees of economic turbulence and different levels of employment protection. The Welfare-state model economy predicts that labor force participation among older workers is highly responsive to these incentives, in tune with several OECD reports (Blöndal and Scarpetta (1997); Duval (2003)), hence that early retirement incentives help to reduce the numbers of unemployed among older workers. Meanwhile, we find that in a turbulent economic environment they tend to *increase* unemployment among younger workers. Stringent employment protection legislation amplifies this relationship. By making separation costlier, it induces employers to be more selective at the entry level for workers at younger ages. These workers stay unemployed longer and drop from the workforce when they become eligible to early retirement schemes.

In our view, the second set of experiments offers an interesting complement to the shocks-and-institutions hypothesis. The latter posits an interaction between time-varying economic shocks and time-invariant institutions. However, the period under study witnessed substantial changes in early retirement schemes in several European countries, partly in response to persistently high levels of unemployment; see the chapters collected in Wise (2012).[7] Our model predicts that when these policy

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[5] Euwals et al. (2012) provide an insightful case-study of early retirement pathways in the Netherlands that shows how different exit routes to retirement can be substitutes for each other.

[6] For instance, to model explicitly financial incentives, ideally one should consider a model where agents have a finite intertemporal elasticity of substitution and have access to savings. For disability benefits, one should consider a model that includes medical expenditures, health status and health shocks.

[7] France provides an eloquent example of the preference for early retirement in the face of high unemployment rates. Section 1 in the chapter by Salem et al. (2010) gives an overview of the policy debates surrounding early retirement benefits. Behaghel et al. (2014) show that, in France, disability insurance schemes are also relevant to explain part of the decrease in labor force participation shown in Figure 1.

changes were implemented with a view of reducing labor force participation among older workers, they may well have exacerbated the European unemployment problem. This dovetails well with the conclusions of Nickell et al. (2005) (see Footnote 1).

Let us comment briefly on those demographic groups left out of the analysis: younger workers and women. During the period considered, there was a decline in youth labor force participation. This trend is largely driven by the expansion of higher education (OECD (2007)), which is not under the scope of our analysis. Meanwhile, in Appendix B we discuss a number of assumptions to include nonparticipation among younger workers in the model. For women, arguably their secular employment experience deserves a study in its own right, given the stark contrast with that of men. In the online file, we report several figures to support this idea. A very salient fact is that labor force participation among prime-age and older female workers increased throughout most of the period.

As noted in the opening sentence, there is a vast literature on the employment differences between the U.S. and Europe.[8] Within this body of research, our paper is more directly related to the analyzes of Ljungqvist and Sargent (2008), Chéron et al. (2009) and Kitao et al. (2016) who consider heterogeneous-agent life-cycle models to study the age structure of the transatlantic employment gap. Our paper add to this research by explicitly separating unemployment from nonparticipation. We analyze these margins empirically and then through the lens of a quantitative model, which we also use to discuss related labor market policies. We use a general-equilibrium model to study how policies specifically targeted at older workers can have spillover effects onto workers in other age groups.

This paper also contributes to a strand of research outside the shocks-and-institutions literature, which develops frictional models of the labor market with unemployment and nonparticipation. A non-exhaustive list of papers in this research area includes Garibaldi and Wasmer (2005), Pries and Rogerson (2009), Shimer (2013) and Krusell et al. (2011, 2015). Given our focus on skill obsolescence, labor market policies and the life cycle, our model has several layers of heterogeneity. Therefore, compared to these analyzes, it yields a richer set of implications for the participation decisions of workers with different observable characteristics. We think that the model could usefully be employed to investigate issues where the participation margin is of prime importance, such as, e.g., the employment effects of the aging of the baby boom cohorts.

The rest of the paper is organized as follows. Section 2 summarizes 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 characterize several of its outcomes in Section 5. The main results are contained in Section 6: we use the calibrated model to analyze the implications of a turbulent economic environment and the effects of early retirement pathways. Section 7 concludes.

2 Some facts

The main facts that characterize the transatlantic employment gap are well known and are thoroughly presented in Layard et al. (2005), Machin and Manning (1999), Blanchard (2006), and Rogerson and

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[8]See, among others, Bertola and Ichino (1995), Marimon and Zilibotti (1999), Mortensen and Pissarides (1999), den Haan et al. (2005), Hornstein et al. (2007) and the contributions by Ljungqvist and Sargent listed in this Introduction.

Shimer (2011). To sum up, (i) compared to the U.S., unemployment was lower in Europe before the late 1970s and became persistently higher after that period, (ii) the increase was accompanied by a rise in the duration of unemployment and (iii) before and after the 1970s, European labor markets were characterized by stronger employment protection and more generous social insurance schemes. Within this context, the employment experience of older workers has some specificities that we review in this section. The appendix contains additional figures to complement this section.

Life-cycle employment differences. The deterioration of male employment rates in Europe relative to the U.S. was not uniformly spread across demographic groups. In fact, the employment rates of prime-age workers were and remain similar on the two sides of the Atlantic, so much so that the aggregate difference in male employment is explained by lower employment rates among younger and older workers. Figure 1 in the introduction shows that high unemployment rates among workers aged 55 to 64 became common as of the late 1970s. These high unemployment rates are driven by a lower outflow rate from unemployment to employment: for instance Machin and Manning (1999) report that the composition of unemployment among older workers is skewed towards spells with a long duration in most European countries. The bottom panel of Figure 1 highlights that these changes were accompanied by a downward trend in labor force participation which started before the 1970s and was common to the two sides of the Atlantic.[9] The *joint* dynamics of these two nonemployment margins is a key fact of interest for this paper.

Nonemployment margins. Using simple accounting exercises, the first fact that we establish in this section is that labor force participation is quantitatively more important than unemployment to explain the employment rates of older workers. Figure 2 reports the employment rates of prime-age workers and older workers in panels a. and b., respectively. To highlight the role of each margin, the charts also show two counterfactual time series of employment which hold either the unemployment rate or the labor force participation rate fixed to its initial value.[10] The message conveyed by Figure 2 is as follows. When looking at prime-age workers, changes in unemployment and labor force participation both seem to play a role in shaping the employment rate and no clear cross-country pattern emerges. Conversely, for older workers labor force participation plays a dominant role in explaining the long-run dynamics of the employment rate. Had their labor force participation remained unchanged since the end of the 1960s, the employment rates of older workers in the four countries analyzed would have remained constant as well (or almost constant in the case of Germany). In Appendix C.3, we further report that changes in labor force participation among older workers contributed to a decline in *aggregate* male employment by 2 to 5 percentage points, depending on the country considered. Changes in their unemployment rates had a more negligible impact.

To lend more precision to the exercise, we use a variance decomposition to measure the contribution of unemployment and labor force participation to the employment rates of each age group. Let

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[9]Both in Europe and in the U.S., male labor force participation among all age groups of workers has been falling throughout the past decades (Appendix C.1). The reduction of labor force participation among prime-age workers was more modest relative to the other age groups. For younger workers, the downward trends in participation would be worthy of a separate study to include a number of factors specific to that age category.

[10]The analysis undertaken in Figure 2 is merely an accounting exercise: we do not attach a causal interpretation to these 'counterfactual' time series because it seems unlikely that one nonemployment margin can remain constant independently of the behavior of the other margin.

(a) Prime-age workers
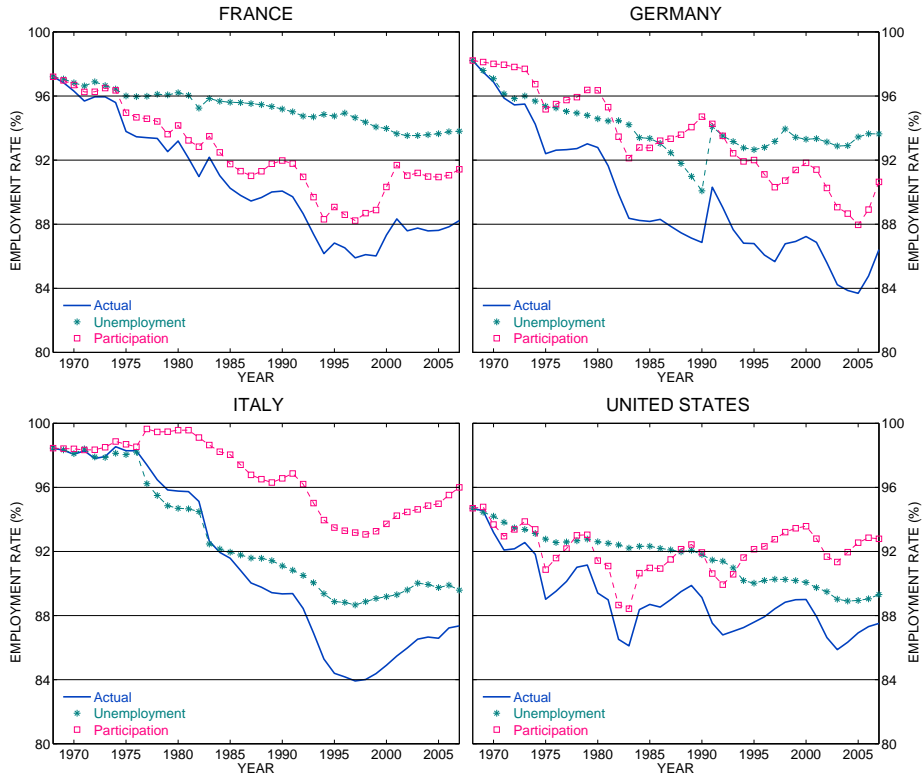
(b) Older workers
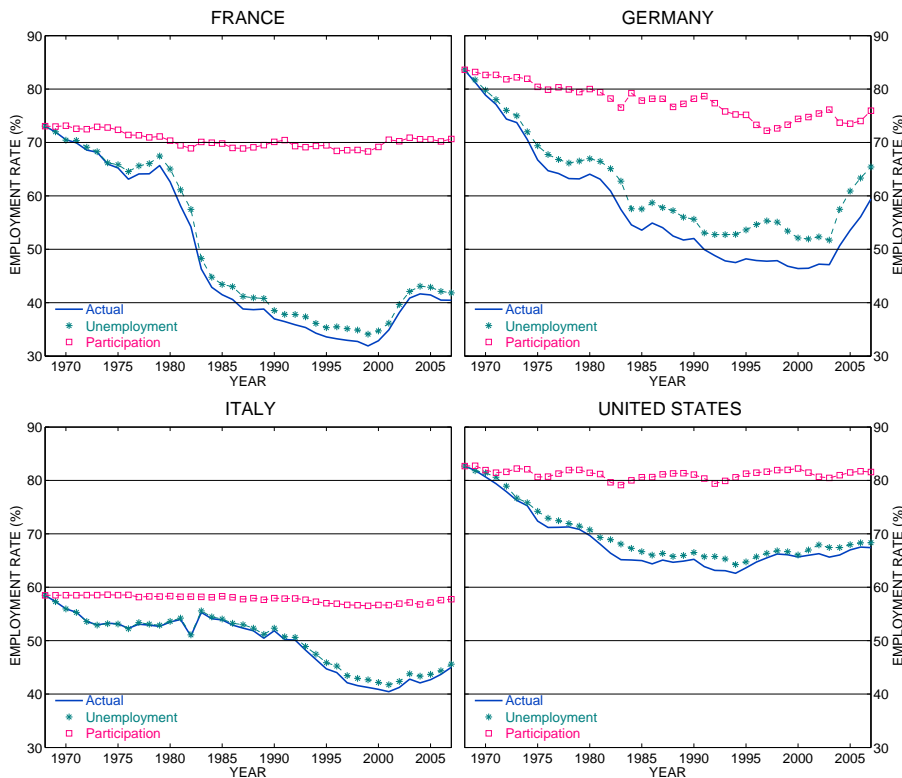
Figure 2. Actual vs. counterfactual employment rates of male workers

NOTE: Own calculations based on data from the OECD labour force database for male workers (see Appendix C). Data for Germany refers to Western Germany prior to 1991. The solid line shows the actual employment rate. The stars (resp. squares) denote the counterfactual employment rate that holds the unemployment rate (resp. labor force participation rate) fixed to its value in the first year of the period. 'Prime-age workers' (panel a.) refers to workers aged 25 to 54; 'Older workers' (panel b.) refers to workers aged 55 to 64.

$e_{a,t}$, $u_{a,t}$ and $p_{a,t}$ denote the employment, unemployment and labor force participation rates, respectively, for age group a in year t; those are related by the identity $e_{a,t} = (1 - u_{a,t}) p_{a,t}$. Taking logs, one can decompose the variance of $\log(e_{a,t})$ into the covariance between $\log(e_{a,t})$ and $\log(1 - u_{a,t})$ and the covariance between $\log(e_{a,t})$ and $\log(p_{a,t})$. Table 1 reports the results of this accounting exercise for the four countries of Figure 2 and also for Norway, Portugal, Spain and Sweden. The findings confirm the picture we have been constructing thus far. Changes in the employment rate of older workers are predominantly driven by changes in labor force participation, whereas the role of unemployment with respect to the employment rate of these workers is quite limited: except for Sweden, its variance contribution is less than 25 percent. On the other hand, the participation margin plays a more marginal role in explaining the employment rates of prime-age workers.

Table 1. Contributions of unemployment and participation to changes in male employment

Variance of $\log(e_{a,t})$ explained by the covariance with:	Prime-age workers		Older workers	
	$\log(1 - u_{a,t})$	$\log(p_{a,t})$	$\log(1 - u_{a,t})$	$\log(p_{a,t})$
France	73.1	26.9	5.9	94.1
Germany	66.6	33.4	20.4	79.6
Italy	36.6	63.4	9.9	90.1
Norway	48.8	51.2	15.2	84.8
Portugal	62.8	37.2	18.1	81.9
Spain	82.3	17.7	19.5	80.5
Sweden	59.4	40.6	28.6	71.4
United-States	40.7	59.3	3.7	96.3

NOTE: Own calculations based on data from the OECD labour force statistics database for male workers (see Appendix C). Data for Germany refers to Western Germany prior to 1991. The period of analysis is 1968–2007 except for Norway, Portugal and Spain. For each age group, the first (resp. second) column reports the percentage share of the time-series variation of $\log(e_{a,t})$ explained by the covariance between $\log(e_{a,t})$ and $\log(1 - u_{a,t})$ (resp. between $\log(e_{a,t})$ and $\log(p_{a,t})$). 'Prime-age workers' refers to workers aged 25 to 54; 'Older workers' refers to workers aged 55 to 64.

Unemployment vs. nonparticipation. Having established the importance of labor force participation in shaping the employment rates of older workers, we outline a second fact by addressing a different (though related) question: when the employment rate is lower, should we care whether this is driven by a high unemployment rate or by a low labor force participation rate? Why does it matter whether nonemployed workers are unemployed or out of the labor force?

The answer lies in recognizing that unemployment and nonparticipation are 'behaviorally distinct labor force states', in the words of Flinn and Heckman (1983). It is beyond the scope of this paper to conduct an in-depth investigation of this issue, but nevertheless we can provide a number of observations. First, in Appendix A, we use U.S. data to analyze the life-cycle profile of labor market transition probabilities. We find that the odds of moving to employment from unemployment rather than from nonparticipation are always greater than one, and that they increase substantially with age. Workers aged 55 to 64 are 7 times more likely to regain employment from unemployment than from out of the labor force. Second, and relatedly, unemployment and nonparticipation capture, albeit imperfectly, different job search behaviors. It is well known at least since Jones and Riddell (1999) that nonemployment spans a variety of situations ranging from the willingness not to work to intense

job search activity. The evidence provided by recent time use surveys supports the view that high search effort is picked up by unemployment rather than nonparticipation. For example, Krueger and Mueller (2010) report that unemployed workers spend on average 41 minutes a day searching for a job on weekdays, whereas for nonparticipants the corresponding figure is 1 minute. Last, there is rich empirical evidence showing that individuals display a form of labor force attachment which is stronger when they manage to stay longer in the workforce. Elsby et al. (2015) for instance find that older workers as well as new entrants or re-entrants are less attached to the labor force relative to the average employed worker. As a result, they are more likely to drop from the labor force, and less prone to move to employment than the average worker. Labor force attachment is related to the notion of history dependence: the probability to regain employment is strongly related to time spent out of employment for those workers who stay away from the labor force.

The framework developed in the next section takes stock of those facts. Workers who are not employed in the model face a risk of losing their skills that generates some form of history dependence. When they remain out of the labor force, they do not receive job offers, and therefore their labor force attachment deteriorates further.

3 The model

This section presents the model that we propose in order to analyze the joint 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). First, we cast this economy in a general equilibrium setup with endogenous job creation, Nash-bargained wages and job separations as in the standard framework of Mortensen and Pissarides (1994). Second, and more importantly, we introduce an idiosyncratic component in the utility that workers derive from leisure. So doing, we create a meaningful distinction between unemployment and nonparticipation, and in the model that results there are worker flows into and from nonparticipation.

3.1 Economic environment

Individuals. One side of the market is populated by a continuum of workers, each of whom belongs to a given age class $a \in \{1, \cdots, A\}$. 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 $a \in \{1, \cdots, A - 1\}$. Generations overlap and entries equal exits so that the measure of the labor force remains constant and is set to unity. Thus, at each point in time the mass of workers entering the labor force is equal to the fraction $1 - \alpha(A, A)$ of the mass 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 n_t is an indicator that takes the value of one if the individual chooses not to participate in the labor force in period t and is zero otherwise. Workers are endowed with a time-varying component z_t that multiplies n_t, so that they enjoy utility from leisure only when out of the labor force. z_t is idiosyncratic to the worker and evolves according to a first-order

Markov process. $F(z'|z)$ denotes the transition function for z, i.e. $F(z'|z) = \Pr\{z_{t+1} < z'|z_t = z\}$. Finally, the utility derived from z_t is allowed to depend on age a (i.e. $z_t \equiv z_t(a_t)$). We highlight below how this variable interacts with the other features of the economic environment to generate movements in labor force participation.[11]

Denoting by β the subjective discount factor, workers maximize

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \beta^t (c_t + z_t n_t). \tag{1}$$

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

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

$$\mathbb{E}_0 \sum_{t=0}^{+\infty} \beta^t (c_t - \eta v_t). \tag{2}$$

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

Search-matching frictions. Workers can be in one of three mutually exclusive labor market states: employment, unemployment and nonparticipation. They cannot search for jobs when they are employed or while out of the labor force.[12] When unemployed, workers meet employers stochastically: a constant returns-to-scale matching function determines the probability that a randomly chosen job-seeker meets a randomly chosen employer. The number of contacts per period is given by

$$m(u_t, v_t) = Mu_t^\kappa v_t^{1-\kappa}, \tag{3}$$

where u_t is the number of unemployed and v_t is the number of vacancies. Letting $\theta_t \equiv v_t/u_t$ denote labor-market tightness, the probability to meet a vacancy for a worker is $f(\theta_t) = M\theta_t^{1-\kappa}$ and the probability to meet a worker for an employer is $f(\theta_t)/\theta_t = M\theta_t^{-\kappa}$.

Production. The unit of production is a matched worker-entrepreneur pair. Each pair produces a flow quantity y and is subjected to various idiosyncratic shocks. First of all, a match is destroyed if the worker is hit by the retirement shock (that is, the worker is in age group A and retires exogenously with probability $1 - \alpha(A,A)$). Second, a match is destroyed exogenously with per-period probability λ; the interpretation of this shock is explained momentarily. Finally, when none of these events occur, the productivity of the match evolves according to a first-order autoregressive process:

$$y_{t+1} = (1-\rho)\bar{y}_h + \rho y_t + \varepsilon_{t+1}. \tag{4}$$

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[11]An alternative strategy to trigger such movements is to introduce a cost of entering the labor market. In Appendix B.1, we discuss the relationship between such entry costs and the utility component z_t of the model.

[12]In this respect the model adheres to the official definitions of unemployment and nonparticipation, according to which unemployed individuals are searching for work and nonparticipation is a residual category of nonemployed individuals. Another reason for precluding nonparticipants from searching for jobs is that the model rationalizes nonparticipation among older workers; we highlight in Section 2 and in Appendix A.1 that these workers are much more likely to move to employment from unemployment than from nonparticipation.

$\rho \in (0,1)$ is the persistence of the process, $\varepsilon \sim N\left(0, \sigma_\varepsilon^2\right)$ is the innovation and h is the skill level of the worker. It is assumed that $\bar{y}_1 < \ldots < \bar{y}_H$: the productivity of matches with workers of higher skill levels is higher on average. Hereafter $G_h(y'|y)$ denotes the transition function for y when the skill level of the worker is h, i.e. $G_h(y'|y) = \Pr\{y_{t+1} < y'|y_t = y, h_t = h\}$.

The timing of employment relationships is as follows. Upon meeting, an employer and a worker whose current skill level is h draw a productivity y from the distribution $G_h^0(y) = G_h(y|\bar{y}_h)$.[13] They decide whether to start producing or to walk away. In the latter event, they are returned to the pool of unmatched agents. If they choose to stay together, y_t evolves according to the sequence of events just described. Production stops when either one of the following occurs: the match is hit by an exogenous shock (retirement in age group A or the λ shock) or the two parties endogenously dissolve the match. Note that both the λ shock and endogenous job destruction can be followed by a transition into nonparticipation: this occurs when the worker prefers to be out of the labor force rather than in the unemployment pool.

Skill dynamics. Each individual worker is endowed with a certain amount of skills denoted by h, which is distributed on a finite and discrete support $\{1,\ldots,H\}$. When he enters the economy, a worker is endowed with the lowest skill level. Thereafter, his human capital evolves according to his own idiosyncratic labor market trajectory. This is captured by three first-order Markov processes, with $\mu^e(h,h')$, $\mu^o(h,h')$ and $\mu^\ell(h,h')$ denoting the transition probability from h to h' for a worker who retains his job (e for employment), for a worker without a job (o for out-of-work) and for an exogenously displaced worker (ℓ for laid off), respectively. The latter are identified to those workers who are separated from their job by the λ shock.[14]

Accumulation of human capital occurs gradually in employment and depreciation takes place when the worker is out of work. The specification of the two Markov processes governing transition in skill levels conditional on not being laid-off boils down to two probabilities μ^e and μ^o:

$$\mu^e(h,h') = \begin{cases} 1 - \mu^e & \text{if } h < H \text{ and } h' = h \\ \mu^e & \text{if } h < H \text{ and } h' = h+1 \end{cases} \tag{5a}$$

$$\mu^o(h,h') = \begin{cases} \mu^o & \text{if } h > 1 \text{ and } h' = h-1 \\ 1 - \mu^o & \text{if } h > 1 \text{ and } h' = h \end{cases} \tag{5b}$$

and, in addition, $\mu^e(H,H) = 1$, $\mu^o(1,1) = 1$. The third Markov process, $\mu^\ell(h,h')$, operationalizes

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[13]Observe that since $G_h^0(y) = G_h(y|\bar{y}_h)$, $G_{h'}^0(y)$ dominates $G_h^0(y)$ in a first-order stochastic sense for any $h' \geq h$. Individual skill dynamics is therefore similar to the dynamics proposed by den Haan et al. (2005): matching with more experienced workers yields a higher average initial draw for productivity.

[14]Critically, we let quitters retain their human capital level in the period when they leave the job. In an interesting debate with Ljungqvist and Sargent (2004), den Haan et al. (2005) discussed the turbulence hypothesis in a context where voluntary quitters also suffer skill obsolescence. An implication of this assumption is that times of economic turbulence deter workers from leaving their job. This results in lower inflows into unemployment and a negative relationship between turbulence and the unemployment rate. We adopt the interpretation of turbulence put forward by Ljungqvist and Sargent (2008) which draws on the association between skill loss and disruptive labor market experiences (exogenous separations). Ljungqvist and Sargent (2007) show that this formulation is robust to numerous modeling environments.

the notion of economic turbulence which, following Ljungqvist and Sargent (1998), is defined as the risk of skill obsolescence after job loss. Throughout the analysis, it is assumed that layoffs are never followed by skill upgrading: $\mu^\ell(h, h') = 0$ for all $h' > h$. A higher degree of economic turbulence therefore means a decrease in $\mu^\ell(h, h)$. We defer to Subsection 4.3 the specification of the transition probabilities $\mu^\ell(h, h')$ for $h' \in \{1, \ldots, h\}$.

Government-mandated programs. To understand labor market performances on the two sides of the Atlantic, we will compare a Laissez-faire (henceforth LF) economy to a Welfare state (henceforth WS) economy. The defining features of the WS economy are employment protection and social insurance schemes, which will be parametrized to capture labor market institutions in Europe.

Employment protection is modeled as a lump-sum tax Ω on job destruction paid by the employer. It is assumed that the government does not observe whether job destruction occurs for exogenous or endogenous reasons, and therefore the tax is enforced for both types of job separations.[15] It is also assumed that the proceeds of the tax are not rebated towards workers after job separation: as is well known since Lazear (1990)'s seminal study of job-security provisions, such transfers would be undone by efficient employer-employee bargains. Hence Ω acts as a deadweight loss for the economy; our preferred interpretation is that Ω encompasses those costs of barriers to exit and regulations that deter job destruction in European labor markets.

Social insurance schemes include various safety nets such as unemployment compensation and subsidized early retirement benefits. For brevity, the exposition in the rest of this section focuses on unemployment compensation benefits only, while in the calibrated model we will allow individuals out of the labor force to receive some income insurance benefits (see Sections 4 and 6). Social insurance benefits work as follows. A worker with skill level h who is separated from his job collects a benefit payment of indefinite duration $b \equiv b(h)$.[16] b is effectively a state variable in the WS economy. The schedule $b(h)$ is calculated as a replacement ratio γ_u times $\bar{y}_h$, the mean productivity of matches for workers with skill level h. Therefore γ_u summarizes the generosity of the social insurance system. This system is financed through a flat-rate tax τ raised on the product of active matches.

Two-tier labor market. In the WS economy, employment protection and social insurance schemes give rise to a two-tier labor market structure for two reasons. First, there is a nondegenerate match formation decision: if the employer does not hire the worker after observing the initial productivity level drawn from G^0, the tax Ω is waived (no job was created). Second, on meeting an employer, an unemployed worker may be collecting an unemployment benefit payment b that will differ from the benefit to which he will be entitled after starting the new job. For these two reasons, the match formation stage needs to be distinguished from any subsequent period of the job. An index $i \in \{0, +\}$ subsumes these two phases of the employment relationship.

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[15]On the other hand, the tax is waived if the match is dissolved because the worker is in age group A and retires exogenously from the labor market. We comment on this assumption in Subsection 6.2 below.

[16]To simplify the analysis of social insurance benefits, it is assumed that a worker whose skill level increases from h to h' is immediately entitled to the new benefit level $b(h')$ if the match is dissolved endogenously. Otherwise, workers who have been working at least one period with their new skill level need to be distinguished from those who have just experienced an upgrade in skills, which is an unnecessary complication of the model.

3.2 Bellman equations

We use a system of Bellman equations to describe the behavior of workers and employers who populate the economy. Accordingly, we drop the time subscript from the notations in the remainder of this section. Denoting by v^n, v^u, v^e_i the value of being in nonparticipation, unemployment, employment with $i \in \{0,+\}$, respectively, and by $v^o(.) \equiv \max\{v^n(.), v^u(.)\}$ the value of being out of work, workers' decisions are governed by:[17]

$$v^n(b,h,z,a) = z(a) + \beta \sum_{a'} \alpha(a,a') \sum_{h'} \mu^o(h,h') \int v^o(b,h',z'a') \, dF(z'|z), \tag{5}$$

$$v^u(b,h,z,a) = b + \beta \sum_{a'} \alpha(a,a') \sum_{h'} \mu^o(h,h') \int \Big[(1-f(\theta)) v^o(b,h',z',a')$$
$$+ f(\theta) \int \max \{v^e_0(y',b,h',z',a'), v^o(b,h',z',a')\} \, dG^0_{h'}(y') \Big] dF(z'|z), \tag{6}$$

$$v^e_0(y,b,h,z,a) = w_0(y,b,h,z,a) + \beta \sum_{a'} \alpha(a,a') \int \Big[\lambda \sum_{h'} \mu^\ell(h,h') v^o(b(h),h',z',a') + (1-\lambda)$$
$$\times \sum_{h'} \mu^e(h,h') \int \max \{v^e_+(y',h',z',a'), v^o(b(h'),h',z',a')\} \, dG_{h'}(y'|y) \Big] dF(z'|z), \tag{7}$$

$$v^e_+(y,h,z,a) = w_+(y,h,z,a) + \beta \sum_{a'} \alpha(a,a') \int \Big[\lambda \sum_{h'} \mu^\ell(h,h') v^o(b(h),h',z',a') + (1-\lambda)$$
$$\times \sum_{h'} \mu^e(h,h') \int \max \{v^e_+(y',h',z',a'), v^o(b(h'),h',z',a')\} \, dG_{h'}(y'|y) \Big] dF(z'|z). \tag{8}$$

In equations (7) and (8), $w_0(.)$ and $w_+(.)$ are the wages paid in the corresponding labor market state. The wage-setting rule is provided below. Assuming that there is free entry of firms, employers' values v^f_0 and v^f_+ of being matched to a worker are given by:

$$v^f_0(y,b,h,z,a) = (1-\tau)y - w_0(y,b,h,z,a) + \beta \sum_{a'} \alpha(a,a') \int \Big[-\lambda\Omega$$
$$+ (1-\lambda) \sum_{h'} \mu^e(h,h') \int \max \{v^f_+(y',h',z,'a'), -\Omega\} \, dG_{h'}(y'|y) \Big] dF(z'|z), \tag{9}$$

---

[17] The Bellman equations are written with a summation over h' with the understanding that $h' = 1,\ldots,H$, and a summation over a' with the understanding that $a' = a, a+1$. We let $\alpha(A, A+1) = 0$. So doing, when we write the employer's value of being matched with a worker of age A (equations (9) and (10)), we account for the fact that the layoff tax is waived if the job is destroyed by the exogenous retirement shock.

$$v_+^f(y,h,z,a) = (1-\tau)y - w_+(y,h,z,a) + \beta \sum_{a'} \alpha(a,a') \int \Bigg[-\lambda \Omega$$

$$+ (1-\lambda) \sum_{h'} \mu^e(h,h') \int \max \left\{ v_+^f(y',h',z',a'), -\Omega \right\} dG_{h'}(y'|y) \Bigg] dF(z'|z). \quad (10)$$

Match formation and continuation decisions can be derived from the maximization operator in the above set of Bellman equations. These decisions are privately efficient from the viewpoint of each employer-worker pair under the assumption that they bargain over the surplus of the match.

3.3   Nash bargaining

As is standard, wages are set by Nash bargaining each period. Denoting by $\phi \in [0,1]$ the bargaining power of workers, the two-tier wage schedule under free entry of firms is given by:

$$w_0(y,b,h,z,a) = \arg\max_w \left\{ (v_0^e(y,b,h,z,a) - v^o(b,h,z,a))^\phi \, v_0^f(y,b,h,z,a)^{1-\phi} \right\}, \quad (11)$$

$$w_+(y,h,z,a) = \arg\max_w \left\{ \left(v_+^e(y,h,z,a) - v^o(b(h),h,z,a) \right)^\phi \left(v_+^f(y,h,z,a) + \Omega \right)^{1-\phi} \right\}. \quad (12)$$

We can use the first-order conditions associated with (11) and (12) to obtain the joint match formation and continuation decisions $\widetilde{y}_0(b,h,z,a)$ and $\widetilde{y}_+(h,z,a)$. They are pinned down by:

$$v_0^f(\widetilde{y}_0(b,h,z,a),b,h,z,a) = 0, \quad (13)$$

$$v_+^f(\widetilde{y}_+(h,z,a),h,z,a) = -\Omega. \quad (14)$$

3.4   Participation margin

In the above Nash bargaining protocol, the outside option of workers is $v^o(.)$ which is the maximum of $v^n(.)$ and $v^u(.)$. This maximization delivers workers' labor force participation decision as the reservation rule $\widetilde{z}(b,h,a)$ that satisfies:

$$v^u(b,h,\widetilde{z}(b,h,a),a) = v^n(b,h,\widetilde{z}(b,h,a),a). \quad (15)$$

It is useful to note that $\widetilde{z}(b,h,a)$ solves:

$$\widetilde{z}(b,h,a) = b + f(\theta) \times \beta \sum_{a'} \alpha(a,a') \sum_{h'} \mu^o(h,h') \int \int \max \left\{ v_0^e(y',b,h',z',a') \right.$$

$$\left. - v^o(b,h',z',a'), 0 \right\} dG_{h'}^0(y') \, dF(z'|\widetilde{z}(b,h,a)), \quad (16)$$

which follows from equations (5) and (6). This condition 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 positive expected returns to being employed (the term after $f(\theta)$).

3.5 Aggregate conditions

Labor-market tightness θ and the payroll tax τ are pinned down by aggregate equilibrium conditions. To write these conditions, denote by $\varphi_n(b,h,z,a)$, $\varphi_u(b,h,z,a)$, $\varphi_0(y,b,h,z,a)$, $\varphi_+(y,h,z,a)$ the measures of workers in nonparticipation, unemployment and employment in $i=0$ and $i=+$.

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

$$
\eta = \beta \frac{f(\theta)}{\theta} \sum_{b,h,a} \int \int \left[\sum_{a'} \alpha(a,a') \sum_{h'} \mu^o(h,h') \int \max \left\{ v_0^f(y',b,h',z',a') \right.\right.
$$
$$
\left.\left. ,0 \right\} dG_{h'}^0(y') \right] dF(z'|z) \frac{\varphi_u(b,h,z,a)}{u} dz, \quad (17)
$$

where $u = \sum_{b,h,a} \int \varphi_u(b,h,z,a) \, dz$ is the size of the unemployment pool ($\frac{\varphi_u(b,h,z,a)}{u}$ gives the conditional probability of finding an unemployed worker whose state variables are b, h, z, a).

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

$$
\tau \sum_{h,a} \int \int y \left(\varphi_+(y,h,z,a) + \sum_b \varphi_0(y,b,h,z,a) \right) dy dz = \sum_{b,h,a} \int b \varphi_u(b,h,z,a) \, dz. \quad (18)
$$

As already mentioned, in the computations we will allows individuals out of the labor force to collect some social insurance benefits. This will add a term to the right-hand side of equation (18).

3.6 Equilibrium

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

Definition. An equilibrium is a list of value functions $v^n(b,h,z,a)$, $v^u(b,h,z,a)$, $v_0^e(y,b,h,z,a)$, $v_+^e(y,h,z,a)$, $v_0^f(y,b,h,z,a)$, $v_+^f(y,h,z,a)$, a set of rules for match formation and continuation decisions $\widetilde{y}_0(b,h,z,a)$, $\widetilde{y}_+(h,z,a)$ and for 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 $\varphi_n(b,h,z,a)$, $\varphi_u(b,h,z,a)$, $\varphi_0(y,b,h,z,a)$, $\varphi_+(y,h,z,a)$, and a value for labor-market tightness θ and the tax τ such that:

1. Optimal match formation and continuation decisions: Given θ, τ and the value functions $v_0^f(y,b,h,z,a)$, $v_+^f(y,h,z,a)$, match formation and continuation decisions $\widetilde{y}_0(b,h,z,a)$, $\widetilde{y}_+(h,z,a)$ solve equations (13) and (14), respectively.

2. Optimal participation decisions: Given θ, τ and the value functions $v^n(b,h,z,a)$, $v^u(b,h,z,a)$, participation decisions $\widetilde{z}(b,h,a)$ solve equation (15).

3. Nash bargaining: Given θ, τ and the value functions $v^n(b,h,z,a)$, $v^u(b,h,z,a)$, $v_0^e(y,b,h,z,a)$, $v_+^e(y,h,z,a)$, $v_0^f(y,b,h,z,a)$, $v_+^f(y,h,z,a)$, the wage functions $w_0(y,b,h,z,a)$, $w_+(y,h,z,a)$ are given by equations (11) and (12), 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 laws of motion for y, b, h, z, a, the measures $\varphi_n(b,h,z,a)$, $\varphi_u(b,h,z,a)$, $\varphi_0(y,b,h,z,a)$, $\varphi_+(y,h,z,a)$ are time-invariant and they add up to one.

5. Free entry: Given the measure of unemployed workers $\varphi_u(b,h,z,a)$ and the value of match formation $v_0^f(y,b,h,z,a)$, labor-market tightness θ solves the free-entry condition (17).

6. Balanced budget: given the measures $\varphi_n(b,h,z,a)$, $\varphi_u(b,h,z,a)$, $\varphi_0(y,b,h,z,a)$, $\varphi_+(y,h,z,a)$, τ satisfies the balanced budget condition given by equation (18).

The following assumptions complete the description of condition 4 (time-invariant distribution): initially, newborn workers are out of work, they are entitled to the lowest level of welfare benefits and they draw an initial opportunity cost of participation from the distribution $F(.|\bar{z})$. As we explain in the calibration section, the last assumption is largely innocuous for the equilibrium.

4 Calibration

This section details the calibration of Laissez-faire and Welfare state economies. Subsection 4.1 describes the parameters that are *common* to both setups; these are based on data moments for the United States. Subsection 4.2 explains the calibration of parameters that are *specific* to each economy. They fall into two categories: (i) the parameters for government-mandated programs in the WS economy and (ii) the job creation cost, which is allowed to differ across economies to capture residual differences in labor market dynamics. The working assumption is that the parameters discussed in these two subsections are invariant across time. Subsection 4.3 explains how we measure economic turbulence and its changes over time. A table summarizing the model fit is provided in Appendix A.5.

4.1 Common parameters

The parameter values for β, μ^e, μ^o, $\bar{y}_0$, $\bar{y}_H$, ρ, λ, κ, ϕ are set externally using auxiliary information (Table 2 provides a summary of the meaning of the variables). The parameters values for σ_ε M and the stochastic process of z are calibrated jointly to match four labor-market data moments. We take the model period to be half a quarter.

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

Demographics. The working life of individuals is divided into the following periods. While in the age bracket 20-49, individuals transit across six consecutive 5-year long age groups.[18] The

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[18]Since we are not addressing the specific employment experience of younger workers, we do not introduce any such category in the model. We let workers enter the labor market at age 20 and we lump them together with workers aged 25 to 49 and 50 to 54 to form an extended group of prime-age workers.

probability of remaining in each of these groups is 0.975. The subsequent age bracket, 50-54, has five 1-year long age groups; the corresponding probability is 0.875. The last age bracket 55-64 is composed of twenty 6-month age groups. The probability of remaining in each of these groups is 0.750. This decomposition of the life-cycle allows to maintain smooth transitions between age groups while reducing the memory requirements of the computations.

Utility of leisure. To parametrize the utility of leisure, we assume that it increases with age from an initial which is set to zero. This assumption rests on the observation that shocks to the utility of leisure in this model cannot explain nonparticipation among younger workers. Consider for instance the role of human capital for earnings growth over the life cycle: it generates a strong incentive for younger workers to participate in the labor market. As a consequence, a very large utility of leisure would be needed to rationalize nonparticipation among these workers. In order to fit the data, the value of leisure would then have to decline steeply with age, and finally to increase towards the end of the life cycle. We find that there is little appeal in this *ad hoc* process of explaining the data.[19] Hence we choose to instead shut down the labor supply decision for those workers aged 20 to 24 in the model, and focus on nonparticipation among older workers.

Specifically, we posit the following relationship between the value of leisure and age:

$$z(a) = z \times \frac{a-1}{A-1}. \tag{19}$$

The value of leisure is always zero for workers aged 20 to 24 and then it grows linearly as workers enter the subsequent age brackets $(a > 1)$.[20] We assume linear growth to obtain a parsimonious relationship between a and $z(a)$. The Markov process for z is as follows: with probability $1 - \pi$ a new value z is drawn from a distribution F^0 while with probability π the value of leisure remains unchanged. F^0 is taken to be the uniform distribution over $[0, z_{\text{sup}}]$.

We use the following targets to calibrate the upper bound z_{sup} and the probability π: (i) the rate of labor force participation of older workers relative to that of prime-age workers in the pre-1970s period and (ii) the decline in the transition probability from nonparticipation to unemployment for workers aged 55 to 64. Since in the LF economy prime-age workers always participate, the first calibration target dictates a labor force participation rate of 92 percent for older workers. For the other calibration target, we use monthly data from the Current Population Survey (CPS) in the 1970s to compute the life-cycle profile of transition across labor market states (Appendix A.1). It is intuitive that the probability to re-enter the labor force towards the end of the working life should convey information as to the persistence of z. We actually show in the appendix that the calibrated model fits the life-cycle profile of this transition probability very well. The procedure to select z_{sup} and π yields: $z_{\text{sup}} = 3.125$ and $\pi = 0.750$, implying that z is resampled on average after 6 months.

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[19]We think that a model aimed at explaining labor force participation among young workers needs a different driving force, in that shocks to the utility of leisure would not be convincing in explaining nonparticipation among both older and younger workers within the same model. Since most individuals aged 16 to 24 who are out of the labor force are enrolled in education, this explanation could build on schooling investments to accumulate skills prior to labor market entry. Appendix B.2 discusses some changes to the model along these lines.

[20]Observe that since the value of leisure is zero when $a = 1$, the distribution from which newborn workers initially draw their own idiosyncratic utility z has virtually no effect on equilibrium allocations.

Skill dynamics. The number of skill levels H is set equal to 5.[21] To construct the law of motion for the skill level h, we use the returns to human capital accumulation estimated by Kambourov and Manovskii (2009b).[22] Letting x denote a worker's tenure, when we run a regression of their estimates against a quadratic polynomial of x, we obtain the following profiles: $-0.0014 + 0.0487x - 0.0017x^2$ using the OLS estimates, and: $-0.0003 + 0.0287x - 0.0010x^2$ using the IV-GLS estimates. These profiles indicate a peak in the returns to tenure at 14.5 years. Thus, we set the probability of upgrading skills μ^e to 0.033 so that, conditional on being employed continuously (and given the number of grid points H), a worker moves from the lowest skill level to the highest one on average after 14.5 years.

For the probability of losing skills μ^o, we follow Ljungqvist and Sargent (1998, 2008) in assuming that the depreciation of human capital when out of work is stochastically twice as fast as skill accumulation. The main reason is that the literature provides little guidance for choosing this parameter because existing estimates of skill depreciation are (understandably) disparate across studies. We find that the results are robust to varying μ^o by an order of magnitude. As can be inferred from the calibrated model, skill obsolescence affects workers mostly when it destroys their skills immediately on job loss, and less so when it deteriorates skills gradually during spells of nonemployment.

Productivity process and job destruction. The unconditional means of the productivity process $\bar{y}_h$ with $h \in \{1,\ldots,H\}$ are set to evenly partition the $[1,2]$ interval: the productivity of a match with a worker who has reached the plateau for human capital is on average twice higher (unconditionally) than that of match with a new labor-market entrant. It turns out that these values imply almost a doubling of the average wage when comparing newborn and prime-age workers, in tune with the literature (see Bagger et al. (2014)). For the persistence of idiosyncratic productivity ρ, we draw on results reported by Chang and Kim (2006). The authors use annual wage data to infer the parameters of an autoregressive productivity process which they estimate by controlling for selection into employment. They find an annual persistence of 0.809 for men (second panel of Table 1 in their study). Since the model period is half a quarter, this estimate implies: $\rho = 0.809^{1/8} = 0.974$.

The parameter values for the sources of job destruction (other than the exogenous retirement shock) are selected as follows. First, for the probability of exogenous destruction λ, we use data from the Displaced Worker supplements of the CPS to analyze job tenure prior to displacement. We report in Appendix A.2 that workers with at least 1 year of tenure prior to job loss are displaced on average after staying 7.5 years in their job. This observation implies: $\lambda = 0.0166$. Second, we calibrate the standard error of innovations σ_ε to match a monthly transition rate from employment to unemployment of 2 percent for workers in the age bracket 20-49, in line with the long-run behavior of the U.S. labor market.[23] Given the value assigned to λ, this calibration target yields: $\sigma_\varepsilon = 0.221$.

Matching function and bargaining. Following standard practices in the literature (see Petrongolo and Pissarides (2001)), the elasticity of the job-filling probability with respect to labor-market

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[21]The results are robust to increasing H further. $H = 5$ helps to reduce the computational cost.

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

[23]Notice that in the first column of Table 4, the separation rate from employment in the LF economy is 2.05 percent. This separation rate is higher because it includes all transitions out of employment and it is not restricted to workers in the age bracket 20-49.

Table 2. Parameter values (one model period is half a quarter)

Comments	Value
(a) Preference parameters	
Discount factor	$\beta = 0.9951$
Persistence of leisure utility	$\pi = 0.750$
Upper bound for leisure utility	$z_{\text{sup}} = 3.125$
(b) Technology parameters	
Probability of upgrading skills	$\mu^e = 0.033$
Probability of losing skills	$\mu^o = 0.066$
Lower and upper mean of productivity	$\bar{y}_1 = 1.0,\ \bar{y}_H = 2.0$
Persistence of idiosyncratic productivity	$\rho = 0.974$
Standard deviation of idiosyncratic shocks	$\sigma_\varepsilon = 0.221$
Rate of exogenous job destruction	$\lambda = 0.0166$
Matching function	$m(u,v) = 0.456 u^{0.5} v^{0.5}$
Bargaining power of workers	$\phi = 0.5$
(c) Policy parameters (WS economy)	
Job destruction tax	$\Omega = 10.0$
Unemployment benefits replacement ratio	$\gamma_u = 0.40$
Relative generosity of early retirement schemes	$\gamma_n = 0.50$

tightness, κ, and workers' share of the match surplus, ϕ, are set as follows: $\kappa = \phi = 0.50$. Finally, we normalize labor-market tightness to one. We calibrate the aggregate efficiency of the matching function M to match an average duration of unemployment of 3 months, which is again motivated by the long-run behavior of the U.S. labor market. Notice that the job-finding rate refers to the unemployment-to-employment probability and that it may differ from $f(\theta)$ because of the match formation rule $\tilde{y}_0(b,h,z,a)$. The calibrated value of M is 0.456. Thus, the matching function used in the numerical experiments is: $m(u,v) = 0.456 u^{0.5} v^{0.5}$.

4.2 Economy-specific parameters

In the WS economy, although labor-market programs are modeled in a somewhat stylized way, we can, and do, choose values for the layoff tax and unemployment benefits that connect to empirical evidence. Then, the incentives to early retirement are measured *relative* to the generosity of unemployment benefits. We fix the parameter value for this variable and we discuss in the next sections how changing its value affects the equilibrium of the WS economy. Finally we pin down a value for the unit cost of an unfilled job η.

Government-mandated programs. We draw on the estimates of dismissal costs reported by Garibaldi et al. (2016) to select a parameter value for Ω. Specifically, their estimates for unfair dismissals, fair economic dismissals and fair disciplinary dismissals, suggest that the cost of laying off a worker with 20 years of tenure amounts to 17.4 months of wages on average for France, Germany and Italy.[24] Let us assume that one half of the layoff tax is lost from the viewpoint of the employer-

---

[24]For instance, Table 1 in Garibaldi et al. (2016) shows that in France the costs amount to 27.7 months of wages

worker pair, i.e. that it is paid into legal procedures and administrative costs: this 50:50 split is a compromise between the high uncertainty and costs of dismissal procedures reported in Garibaldi et al. (2016) (suggesting a high deadweight loss), and the estimates of Garibaldi and Violante (2005) showing that the pure transfer from the employer to the worker can account for a large share (up to two thirds) of dismissal costs. Thus, our target for Ω is 8.7 months (17.4/2) of the average wage of high tenure workers. Setting $\Omega = 10.0$ matches this target almost exactly: the corresponding monthly wage is 1.25, i.e. one eighth of Ω. We comment on the effects of changing Ω in Section 6.

We choose a value for the replacement ratio of unemployment benefits γ_u consistent with the fact that unemployment insurance systems in Europe are more generous than in the United States. By setting γ_u to 0.40, we obtain a ratio between unemployment benefits and the average wage of 52 percent for workers with $h = 1$ and 42 percent for workers with $h = H$ (recall that benefits are computed as: $b(h) = \gamma_u \times \bar{y}_h$). Notice that these figures trigger a substantial gap in the generosity of unemployment benefits since, in addition, there is no cap on the duration of benefits in the WS economy. With $\gamma_u = 0.40$, the duration of unemployment is already higher by one third of a month in the WS economy compared to the LF economy. We do not increase γ_u further because, as Kitao et al. (2016) point out, there is little to no evidence of a gap in unemployment duration between Europe and the United States before the 1970s.

In the WS economy, it is assumed that older workers are also covered by safety nets when they drop temporarily or permanently from the workforce. There are a variety of public programs that may incentivize older workers into withdrawing from the labor market. As mentioned in the introduction, it is beyond our scope to include these programs explicitly in the model. Instead, we measure the relative generosity of these schemes by allowing workers in the age bracket 55-64 to consume a share γ_n of their unemployment benefits when out of the labor force. Since utility is linear, this formulation implies that, in the trade-off between nonparticipation and unemployment, a workers enjoys a flow of utility z in the first case vs. a flow $(1 - \gamma_n) b$ under the alternative (cf. equation (16)). Hence, γ_n summarizes the generosity of those schemes that lower the instantaneous value of staying in the labor force for older workers. We use $\gamma_n = 0.50$ as a benchmark and we discuss the effects of altering this parameter in Section 6.

Job creation cost. Finally, the free entry condition delivers a value for the job creation cost η. In the next subsection, we will explain how we parametrize tranquil economic times. We use the steady-state equilibrium under tranquil times to pin down η separately for the LF economy and the WS economy. This procedure yields $\eta = 2.208$ and $\eta = 1.282$, respectively. The difference $\eta^{\mathrm{LF}} - \eta^{\mathrm{WS}}$ is mechanically linked to the calibration procedure: $\eta^{\mathrm{LF}} - \eta^{\mathrm{WS}}$ acts as a residual that captures the difference in labor market dynamics implied by the policies of the WS economy. Indeed, unemployment benefits and the deadweight loss of the tax Ω reduce the rents from employment, which implies a lower η in the WS economy to keep the value of θ unchanged (normalized to unity).

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for an unfair dismissal, 7.4 months for a fair economic dismissal and 2.0 months for a fair disciplinary dismissal. The (unweighted) average is 12.4 months of wages. The corresponding average is 22.5 months for Germany and 17.4 months for Italy. These figures are on the high end of estimates of dismissal costs because they do not weight each type of dismissal by the probability that it occurs (which is not available). The estimates for Germany, for example, is inflated by the high compensations provided for unfair dismissals (43.6 months of wages).

In the sections that follow, in each economy we hold η constant to its value under tranquil times and we study the equilibrium allocations obtained under times of economic turbulence.

4.3 Economic turbulence

We retain Ljungqvist and Sargent (1998)'s construct to specify $\mu^{\ell}(h,h')$, the process of skill obsolescence that workers face upon job loss. For each skill level h we draw the probabilities $\mu^{\ell}(h,h')$ from the left half of a Normal distribution with mean h, truncated at h and normalized to integrate to one over $\{1,\ldots,h\}$. Notice that in this construct, we have $\mu^{\ell}(h,h') = 0$ for any $h' > h$. Furthermore the probabilities of moving to a lower skill level are governed by a single parameter, namely the standard deviation of the underlying Normal distribution. A higher degree of economic turbulence refers to an increase in the value of this parameter.

Table 3. Turbulence and the increase in earnings instability

	Time period	1975	1980	1985
(a) Data	$\mathbb{V}\mathrm{ar}(\xi_i)$	0.108	0.129	0.155
	% change	-	19.9	43.2
	$1 - \mu^{\ell}(H,H)$	0.210	0.501	0.774
(b) Model	$\mathbb{V}\mathrm{ar}(\xi_i)$	0.103	0.124	0.150
	% change	-	19.9	45.2

NOTE: Data: Own calculations based on data from the Panel Study of Income Dynamics for prime-age male workers (see Appendix A). 1975 refers to the window 1968-1982; 1980 refers to the window 1973-1987; 1985 refers to the window 1978-1992. Model: For each 'period', the labor market trajectories of 2,000 individuals are simulated over the ages 20 to 54 to obtain a panel dataset of earnings which are aggregated to a yearly frequency. The permanent-transitory decomposition is based on log-earnings detrented from a quartic polynomial of age.

In order to make additional connections between the model and micro evidence, we use the LF economy as a tool to actually estimate the degree of economic turbulence. Bertola and Ichino (1995), Ljungqvist and Sargent (1998), Kambourov and Manovskii (2009a), among others, interpret Gottschalk and Moffitt (1994)'s results 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 standard deviation of the Normal distribution underlying $\mu^{\ell}(h,h')$ to the levels of earnings instability at different points in time during this period.[25] To begin with, we use data from the Panel Study of Income Dynamics (PSID) to perform a permanent-transitory decomposition of (the residual of log) annual earnings according to: $\log(w)_{i,t} = \pi_i + \xi_{i,t}$; see Appendix A.4 for details. For three consecutive windows of time, we compute the transitory component of earnings, which is denoted as $\mathbb{V}\mathrm{ar}(\xi_i)$ and displayed in panel a. of Table 3. We then use the LF economy and search

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[25]It is well known (and we do find this pattern in our analysis) that the increase in earnings instability for men was concentrated in the early 1980s, and that earnings instability remained roughly constant after that period, at least until the late 1990s; see Figure 1 in Gottschalk and Moffitt (2009). Therefore we use the mid-1980s as our measurement of turbulent times. In our view, the fact that the diverging trends between Europe and the United States continued after that period (cf. Figures 1 and 2) reflects movements along the transition path of each economy. Our analysis in Sections 5 and 6 cannot speak to this issue because we focus on steady-state comparisons.

for the degree of turbulence that matches earnings instability in the mid-1970s using the methodology described in the footnote to Table 3. The first column in panel b. is the steady state under tranquil times which is used to fix a value for the job creation cost η. When the degree of economic turbulence increases further, the LF economy replicates Gottschalk and Moffitt (1994)'s finding, that the dispersion of the transitory components of earnings increased after the 1970s: by 20 percent in 1980 and by about 45 percent in the mid-1980s. Our estimate of turbulent times corresponds to the last column of Table 3. Notice that there is a one-to-one mapping between the standard deviation of the Normal distribution used to specify $\mu^\ell(h,h')$ and $1 - \mu^\ell(H,H)$, the probability of skill loss faced by a worker with the highest skill level. Thus, we use the lowest and highest values of $1 - \mu^\ell(H,H)$ displayed in the table to define a 0-to-1 scale of economic turbulence. For example a degree of 0.00 refers to $1 - \mu^\ell(H,H) = 0.210$, a degree of 0.20 refers to $1 - \mu^\ell(H,H) = 0.323$ and so on.

5 Model outcomes

This section discusses a number of outcomes of the calibrated model. The purpose is to gain an understanding of the workings of the model before we move on to the main numerical experiments.

Match formation. Panels a. and b. in Figure 3 show the probability of match formation (conditional on meeting, which occurs with probability $f(\theta)$ for unemployed workers) in the LF economy and the WS economy, respectively.[26] This probability is $1 - G^0(\widetilde{y}_0(b,h,z,a))$: it depends on the welfare benefits b (in panel b.), current skills h, leisure utility z and age a of the worker. In both panels, the plot show the probability evaluated at specific values 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.[27] We interpolate the probability with respect to the skill variable h to improve legibility.

In the LF economy (panel a.), when an unemployed worker and a vacancy meet, they often match with probability one.[28] Towards the end of the working life, this probability deteriorates if the worker's current opportunity cost of being in the labor force is high. A worker bargains with the employer using the upper envelope of the value of unemployment and the value of nonparticipation as an outside option. A high utility of leisure z raises the value of nonparticipation and thereby it lowers the surplus of a match. This effect is more potent when the expected duration of the match is shorter due to the age of the worker (the horizon effect), and it is further reinforced by the persistence of the state variable z. Consequently, in the LF economy older workers with a high opportunity cost of labor force participation and/or a lower skill level are less likely to find a job.

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[26]Comparing the policy function $\widetilde{y}_0(b,h,z,a)$ for different skill levels h is less straightforward. The reason is that 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, although the reservation value $\widetilde{y}_0(b,h,z,a)$ tends to *increase* with h, in general it does not imply that the probability of match formation *decreases* with h. In practice, in the computation, the interval where y resides for a worker with skill level h is: $\left[\bar{y}_h - \frac{2\sigma_\varepsilon}{\sqrt{1-\rho^2}}, \bar{y}_h + \frac{2\sigma_\varepsilon}{\sqrt{1-\rho^2}}\right]$.

[27]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.

[28]Since $G_h^0(y) = G_h(y|\bar{y}_h)$ and the interval for y conditional on h is centered at $\bar{y}_h$, there is very little mass in the tails of the probability distribution G_h^0. Therefore the matching probability can be very close to one even if the productivity

(a) LF Economy
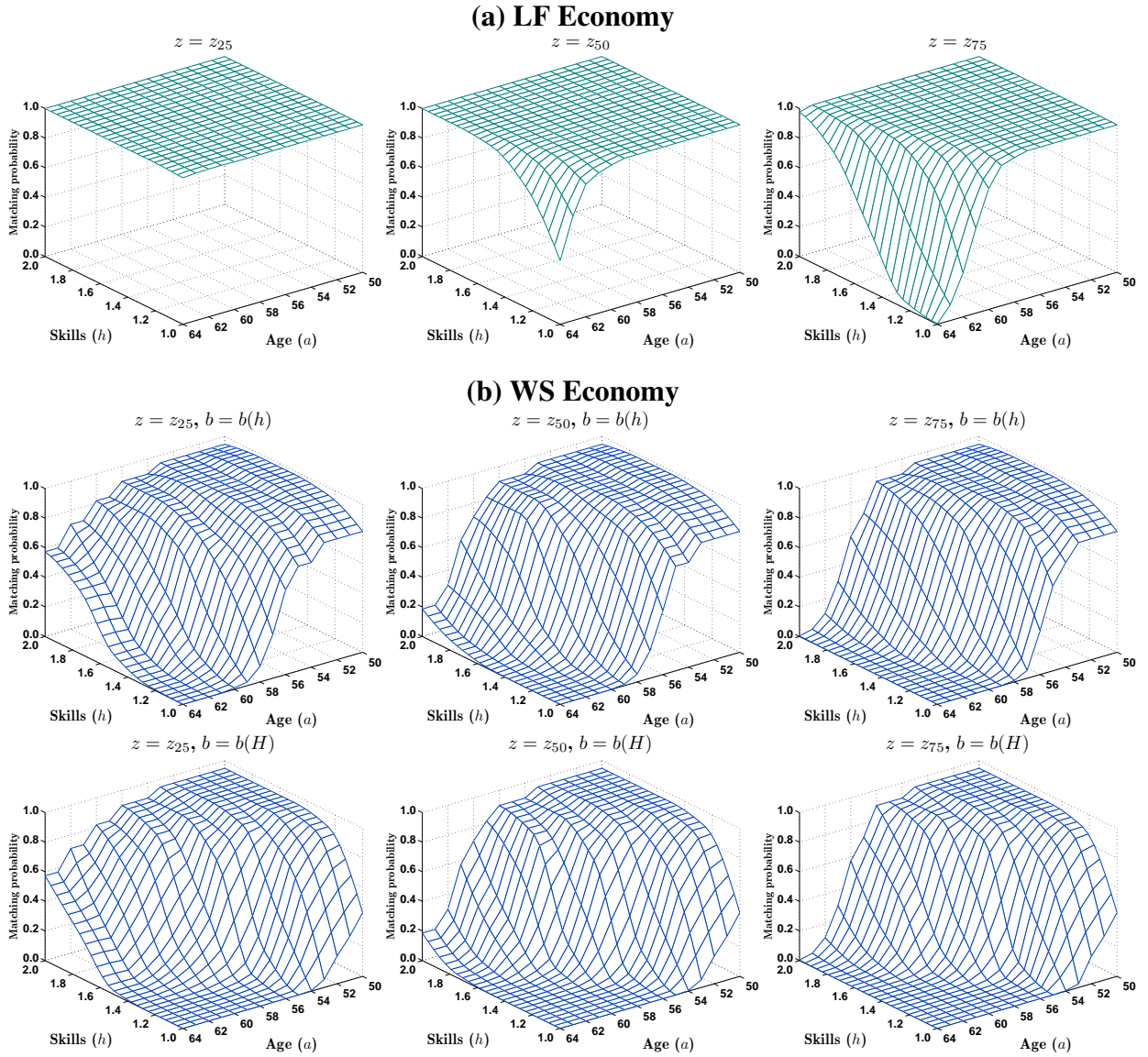
(b) WS Economy

Figure 3. Conditional probability of match formation, $1 - G_h^0(\widetilde{y}_0(b, h, z, a))$

NOTE: Panel a. refers to the LF economy. Panel b. refers to the WS economy. In panel b., the first set of graphs shows the matching probability for workers whose unemployment benefits, b, matches their current skill level, h. The bottom set of graphs shows the matching probability for workers with the highest level of unemployment benefits, $b(H)$.

In the WS economy (panel b.), we report two sets of plots for the probability of match formation. In the first set, a worker's unemployment benefit b matches his current skill level ($b = b(h)$). We observe that, as in the LF economy, a higher utility of leisure reduces the matching probability, especially so at lower skill levels and near the retirement age. Welfare benefits magnify this effect: b increases the value of unemployment, and also the value of nonparticipation for workers aged 55 and more (recall that they consume $\gamma_n \times b$ when out of the labor force). The model predicts that for a nontrivial region of the state space, workers are not employable: conditional on meeting an employer, they never draw a productivity level that results in positive match surplus. However, since age and skills are positively correlated in the cross-section, few workers reside in this region of the state space.

The second set of plots for the WS economy shows the matching probability of workers who are entitled to the highest level of unemployment benefits ($b(H)$) due to their past work experience.

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threshold $\widetilde{y}_0(b, h, z, a)$ is well above the lower bound of the support.

Thus, in these plots except for $h = H$, a worker who accepts a job 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 raises the reservation wage of the worker on meeting an employer with a vacant job. As a result, the matching probabilities flatten out relative to the first set of plots. In tranquil economic times, there are few workers with state variables $b = b(H)$ and $h < H$ since the duration of nonemployment spells remains short and workers enjoy a high probability of retaining their skills after a layoff. In turbulent times, there are more workers who are thrown in this part of the state space, which increases the nonemployment rate in the WS economy more than in the LF economy.

Match continuation. In the WS economy the job destruction tax Ω shifts the thresholds for continuation decisions downwards relative to match formation thresholds.[29] That is, the decision rules in equations (13) and (14), together with the positive relationship between match surplus and idiosyncratic productivity y, imply that the layoff tax makes employers retain their incumbent workers more often. As a result, there is a lower separation rate in the WS economy compared to the LF economy (by 30 percent; see the first column of Table 4 in the next section), and under tranquil times the unemployment rate is also lower in the WS economy. The same mechanism operates in Ljungqvist and Sargent (2007, 2008) and Kitao et al. (2016) to explain why labor markets with generous unemployment benefits can escape high unemployment rates. We provide additional observations on the match continuation rule in Subsection 6.2 where we analyze several experiments to explore the employment effects of different values of Ω.

Participation decisions. Figure 4 plots the probability of moving to nonparticipation when the utility of leisure switches to a new value. With the stochastic process chosen for z, this probability is: $1 - F^0(\widetilde{z}(b,h,a)) = 1 - \widetilde{z}(b,h,a)/z_{sup}$. Panel a. refers to the LF economy and panel b. refers to the WS economy with either $b = b(h)$ or $b = b(H)$. Firstly, as per the horizon effect, the exit probability increases with age because older workers' decisions are more directly related to their instantaneous utility, whereas for younger workers the continuation value of search can compensate more the opportunity cost of staying in the unemployment pool. Second, equation (16) highlights that there is an inverted relationship between the matching probability and the exit probability faced by a worker: when the odds of finding a match with positive surplus is lower, the returns to staying in the unemployment pool are also lower and the reservation threshold $\widetilde{z}(b,h,a)$ shifts downwards. By this token, in the LF economy and the WS economy, workers with a lower skill level are more likely to move to nonparticipation compared to more skilled workers (controlling for age).[30]

The effects of unemployment benefits on the exit probability are *a priori* ambiguous. On the one hand, more generous unemployment benefits raise the flow value of staying in the labor force. This

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[29]Unlike the match formation policy function $\widetilde{y}_0(b,h,z,a)$, the match continuation rule $\widetilde{y}_+(h,z,a)$ cannot be easily represented by plugging it into a probability distribution. Consider for instance the probability of endogenous job destruction in a match with current state variables y, h, z, a: it is given by $F_h(\widetilde{y}_+(h,z,a)|y)$, which is a 4-dimensional object. The 'y' dimension makes it especially inconvenient to represent $F_h(\widetilde{y}_+(h,z,a)|y)$ graphically because y and h are correlated. As a consequence, it is unclear how to fix y in order to compare the job destruction probability at two different values of h for instance. The alternative which takes the average of the job destruction probability with respect to the cross-sectional distribution of y is not satisfactory either.

[30]Notice the effects of the persistence of leisure utility: a high value of z on meeting an employer entails a lower matching probability, which raises the probability that the worker moves to nonparticipation prior to meeting a vacancy.

(a) LF Economy
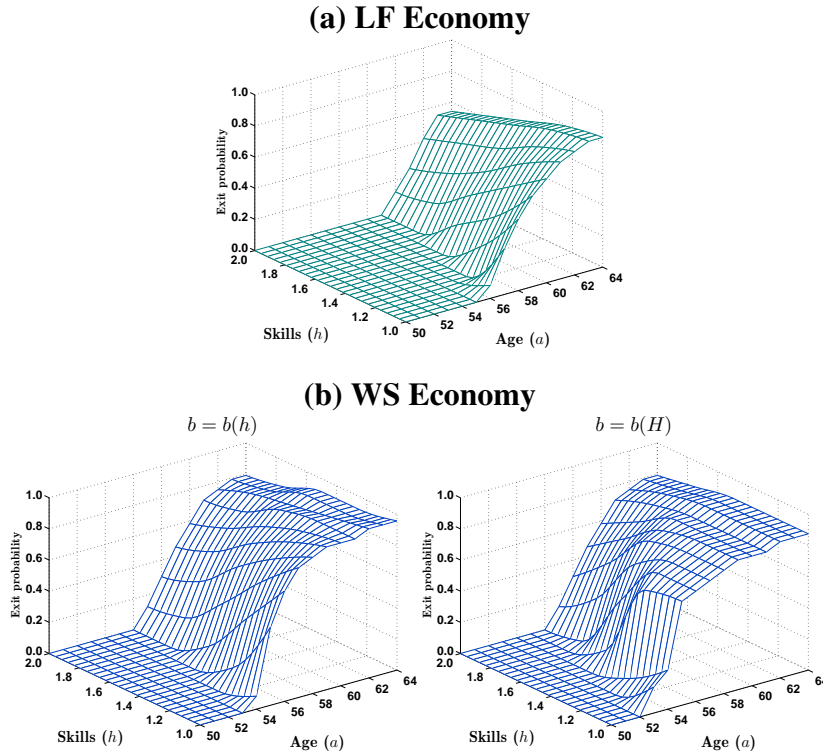
(b) WS Economy

Figure 4. Conditional probability of moving to nonparticipation, $1 - F^0\left(\widetilde{z}(b,h,a)\right)$

NOTE: Panel a. refers to the LF economy. Panel b. refers to the WS economy. In panel b., the left graph shows the exit probability for workers whose unemployment benefits, b, matches their current skill level, h. The right graph shows the exit probability for workers with the highest level of unemployment benefits, $b(H)$.

channel may result in higher unemployment because it deters workers from moving to nonparticipation. Hence, it is different from the usual channel through which unemployment benefits increase unemployment, namely by raising a worker's reservation wage. This other channel is also present in the WS economy: workers with generous unemployment benefits face a lower expected matching probability. However, in this economy, this provides an incentive to abandon job search by moving to nonparticipation. The comparison of panels a. and b. suggests that the negative effects of unemployment benefits on the matching probability dominate, so much so that older workers in the WS economy are more prone to move to nonparticipation relative to workers in the LF economy. This is partly explained by the generosity of the other safety nets captured by the parameter γ_n: they diminish the ability of unemployment benefits to retain workers in the labor force.

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, it is useful to document the individual effects of the loss of skill. Figure 5 does so by comparing the earnings of two cohorts of workers in the LF economy.[31] The dashed line refers to displaced workers defined, as in Ljungqvist and Sargent (2008), as those workers hit by the λ shock and who incur a loss of skill exceeding one third of their skill level h in period 0. As illustrated in the graph, the model predicts that such events

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[31]In this figure, we use the LF economy with turbulence set to 0.50: we show in Table 3 that this degree of turbulence matches well the period centered at 1980, which is the period spanned by the study of Jacobson et al. (1993). Meanwhile, we find that the degree of economic turbulence does not seem to affect the relative earnings losses of displaced workers. While it increases their skill losses, it also lowers the effects of human capital on earnings profile and thereby reduces their earnings losses relative to stayers. Appendix A.3 illustrates this point.

can trigger a drop in earnings by about 30 percent, half of which is not recovered after 5 years.[32] This finding gives us confidence in the ability of our framework to capture the effects of major labor market disruptions. Indeed, the estimates in Figure 5 line up well with the size and persistence of the earnings losses documented in the empirical literature following the work of Jacobson et al. (1993).
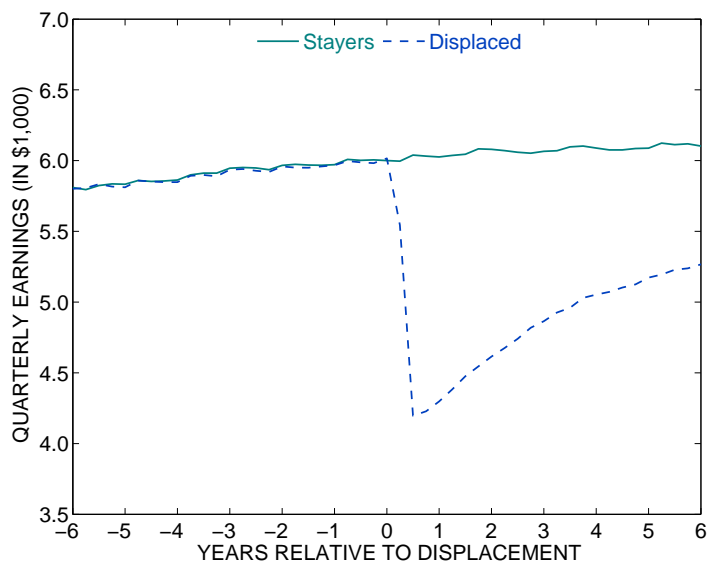
Figure 5. Earnings losses of displaced workers

NOTE: 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 0. Both cohorts contain 5,000 individuals whose labor market trajectories are simulated for 25 years prior to the displacement shock. Quarterly earnings at time 0 are normalized to $6,000 to facilitate comparison to the study by Jacobson et al. (1993).

6 Numerical experiments

This section contains two sets of numerical experiments. In the first one, we quantify how much of the dynamics of labor force participation and unemployment in the U.S. and in Europe is explained by the interaction between shocks (economic turbulence) and the institutions embedded in the model. Subsequently, we analyze how differences in incentives towards early retirement affect labor market outcomes at various point in time (i.e. at a given degree of economic turbulence) and under different levels of employment protection.

6.1 1st experiments: Changes in unemployment and labor force participation

This subsection unfolds as follows. First, we analyze the outcomes and main mechanisms at work in the two economies, using the LF model to analyze the U.S. employment experience and the bench-mark WS model for the average experience of the 'big three' of continental Europe. At the end of

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[32]Davis and von Wachter (2011) note that the canonical search-matching model delivers a substantial amount of transitory variations in earnings (as workers move in and out of employment), but that without any additional ingredients it cannot generate large *persistent* earnings shocks. In particular, it cannot match the large earnings losses found in displaced worker studies. Our model does not suffer this problem.

the subsection, we compare the results to the data and, in addition, we study whether changes in the policy parameters of the WS economy can explain differences across the three European countries.

Aggregate outcomes. Table 4 reports the effects of raising the degree of turbulence in the LF and WS economies. Looking at panel a. first, the two model economies reproduce Ljungqvist and Sargent (1998, 2008)'s finding that the high European unemployment rates since the late 1970s can be imputed to the Welfare state's lower ability to cope with more turbulent times. Tougher employment protection explains why unemployment used to be lower in Europe at the beginning of the period. Generous social insurance schemes, on the other hand, make workers with depleted skills less employable because they accept to give up their unemployment compensations only if they find a highly productive match. These workers are more numerous in turbulent times and they stay unemployed longer: the mean duration of unemployment spells in the WS economy increases by more than 50 percent. The LF economy is more resilient to adverse shocks because past labor market history does not affect the outside option of unemployed workers.[33]

Next, as shown in panel a., the employment rate in this model is not exactly the converse of the unemployment rate. For example, the unemployment rate of the WS economy rises by 2.7 percentage points but the employment rate decreases by 7.2 percentage points. The difference is explained by the labor force participation margin, which we analyze momentarily. By comparing the employment and unemployment rate, one can also see that the LF economy and the WS economy exhibit aggregate labor force participation rates that are much higher than in the data. That difference is due to the way in which we specialized the model: we abstract from nonparticipation at younger ages, so that nonparticipation is concentrated among older workers (in tranquil times in the LF economy, workers aged 56 to 64; in the WS economy, workers aged 54 to 64).

The upper part of the table allows to gauge the implications of economic turbulence with respect to average skill levels, wages and output. By construction, a higher degree of turbulence deteriorates the value of these variables. We display these values in their raw units of measurement to underline the following differences between the LF economy and the WS economy. Since the job destruction tax Ω entails a less efficient allocation of labor, output per worker and wages are lower in the WS economy. The effects of Ω on the difference in skill levels between the two economies is *a priori* ambiguous. On the one hand, Ω lengthens the duration of employment spells, which has a positive impact on the skill level of the WS economy. On the other hand, the duration of nonemployment spells is longer in the WS economy and thereby it lowers the average skill level. In tranquil times these two effects seem to balance out one another, so that there is no difference in skill levels between the two economies. Finally, we find in statistics not reported in the table that both environments generate a substantial degree of earnings dispersion over the working life of individuals.[34]

Older workers. Panel b. of Table 4 characterizes the employment experience of older workers. Firstly, their labor-market outcomes reiterate the finding that the problem of Welfare state unemployment stems from long-term unemployment, not from separations from employment into unemploy-

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[33]Observe nevertheless that unemployment increases in the LF economy because of endogenous job creation: economic turbulence lowers the returns to filling a vacancy.

[34]We emphasize this feature because the amount of life-cycle earnings variations turned out to be a quantitatively-relevant issue in the debate between den Haan et al. (2005) and Ljungqvist and Sargent (2004).

Table 4. Labor markets of the 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		2.94	3.37	4.69	5.11	5.25	5.29
Output per worker [a]	LF	2.013	1.950	1.830	1.809	1.802	1.799
	WS	1.940	1.877	1.755	1.735	1.728	1.725
Average skill level	LF	1.724	1.651	1.509	1.481	1.472	1.469
	WS	1.724	1.648	1.501	1.472	1.462	1.459
Average wage	LF	1.808	1.748	1.638	1.618	1.611	1.608
	WS	1.564	1.497	1.367	1.340	1.330	1.327
Unemployment rate	LF	6.53	6.74	7.42	7.63	7.68	7.71
	WS	5.77	6.24	7.76	8.26	8.44	8.50
Employment rate	LF	91.9	91.2	89.3	88.9	88.7	88.6
	WS	90.3	88.8	84.6	83.6	83.3	83.1
Separation from employment [b]	LF	2.05	2.08	2.15	2.18	2.18	2.18
	WS	1.44	1.43	1.43	1.44	1.44	1.44
Duration of unemployment spells [c]	LF	2.97	3.05	3.32	3.38	3.41	3.42
	WS	3.31	3.64	4.58	4.86	4.97	5.01
(b) Outcomes among older workers							
Unemployment rate	LF	5.70	5.86	6.39	6.54	6.55	6.57
	WS	5.76	6.60	9.86	10.78	11.09	11.20
Labor force participation rate	LF	92.2	90.1	84.2	82.9	82.3	82.2
	WS	81.3	76.0	63.2	60.4	59.5	59.2
Separation from employment [b]	LF	2.24	2.31	2.49	2.53	2.53	2.54
	WS	1.29	1.30	1.31	1.31	1.32	1.32
Duration of unemployment spells [c]	LF	2.86	2.89	3.04	3.08	3.09	3.10
	WS	3.67	4.17	5.47	5.71	5.78	5.81
Transition into nonparticipation							
From employment [d]	LF	0.72	0.83	1.15	1.21	1.23	1.24
	WS	0.63	0.71	0.89	0.93	0.94	0.94
From unemployment [e]	LF	2.27	2.78	4.09	4.38	4.46	4.49
	WS	8.29	9.90	12.53	12.89	12.99	13.03

NOTE: Tax rates, employment rates, labor force participation rates, unemployment rates and transition rates are expressed in percentage points. [a] Gross output divided by employment. [b] Monthly flows out of employment, expressed as a percentage of employment. [c] Average duration measured in months. [d] Monthly flows from employment to nonparticipation, expressed as a percentage of employment. [e] Monthly flows from unemployment to nonparticipation, expressed as a percentage of unemployment.

ment. However, the increase in long-term unemployment is lower than it would be in a two-state model: a significant fraction of nonemployed workers in this model escape unemployment by moving out of the labor force. Nonemployment is concentrated on older workers for two reasons. Firstly, the process to build up human capital implies that age is correlated with a higher skill level (larger relative skill losses in turbulent times) and more generous welfare benefits. Second, regardless of such features, the horizon effect implies that the returns to hiring older workers are lower.
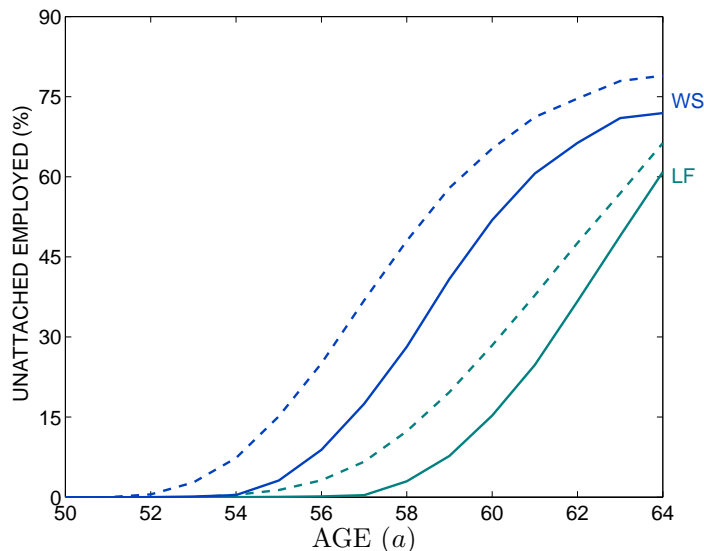
Figure 6. Fraction of unattached employed workers

The second and more important remark is that, as shown in the bottom panel, both economies attribute part of the decline in employment during turbulent times to an increase in the flows from employment and unemployment into nonparticipation. For unemployment-to-nonparticipation flows, recall from Section 5 that when a worker faces a lower matching probability, he becomes at a higher risk of dropping from the labor market. For employment-to-nonparticipation, to summarize this outcome, we report in Figure 6 the fraction of unattached employed workers between the ages of 50 and 64, whom we define as those workers who would choose nonparticipation over unemployment if they were not employed.[35],[36] Turbulent times increase the fraction of such workers in all age groups for two reasons: there are more workers with lower skill levels (shift in the cross-section) and the individual participation thresholds move downwards (shift in policy functions) because workers face a lower matching probability when unemployed.

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[35]For each age group a, let $u_a = \sum_{b,h} \int \varphi_u(b,h,z,a) \, dz$. For each a, the statistics shown in Figure 6 is:

$$\frac{1}{1-u_a} \left(\sum_{b,h} \int \int_{\tilde{z}(b,h,a)}^{z_{\sup}} \varphi_0(y,b,h,z,a) \, dz dy + \sum_{h} \int \int_{\tilde{z}(b(h),h,a)}^{z_{\sup}} \varphi_+(y,h,z,a) \, dz dy \right).$$

[36]Hairault et al. (2015) analyze that, in a life-cycle employment model, when older workers prefer retirement over unemployment conditional on being out of work, the search externality vanishes for older employed workers because their Nash-bargained wage is independent of labor-market tightness. The 'unattached employed workers' of Figure 6 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 that reverses this ordering. The elasticity of wages with respect to labor-market tightness is nonetheless close to zero at older ages in the present model.

When we piece together the findings from panels a. and b., we observe that the two economies consistently explain why lower employment rates in the aggregate are disproportionately concentrated on older workers. The labor market institutions included in the WS economy imply a larger decline in aggregate employment, which is explained by a more pronounced increase in unemployment and a larger decrease in labor force participation. Before we compare these results to the data at the end of this section, we discuss some additional mechanisms related to the participation margin.

Tightness and participation. In this environment with a single matching function, when older workers drop from the labor force, they improve the average quality of the pool of job seekers and thereby the returns to posting a vacancy. On the other hand, when the job-finding probability decreases, workers face lower expected returns to staying in the workforce and they become more likely to move to nonparticipation. Thus, the model predicts a two-way relationship between the job-finding probability $f(\theta)$ and labor force participation decisions. We expect this relationship to be quantitatively *small*, which we verify by conducting some out-of-equilibrium exercises below. These can be interpreted as an over-identifying test of the assumptions made about search frictions in this economy.

Table 5. Actual vs. counterfactual job-finding and labor force participation rates

		Tranquil times		Turbulent times	
		Actual	Counterfactual	Actual	Counterfactual
(a) Job finding $f(\theta)$	LF	33.3	33.5	28.7	28.4
	WS	33.3	33.6	24.2	24.0
(b) Participation rate	LF	92.2	91.3	82.2	83.3
	WS	81.3	77.9	59.2	61.9

NOTE: The counterfactual monthly job-finding probability measures the effects of shifts in workers' participation decisions on firms' incentives to post vacancies. The counterfactual labor force participation measures the effects of shifts in the job-finding probability on older workers' labor force participation. See the text in Subsection 6.1 for details.

Panel a. of Table 5 reports two counterfactuals for labor-market tightness: in the first (resp. second) column, firms face the surplus $v_0^f(y,b,h,z,a)$ that prevails under tranquil (resp. turbulent) times weighted by the $\varphi_u(b,h,z,a)$ implied by participation decisions under turbulent (resp. tranquil) times.[37] In the column for turbulent times, for example, too many older workers remain in the unemployment pool (their reservation values $\widetilde{z}(b,h,a)$ are not downward-adjusted) which lowers the expected returns to filling a job. The counterfactual for tranquil times explores the opposite scenario. In both instances, we verify that such compositional changes have almost no impact on $f(\theta)$. This dovetails with the fact that older workers account for a very small share of pool of job seekers.

In Panel b. of Table 5, we analyze a different set of counterfactuals wherein workers behave optimally but the aggregate variable $f(\theta)$ remains off-equilibrium. In the left (resp. right) column, all the features of the environment are those from tranquil (resp. turbulent) times expect the job-finding probability which is set to its value under turbulent (resp. tranquil) times.[38] We find in the right

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[37]The counterfactual θ is pinned down by the free-entry condition (17).

[38]Recall that, in the WS economy, there is an aggregate condition to pin down τ in addition to the market-clearing

column that labor force participation rates among older workers would be higher by about 1.1 and 2.7 percentage points in the LF economy and the WS economy, respectively, without the equilibrium decrease in $f(\theta)$. These effects are plausibly small: participation decisions are not very elastic with respect to the aggregate job-finding probability $f(\theta)$ because the main determinant of the returns to search from a worker's perspective are the conditional matching probabilities displayed in Figure 3.

Taking stock. In Table 6, we summarize the observed trends in older workers' unemployment and labor force participation rates, and in panel b. we report the changes predicted by the LF economy and three different WS economies: the benchmark model with $\gamma_n = 0.50$ and two models with respectively weaker ($\gamma_n = 0.25$) and stronger ($\gamma_n = 0.75$) incentives to move to nonparticipation.

The first remarks concern the performance of the LF economy and the benchmark WS economy in explaining the trends respectively in the U.S. and the (unweighted) average of the three European countries. The LF economy accounts for virtually all of the 11–12 percent decline in older workers' labor force participation in the U.S. In Europe, the downward trend in labor force participation came to an end after the trend observed in the U.S. and the average decrease is 25 percent by the end of the 1980s and 27 percent in the 1980s. The WS economy matches these figures remarkably well. Turning to changes in the unemployment rate, it must be noted that in panel a. those are inflated by the fact that unemployment rates in the 1960s were very low in the U.S. and in Germany (Figure 1). If instead we compare the period 1980s to 1970s, we find an increase in the unemployment rate by 1.88/1.61 = 17 percent for the U.S., and by 51 percent in the 1980s and 116 percent in the 1990s in Europe. The change in unemployment concomitant with that of labor force participation is 15 percent in the LF economy and 90 percent in the WS economy. Both figures line up well with the data.

The second remark is that variations in the generosity of early retirement schemes in the WS economy generate outcomes that are consistent, qualitatively and to a large extent quantitatively, with the respective employment experience of each of the big three European economies. Consider the labor force participation *rates* of older workers displayed in panel b. of Table 6. These suggest that we interpret $\gamma_n = 0.25$ as Germany, $\gamma_n = 0.50$ as France and $\gamma_n = 0.75$ as Italy based on the participation rates observed in those countries. According to the WS economy, the largest increases in unemployment occur in those labor markets with a high labor force participation rate. This seems to accord with the data in panel a. There are, however, some discrepancies: the change in labor force participation in the WS economy with $\gamma_n = 0.75$ is too large compared to the Italian data, while the WS economy with $\gamma_n = 0.50$ understates the decrease in labor force participation in France. The fit to the trend in labor force participation is higher between the WS economy with $\gamma_n = 0.25$ and Germany.

In the next section, we explore the idea that changes in the parameter γ_n over time may play a role in explaining the remaining discrepancies between the model and data. The WS economy with $\gamma_n = 0.50$ illustrates this point well: with a constant γ_n, it matches reasonably well the relative participation rates of older workers in France at the beginning of the period, but it overestimates them at the end of the period. However, this account ignores the inception of pre-retirement programs in

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condition for θ. We assume that the payroll tax τ adjusts to satisfy the budget constraint of the government. The effects are larger if we assume that τ is off-equilibrium at 5.29 percent in the left column and 2.94 percent in the right column (its respective values in turbulent and tranquil times; see Table 4). The counterfactual participation rates in such circumstances are 76.2 percent and 63.2 percent, respectively.

Table 6. The employment experience of older workers: Data vs. model

(a) Data	1960s	1970s	1980s	1990s	2000s
		Unemployment (ref. = 1960s)			
France	1.00	2.51	3.66	3.76	2.79
Germany	1.00	4.66	7.35	11.04	10.55
Italy	1.00	1.22	1.82	3.20	2.63
United States	1.00	1.61	1.88	1.52	1.47
		Labor force participation (ref. = 1960s)			
France	1.00	0.89	0.58	0.51	0.61
Germany	1.00	0.85	0.73	0.68	0.78
Italy	1.00	0.95	0.98	0.85	0.83
United States	1.00	0.89	0.83	0.85	0.88

(b) Model	Unemployment		Labor force participation	
	Rate	Change	Rate	Change
WS, $\gamma_n = 0.25$	11.22	2.11	70.3	0.79
WS, $\gamma_n = 0.50$	11.20	1.94	59.2	0.73
WS, $\gamma_n = 0.75$	8.38	1.57	44.6	0.68
LF	6.57	1.15	82.3	0.89

NOTE: Data: Own calculations based on data from the OECD labour force database for male workers aged 55 to 64 (see Appendix C). Data for Germany refers to Western Germany prior to 1991. The figures for each decade are computed by averaging values for the last 3 years of the decade, except for the 2000 decade which use the average value for 2005 to 2007 to avoid confounding effects from the Great Recession. The labor force participation rates of older workers are measured relative to participation among prime-age workers for consistency with the model. Model: Labor-market outcomes of older workers in turbulent times and changes relative to tranquil times.

the 1970s for workers aged 60 to 64 and in the 1980s for workers aged 54 to 59, which substantially decreased labor force participation rates in France.

6.2 2nd experiments: Effects of early retirement incentives

We complement the previous subsection with another set of experiments. The evidence collected in Wise (2012) shows that, over the past decades, early retirement schemes underwent significant changes in numerous European countries. To sum up, in the face of high unemployment rates, the incentives towards early retirement were raised in several labor markets, while in a more recent period these changes were often repealed.[39,40] The WS economy can speak to the effects of such policy

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[39]That way of using early retirement schemes is sometimes referred to as 'Malthusian' because at the limit it seems to assume that the number of jobs is fixed. In principle, the WS economy provides a better rationale for increasing the generosity of early retirement schemes: it helps to improve the quality of the pool of job-seekers and thereby to raise the incentives to create more jobs. However, the off-equilibrium exercise in Subsection 6.1 shows that this effect is quantitatively too limited to be taken as a serious justification.

[40]Another policy change that could reinforce the effects analyzed in this subsection are changes in the retirement age. Hairault et al. (2010) demonstrate that a lower retirement age *causes* the employment rate of workers near the retirement

changes: a worker aged 55 to 64 consumes $(1 - \gamma_n)b$ in unemployment, where the parameter γ_n measures the relative generosity of early retirement schemes that lower the value of staying in the labor force. In this subsection, we discuss the effects of varying γ_n from 0 to 100 percent.

Different labor market conditions. There are two sets of economic conditions worth discussing in relation to early retirement schemes. First, the empirical literature finds that technological change tends to be more detrimental to the employment of older workers. This effect occurs both directly through the use of new information technologies and through the induced changes in organizations and work practices (see, e.g., Aubert et al. (2006); Behaghel et al. (2014)). Thus, we find it useful to analyze the effects of early retirement schemes under different degrees of skill obsolescence. Second, the literature shows that tougher employment protection affects employment among older workers negatively. There are, again, direct effects coming from costly layoff procedures (e.g. Behaghel et al. (2008)) and several indirect effects that are related to increased labor market rigidities. For instance, Blau and Shvydko (2011) provide evidence that some rigidities prevent a smooth transition towards retirement, hence that their impact is more negative among older workers. Consequently, we also study the effects of early retirement schemes under different levels of employment protection.

Unemployment effects. Figure 7 reports the steady-state unemployment effects of changing the incentives to early retirement in economies characterized by different levels of employment protection, and facing different degrees of economic turbulence.

The first remark is that strong early retirement incentives are effective in reducing unemployment numbers among older workers. As shown in Panel b., in tranquil times when the generosity of early retirement schemes is worth 80 percent of the unemployment benefit, older workers start to drop from the labor market and thereby they shrink the size of the unemployment pool. This substitution effect between unemployment and nonparticipation is stronger in turbulent times in that it occurs at less generous levels of the parameter γ_n. The mechanism is, again, driven by the relationship between the individual participation decision and the expected probability of finding a suitable match. By the same token, the substitution effect is more pronounced with a high job destruction tax because the latter reduces the employment probability faced by older workers.

Next, we analyze the impact on unemployment among workers at younger ages (panel a.). In tranquil times, their unemployment rate is virtually independent of the welfare programs available out of the labor force at older ages. Meanwhile, for the rate of skill obsolescence that seems to prevail since the 1980s, we find that their unemployment rate increases by a substantial amount with nonparticipation among older workers. This reflects the lower surplus of employment in times of economic turbulence. What is more, panel a. shows that the job destruction tax Ω amplifies the complementarity between nonparticipation at older ages and unemployment at younger ages. Chéron et al. (2011) provide several insights that shed a light on this result. Since exogenous retirement allows firms to avoid paying the layoff tax, it is almost never optimal to destroy a job when the worker is near the retirement age: $\widetilde{y}_+(h, z, a)$ is lower when a gets closer to A. Agents anticipate that low productivity jobs are less likely to be destroyed at the end of the working life cycle. In turn, at the match formation stage when an employer meets a worker who could remain in the job until retirement, they become

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age to decrease.

more selective as to the initial productivity draw. Thus, the forward-looking nature of employment relationships explain why raising workers' bargaining position at the end of the working life (higher γ_n) has negative spillovers onto employment at younger ages.

(a) Prime-age workers
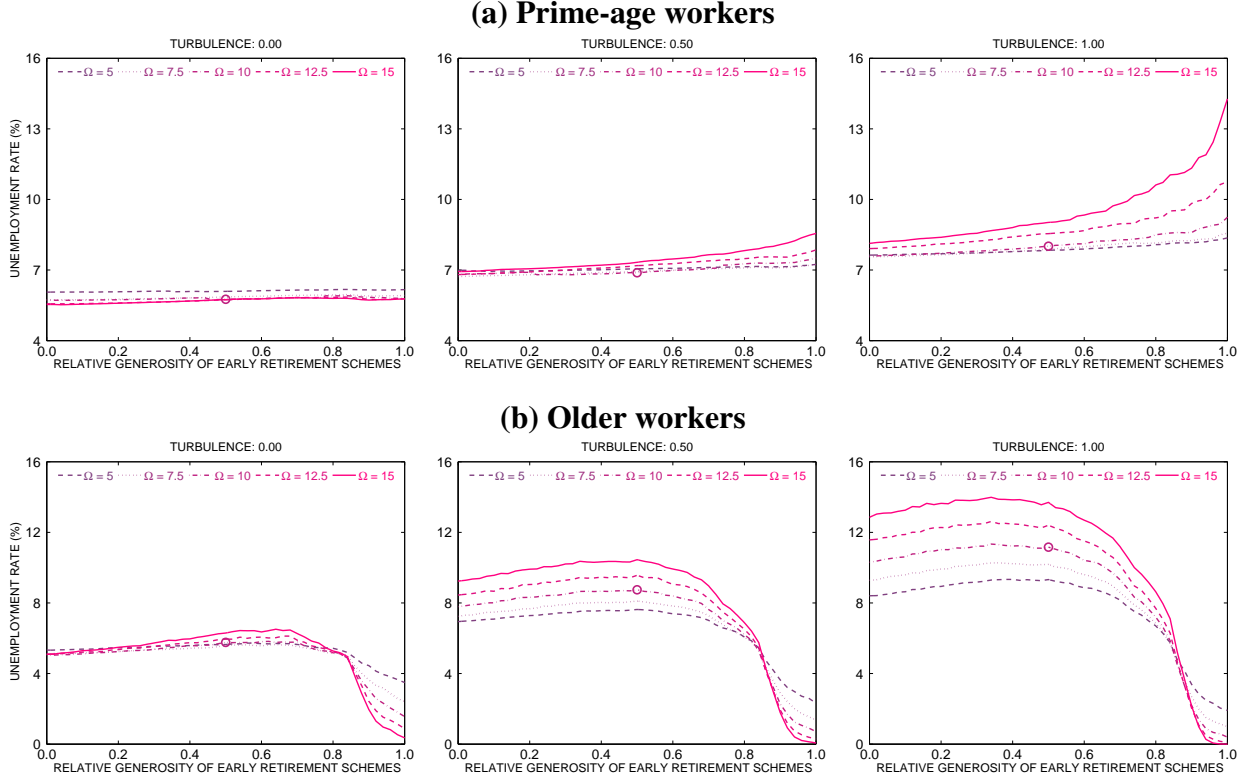
(b) Older workers

Figure 7. Unemployment effects of early retirement incentives

NOTE: Panel a. refers to the unemployment rate of prime-age workers. Panel b. refers to the unemployment rate among older workers. The left, middle, right graphs refer to a degree of turbulence of 0.0, 0.5, 1.0, respectively. The different lines in each graphs refer to different levels of employment protection indicated by the value of the layoff tax, Ω. The circle shows the unemployment rate (among prime-age workers and among older workers) in the benchmark WS economy.

Adding it all up. To synthesize the results of these experiments, we evaluate several employment and unemployment elasticities with respect to labor force participation among older workers. Following Section 2, we use e_a, u_a, p_a to denote the employment, unemployment and labor force participation rates, respectively, of age group a with $a = 20 - 54$ for prime-age workers and $a = 55 - 64$ for older workers. We let ω_a denote the population share of age group a. Finally, $\varepsilon_{i,j}$ denotes the elasticity of variable i with respect to variable j. The main accounting equation is:

$$\varepsilon_{e,p_{55-64}} = \omega_{20-54} \frac{e_{20-54}}{e} \varepsilon_{e_{20-54},p_{55-64}} + \omega_{55-64} \frac{e_{55-64}}{e} \varepsilon_{e_{55-64},p_{55-54}}. \tag{20}$$

It decomposes the effects of older workers' participation rates on the aggregate employment rate through two channels: directly through employment in this age group ($\frac{e_{55-64}}{e} \varepsilon_{e_{55-64},p_{55-54}}$) and indirectly through employment among younger workers ($\frac{e_{20-54}}{e} \varepsilon_{e_{20-54},p_{55-64}}$).

Table 7 reports the employment elasticities that enter equation (20) and two unemployment elasticities. Let us start with the employment effects among older workers in columns 3 and 4, which are related by: $\varepsilon_{e_{55-64},p_{55-54}} = 1 - \frac{u_{55-64}}{1-u_{55-64}} \varepsilon_{u_{55-64},p_{55-64}}$. In line with Figure 7, under most combinations of early retirement schemes and employment protection, nonparticipation is a substitute to unem-

Table 7. Labor market effects of early retirement incentives

	Elasticities by age groups				Total
	$\varepsilon_{u_{20-54},p_{55-64}}$	$\varepsilon_{e_{20-54},p_{55-64}}$	$\varepsilon_{u_{55-64},p_{55-64}}$	$\varepsilon_{e_{55-64},p_{55-64}}$	$\varepsilon_{e,p_{55-64}}$
	(1)	(2)	(3)	(4)	(5)
(a) $\gamma_n = 0.25$					
$\Omega = 5.0$	0.161	0.011	-0.632	1.063	0.195
$\Omega = 7.5$	0.016	0.019	-0.594	1.066	0.196
$\Omega = 10.0$	-0.126	0.021	-0.306	1.038	0.187
$\Omega = 12.5$	-0.205	0.027	-0.355	1.050	0.189
$\Omega = 15.0$	-0.384	0.039	-0.334	1.053	0.193
(b) $\gamma_n = 0.50$					
$\Omega = 5.0$	-0.063	0.011	0.171	0.983	0.162
$\Omega = 7.5$	-0.223	0.018	0.291	0.967	0.159
$\Omega = 10.0$	-0.267	0.022	0.169	0.979	0.157
$\Omega = 12.5$	-0.170	0.017	0.120	0.983	0.147
$\Omega = 15.0$	-0.330	0.025	0.333	0.948	0.144
(c) $\gamma_n = 0.75$					
$\Omega = 5.0$	-0.195	0.009	1.528	0.877	0.121
$\Omega = 7.5$	-0.136	0.003	1.620	0.863	0.107
$\Omega = 10.0$	-0.323	0.017	1.722	0.844	0.111
$\Omega = 12.5$	-0.435	0.031	1.647	0.838	0.118
$\Omega = 15.0$	-0.561	0.051	1.494	0.836	0.131

NOTE: An entry in columns 1 and 3 (resp. 2, 4 and 5) of the table is an unemployment (resp. employment) elasticity with respect to the labor force participation rate of older workers in the WS economy under turbulent times. The employment protection level is indicated by the value of Ω and different values of γ_n are indicated in panels a, b and c.

ployment ($\varepsilon_{u_{55-64},p_{55-64}}$ is positive). The elasticity of their employment rate remains close to 1 in all instances. Turning to the effects among prime-age workers, we find in column 1 that nonparticipation of older workers tends to complement unemployment among younger workers ($\varepsilon_{u_{20-54},p_{55-64}}$ is negative). The bottom of the table shows that the elasticity can be as high as 0.5 in absolute value. The effects on the employment rate of prime age workers is necessarily more modest. Indeed, the accounting equation for column 2 is: $\varepsilon_{e_{20-54},p_{55-64}} = \varepsilon_{p_{20-54},p_{55-64}} - \frac{u_{20-54}}{1-u_{20-54}}\varepsilon_{u_{20-54},p_{55-64}}$, which yields smaller absolute values of $\varepsilon_{e_{20-54},p_{55-64}}$ since $\varepsilon_{p_{20-54},p_{55-64}} \approx 0$.

Column 5 of Table 7 allows to gauge the magnitude of the effect of a negative elasticity $\varepsilon_{u_{20-54},p_{55-64}}$ on the aggregate employment elasticity $\varepsilon_{e,p_{55-64}}$. Recall that the employment elasticity among older workers is around 1, that their population share ω_{55-64} is about 0.22 and that their relative employment rate in turbulent times, e_{55-64}/e, is between two thirds and one half. Hence a back-of-the-envelope calculation shows that $\omega_{55-64}\frac{e_{55-64}}{e}\varepsilon_{e_{55-64},p_{55-54}}$ is, in all instances, the main channel that links nonparticipation among older workers to aggregate employment. Meanwhile, at the bottom of the table, we find that the indirect effect is quantitatively large. In the last three rows, for example, $\frac{e_{20-54}}{e}\varepsilon_{e_{20-54},p_{55-64}}$ explains 13, 22, and finally 35 percent of the aggregate employment elasticity $\varepsilon_{e,p_{55-64}}$. These num-

bers indicate that the complementarity between older workers' nonparticipation and unemployment at younger ages can have a a nonnegligible impact on aggregate employment, hence that it cannot be ignored when raising the incentives towards early retirement.

7 Conclusion

This paper provides a unified account of the trends in unemployment and labor force participation that characterize the secular employment experience of older male workers on the two sides of the Atlantic. This account is premised on the hypothesis that the interaction between economic turbulence and institutions deteriorate employment in ways that have been analyzed by Ljungqvist and Sargent (1998, 2008). We subject the shocks-and-institutions hypothesis to a new test: we ask whether it can explain jointly the role of unemployment and labor force participation in the deterioration of employment outcomes. In the model proposed in this paper, we find that the hypothesis is quantitatively successful at explaining: (i) the reduction in labor force participation among older workers in the United States, (ii) the more pronounced decline in labor force participation observed in Europe alongside rising unemployment rates, (iii) the differences across European countries in the role played by unemployment and labor force participation in these dynamics. We also find that under a set of economic conditions that could characterize several European labor markets before efforts were made to delay retirement, early retirement schemes for older workers may have increased unemployment among workers at younger ages.

The general equilibrium model presented in this paper offers avenues for future research. A first application, which follows naturally from the notion of economic turbulence, relates to the effects of retraining policies. An operative labor force participation margin adds an interesting mechanism to the evaluation of retraining policies in that their objective is partly to maintain workers with depleted skills in the workforce. For instance in the present model, the unemployment effects of a policy that restores the skills of laid-off workers are unclear: unemployment numbers may well increase simply because workers drop from unemployment into nonparticipation less often. Hence the model could serve as a structural framework for assessing these effects, which are typically difficult to capture in the context of reduced-form evaluations of labor market policies. Second, the model could be extended to a political economy environment where labor market programs are determined by workers/voters. The numerical experiments show that labor market programs targeted at specific groups of workers can have spillover effects onto workers in the rest of labor market. Thus, an intriguing question is whether such programs can be supported by a majority of workers/voters in equilibrium. Finally, while the focus of this paper in on the employment experience of male workers, it is natural to ask what lessons could be drawn regarding the secular employment experiences of women. To accord with the data, the model would need a pull factor drawing more women into the workforce. The shocks-and-institutions would help to explain why female employment rates over the past half-century have increased less in France, Germany or Italy than in the United States.

Appendices

A Calibration and model fit

This appendix contains auxiliary information for the calibration of the model in Section 4 and the assessment of the model fit in Section 5.

A.1 Life-cycle profile of labor market transitions

To analyze the life-cycle profile of labor market transitions, we use data from the monthly files of the Current Population Survey (CPS). We longitudinally match male CPS respondents using household and person identifiers along with a race/age filter. Using the matched data, we compute the monthly transition probability of moving across labor market states (employment, unemployment, nonparticipation) for each group of individuals of age a in calendar period t. Let q^{ij} be the transition probability of moving from i to j (where i and j denote a labor market state). We run the regression

$$q_{a,t}^{ij} = \vartheta_a \mathbf{D}_a + \vartheta_t \mathbf{D}_t + \varsigma_{a,t}, \tag{21}$$

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}.

Odd ratios. Figure A1 plots the odd ratio of moving to employment from unemployment rather than from nonparticipation, measured over the age range 20-64. A very salient fact in Figure A1 is that the odds are substantially higher at older ages: they increase from 2-2.5 at ages 20 to 25 to 7-8 at ages 55 to 64. Workers who move to nonparticipation at older ages are less likely to re-enter the labor force, compared to younger workers. This fact dovetails well with the idea that nonemployed workers who are in the unemployment pool rather than out of the labor force remain more strongly attached to the labor market. Finally, in Figure A1 we use two different periods to establish this fact. If anything, the life-cycle profile of the odd ratio did not flatten out as male workers in the U.S. became less prone to participate to the labor market.

Our framework assumes that workers cannot switch directly from nonparticipation to employment. We think that Figure A1 provides support for this assumption. Indeed, in the analysis movements in and out of the labor force are concentrated among older workers, and the model dictates that workers can return to employment only by staying in the unemployment pool.

Data vs. model. Figure A2 shows the life-cycle profile (above the age of 50) of the six transition probabilities under study, based on CPS data from January 1976 until December 1979.[41] The solid line refers to the data while the scattered stars refer to the LF economy. Since in the model we abstract

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[41]We use CPS data before 1980 to accord with the calibration strategy, which fits data moments from the period before turbulence increased. Data for more recent periods yield similar results. In this respect, it seems safe to assume that the profiles computed from the late-1970s data are similar to those that we would obtain from the early-1970s data if these were available.
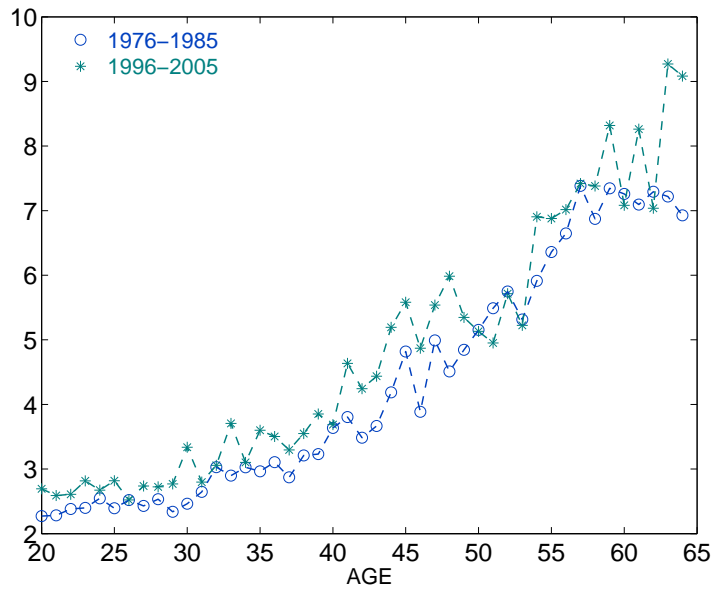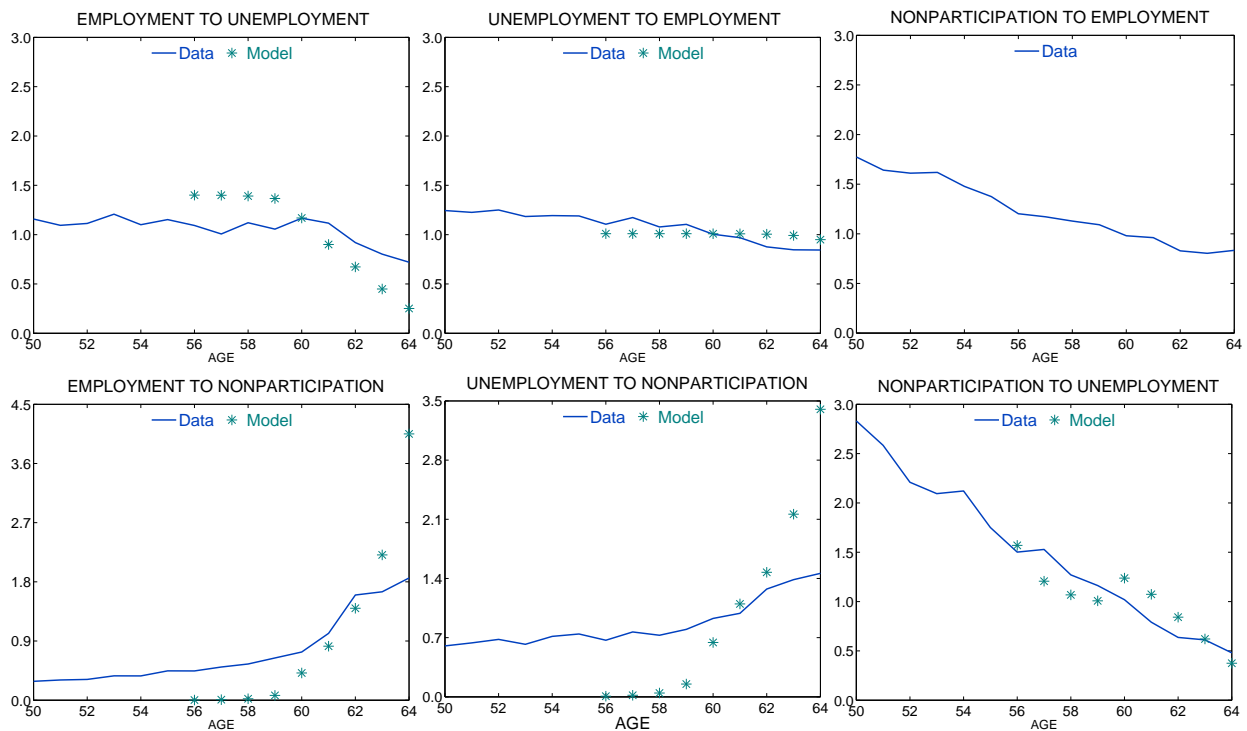
Figure A1. Odd ratio of moving to employment from unemployment relative to nonparticipation

NOTE: Own calculations based on data from the Current Population Survey for the years 1976–1985 (circles) and 1996–2005 (stars). See the text for details on the estimation of transition probabilities used to the compute odd ratios.

from nonparticipation among prime-age workers, we must take a stand on how the life-cycle profiles ϑ_a should be scaled to compare the model and the data. Our approach is to normalize the coefficients by a common factor so that each life-cycle profile is on average 1.0 over the age range 56-64 (the range where workers in the LF economy under tranquil times move in and out of the labor force).

Figure A2. Life-cycle profile of labor market transitions

NOTE: In each graph, transition probabilities are normalized to average one over the ages of 56 to 64. Data (solid lines): Own calculations based on data from the Current Population Survey for the years 1976–1979. See the text for details on the estimation of transition probabilities. Model (stars): Transition rates in the LF economy under tranquil times.

In the calibration, we choose π, the persistence of the utility of leisure, to match the decrease in re-entries from nonparticipation to unemployment. As can be seen in the plot in the right bottom corner, the model matches this profile well. There are other life-cycle profiles worthy of attention in Figure A2. Towards the end of the life cycle, workers in employment and unemployment become at a higher risk of moving to nonparticipation. The model can reproduce this pattern over the age range 56-64 *on average*: it undershoots the corresponding transition probabilities before age 60 and overshoots it afterwards. Finally, as shown in the right top corner, the probability of moving from nonparticipation to employment is also decreasing at the end of the working life.

A.2 Displacement and job tenure

We use data from the biennial Displaced Worker supplements of the CPS to select a value for λ, the probability of being exogenously displaced. These data provide information on: the reason for losing the previous job, the length of time worked at this job and a number of job characteristics. The sample is restricted to male workers aged 30 to 54.[42] We supplement these data with a ranking of declining occupations which we compute from the March CPS (see the footnotes to Table A1). We think of declining occupations as a proxy for the loss of human capital triggered by the λ shock.[43]

Table A1. Years of job tenure prior to job 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: Own calculations based on data from the Displaced Worker supplements of the CPS and the March CPS. All figures refer to 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 declining occupations is constructed as follows: the annual employment share of each 2-digit occupation over the past decades are computed using the March CPS; the employment share of each occupation is regressed against a linear time trend; the OLS coefficient on the time trend is used to rank occupations from the top declining to the top expanding ones.

Table A1 reports the number of years worked at the previous job for groups 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, among those who report that job loss was caused by the plant or the company being closed down or because their previous 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 at least 8.1 years when we look at workers previously employed in declining occupations. The average of the last two numbers is 7.5 years, which we use to parametrize λ.

[42]We remove workers aged 20 to 29 from the sample because of the very large number of individuals who report 0 years of work experience at the lost job.

[43]Returns to tenure indicate that human capital is occupation specific (Kambourov and Manovskii, 2009b). Suppose that a worker is displaced from his job after many years and that his previous occupation of employment has shrunk so that his probability of reemployment in that occupation is small. This situation is akin to: $\mu^{\ell}(h,h) < 1$.

A.3 Displacement and economic turbulence

Figure A3 reports the earnings losses of displaced workers in tranquil times and under turbulent times. Using the same metric as in Figure 5 which normalizes time-0 earnings, Figure A3 illustrates that turbulent times do not necessarily increase the relative earnings losses suffered upon displacement. On the one hand, a higher degree of turbulence increases the probability of suffering a greater skill loss after a layoff, which increases the earnings gap between stayers and displaced workers. On the other hand, turbulence flattens out the life-cycle profile of earnings, so much so that on average at the time of displacement workers fall from a lower rung of the earnings ladder. This second force reduces the earnings difference between stayers and displaced workers. In practice, we find that these effects are small in magnitude and they seem to offset one another. They leave no discernible impact of an increase in turbulence on the earnings losses of displaced workers.
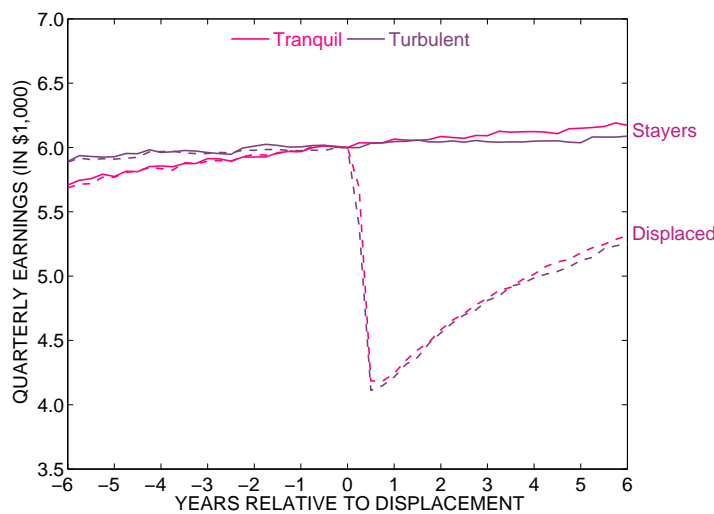
Figure A3. Earnings losses of displaced workers: tranquil and turbulent times

NOTE: The solid lines show the quarterly earnings of a typical cohort of workers in the LF economy. The dashed lines shows the earnings of a cohort of workers displaced at time 0. The lines in light magenta refer to tranquil times. The lines in dark magenta refer to turbulent times. See the footnote to Figure 5 in the main text for additional details.

A.4 Transitory variance of earnings

Our analysis of earnings instability is based on data from the Panel Study of Income Dynamics. We use a sample of male heads of household aged 20 to 54, who are neither self-employed, dual-employed or working for the government. As a preliminary step, we retrieve the residual part of wages that is not explained by life-cycle effects and/or education. That is, for each year of the period considered, we run the OLS regression: $\log{(w)}_{i,t} = \mathbf{x_{i,t}}\delta_t + \upsilon_{i,t}$, where $\log{(w)}_{i,t}$ is the log of annual earnings and $\mathbf{x}_{i,t}$ includes a quartic polynomial of age that we also interact with a set of educational dummies. Thus, for each individual in the sample the earnings variable we use is: $\widehat{\upsilon}_{i,t} = \log{(w)}_{i,t} - \mathbf{x_{i,t}}\hat{\delta}_t$.

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 using $\overline{\widehat{\upsilon}_{i,t}}$ (where the top bar denotes the average with

respect to calendar time). The transitory variance is then estimated using:

$$\widehat{\mathbb{V}(\xi_i)} = \frac{1}{N} \sum_{i=1}^{N} \left[\frac{1}{T_i - 1} \sum_{t=1}^{T_i} \left(\widehat{\upsilon}_{i,t} - \overline{\widehat{\upsilon}_{i,t}} \right)^2 \right]. \tag{22}$$

We refer to a time window by taking the middle year of the time window, e.g. the transitory variance in 1975 is estimated using the time window 1968-1982. In panel a. of Table 3, there is a difference in *levels* with the transitory variances in Gottschalk and Moffitt (1994, 2009): our estimates are much closer to Kambourov and Manovskii (2009a) due to similar sample dispositions and calculation of $\widehat{\upsilon}_{i,t}$. The *trend* in earnings instability displayed in Table 3 is in line with both set of studies.

A.5 Assessment of the model fit

Table A2 compares targeted moments and the corresponding moments generated by the model.

Table A2. Assessment of the model fit

Parameter	Targeted moment	Data	Model[*]
z_{sup}	Labor force participation rate of older workers relative to prime-age workers	92.0 percent	92.2 percent
π	Decrease in transitions from nonparticipation to unemployment (OLS regression on age)	-0.141	-0.115
σ_ε	Separation from employment to unemployment among workers aged 20 to 49	2.0 percent	2.0 percent
M	Average duration of unemployment	3.0 months	3.0 months
$\mu^\ell(H,H)$	Transitory variance of earnings in 1975	0.108	0.103
Ω	Dismissal costs for high tenure workers expressed in months for the worker's wage	8.7 months	8.0 months

NOTE: [*] The model refers to the LF economy except for the last row of the table. z_{sup}: upper bound for the utility of leisure. π: persistence of the utility of leisure. σ_ε: standard deviation of idiosyncratic productivity shocks. M: aggregate efficiency of the matching function. $\mu^\ell(H,H)$: probability of retaining the highest skill level after a layoff. Ω: job destruction tax (WS economy).

B Discussion of modeling choices

B.1 Leisure utility vs. entry costs

The model assumes that participation decisions are driven by a time-varying utility of leisure. That is, when workers choose to participate in the labor force, they must forego the utility derived from their current z_t. There is an alternative to this assumption which builds on the idea that nonparticipants must pay a fixed cost to re-enter the labor market. These two assumptions are actually related. To see this, suppose that, in the model of Section 3, workers incur a fixed cost δ when they move

from nonparticipation to unemployment. Equation (5) that describes the behavior of nonparticipants becomes

$$v^n (b,h,z,a) = z(a) + \beta \sum_{a'} \alpha (a,a') \sum_{h'} \mu^o (h,h') \int \max \left\{ v^n (b,h',z',a'), \right.$$
$$\left. v^u (b,h',z',a') - \delta \right\} dF (z'|z). \quad (23)$$

Let $\widetilde{v^n} (.) \equiv v^n (.) + \delta$ and $\widetilde{z} (.) \equiv z(.) + (1 - \beta) \delta$. The above equation (23) can be rewritten

$$\widetilde{v^n} (b,h,z,a) = \widetilde{z}(a) + \beta \sum_{a'} \alpha (a,a') \sum_{h'} \mu^o (h,h') \int \max \left\{ \widetilde{v^n} (b,h',z',a'), \right.$$
$$\left. v^u (b,h',z',a') \right\} dF (z'|z). \quad (24)$$

In particular, the relationship between $z(.)$ and $\widetilde{z}(.)$ supports the idea that the utility of leisure in the baseline model captures some entry costs that one could introduce in an alternative model.

The following observation suggests that, compared to re-entry costs, a time-varying utility of leisure is better suited to explain older workers' participation decisions. In the data, we observe a decrease in transitions from nonparticipation into employment and unemployment towards the end of the working life (see Figure A2). This feature could be attributed either to a higher utility of leisure or to an increase in re-entry costs. However, at the same time we observe an increase in transitions *into* nonparticipation. This feature is more readily explained by making nonparticipation more attractive through a change in the utility that workers derive when out of the labor force.

B.2 Younger workers

The model is designed to explain the employment experience of older workers. In this appendix, we provide some observations on several changes that could help the model explain the employment experience of younger workers. First, let us note that the model is qualitatively consistent with the following facts: it predicts (i) that employment rates are hump-shaped over the life cycle, and (ii) that the employment rates of prime-age workers are not higher in the U.S. than in Europe. However, there are some features of the employment experience of younger workers that the model does not explain, and which prevent it from matching the dynamics of employment over the whole life cycle.

Employment. In the model, the increase in employment rates at the beginning of the life cycle is explained by the assumption that newborn workers enter the labor market through unemployment. Labor-market frictions are the only force that prevents their employment rates to 'jump' to its plateau level. As a result, the increase in employment rates at the beginning of the working life is too large quantitatively, i.e. unemployment decreases with age too quickly.

To address this deficiency, one needs to generate more transitions in and out of employment at the beginning of the working life. One route to achieve this, and which is pursued by Kitao et al. (2016), is to include some job churning that makes younger workers return to unemployment several times to search for a different job. Suppose that workers first need to find a 'career' in the spirit of the study by Neal (1999). In the context of our model, finding a career could mean acquiring the technology

$\mu^e(h, h')$. Thus, one could introduce job churning as follows: (i) newborn workers cannot accumulate human capital initially, (ii) there is a probability χ that a job gives a worker access to a career and (iii) when a worker finds out that his current job is of the $1 - \chi$ type, he quits to sample another job. After finding his career pathway, a worker faces the same environment as in Section 3. Under these assumptions, young workers would experience repeated transitions into and out of employment. χ would help the model fit the decline of employment-to-unemployment transitions over the life cycle.

Participation. Another discrepancy with the data at the beginning of the life cycle is that the employment rates in the model are only the converse of unemployment rates, i.e. younger workers always participate in the labor force. This is not consistent with the data because a very large fraction of younger individuals are enrolled in education full time.

To replicate this feature of the data, one possibility is to introduce a type of ex ante heterogeneity across individuals that captures the role of education. Suppose, for instance, that there are several individual types that differ with respect to their permanent component of productivity, and such that more productive types enter the labor market with a delay (which matches the time spent in schooling). The permanent component of productivity would shift the unconditional mean of the productivity process of jobs, $\bar{y}_h$, i.e. more productive types yield more productive jobs.

Another possibility (which is not exclusive of the former) is to exploit the idea of 'career' discussed in a previous paragraph. Suppose that newborn workers draw an idiosyncratic cost of enrolling in a program that allows participants to find out their career pathway (e.g. higher education, vocational training, etc). Hence, the program is an alternative to the job churning phase aforementioned. Suppose furthermore that the program cannot be completed instantaneously, so that workers enrolled in the program enter the labor market with a delay. These workers are initially classified as being out of the labor force, and after completing the program they move directly into their career pathway (i.e. they have access to the technology $\mu^e(h, h')$ when on the job).

In both instances, there is a distribution – of productivity types in the first scenario, and of idiosyncratic costs of program participation in the second scenario – that could be calibrated to match the large share of young workers who remain out of the labor force.

C   Data and additional facts

In this appendix, we report more detailed time series of labor force participation (C.1), the time series for four other European countries (C.2), and the results from another accounting exercise that measures the contribution of labor force participation to changes in aggregate employment (C.3).

Data. The data come from the OECD labour force statistics database (`http://stats.oecd.org/`). The OECD provides statistics on employment, unemployment and nonparticipation that are harmonized for the purpose of cross-country comparisons. These data are available as aggregates as well as by gender and by 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 the OECD data for certain countries as follows. (i) For France, the OECD database contains data only from 1983 onwards. We compute the pre-1983 time series 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/`). (ii) For Germany, the OECD database contains data only for Western Germany before 1991. This results in a discontinuity in the German time series, which is visible for instance in Figure 2. We do not adjust the data for Germany, but we have checked that the variance decomposition in Section 2 produces similar results when we use data for Western Germany after 1991 (the Western German data are available in the OECD database until 1998). (iii) For Italy, several time series contained in the OECD database exhibit some large discontinuities in 1982 and 1993. We remove the breaks in the OECD data by aligning those time series to data provided by the Italian National Institute of Statistics (`http://dati.istat.it/`). (iv) For Spain and Portugal, the OECD data start in 1972. For Norway, the OECD data start in 1974. We make no attempt to expand these data before the first period of observation.

C.1 Labor force participation by age groups

Figure C1 plots the time series of labor force participation for younger, prime-age and older male workers. The first remark pertains to differences between continental Europe and the U.S. As evidenced by the four plots, the discrepancies between Europe (especially France and Italy) and the U.S. come from workers at the extremity of the working life cycle. Labor force participation rates of prime-age workers, on the other hand, are similar across the four countries and they remain high over the period considered. This feature provides additional support for our specification of the utility of leisure which shuts down the participation margin for prime-age workers.

Second, Figure C1 shows that the secular decline in labor force participation affects both younger and older workers. The driving forces of the trends shown in Figure C1 are probably different for these two groups of workers. Enrollment in education is a key variable to explain nonparticipation among younger workers; see the discussion in Appendix B. Hence it is conceivable that the expansion of higher education accounts for a large part of the decrease in labor force participation at ages 15 to 24. On the other hand, it seems unlikely that this pattern is explained by the interaction between skill obsolescence, the opportunity cost of labor force participation and welfare benefits. According to the model, this interaction is the driving force behind the trend in older workers' nonparticipation.

C.2 Comparison with other European countries

Like Figure 1 in the introduction, Figure C2 displays the trend component of unemployment and labor force participation of older male workers in a set of European countries (here: Portugal, Norway, Spain and Sweden). It shows that the outbreak of high unemployment rates and lower labor force participation was not confined to the 'big three' of continental Europe; the four countries included in Figure C2 underwent the same evolution. The experience of Spain (the 4th largest country in continental Europe) is very similar to that of France, Germany and Italy: the unemployment rate of older male workers reached a plateau of 11 percent in the mid-1980s and their labor force participation rate declined steadily until the mid-1990s.

In Portugal, Norway, Spain and Sweden, lower male employment rates in the aggregate are also
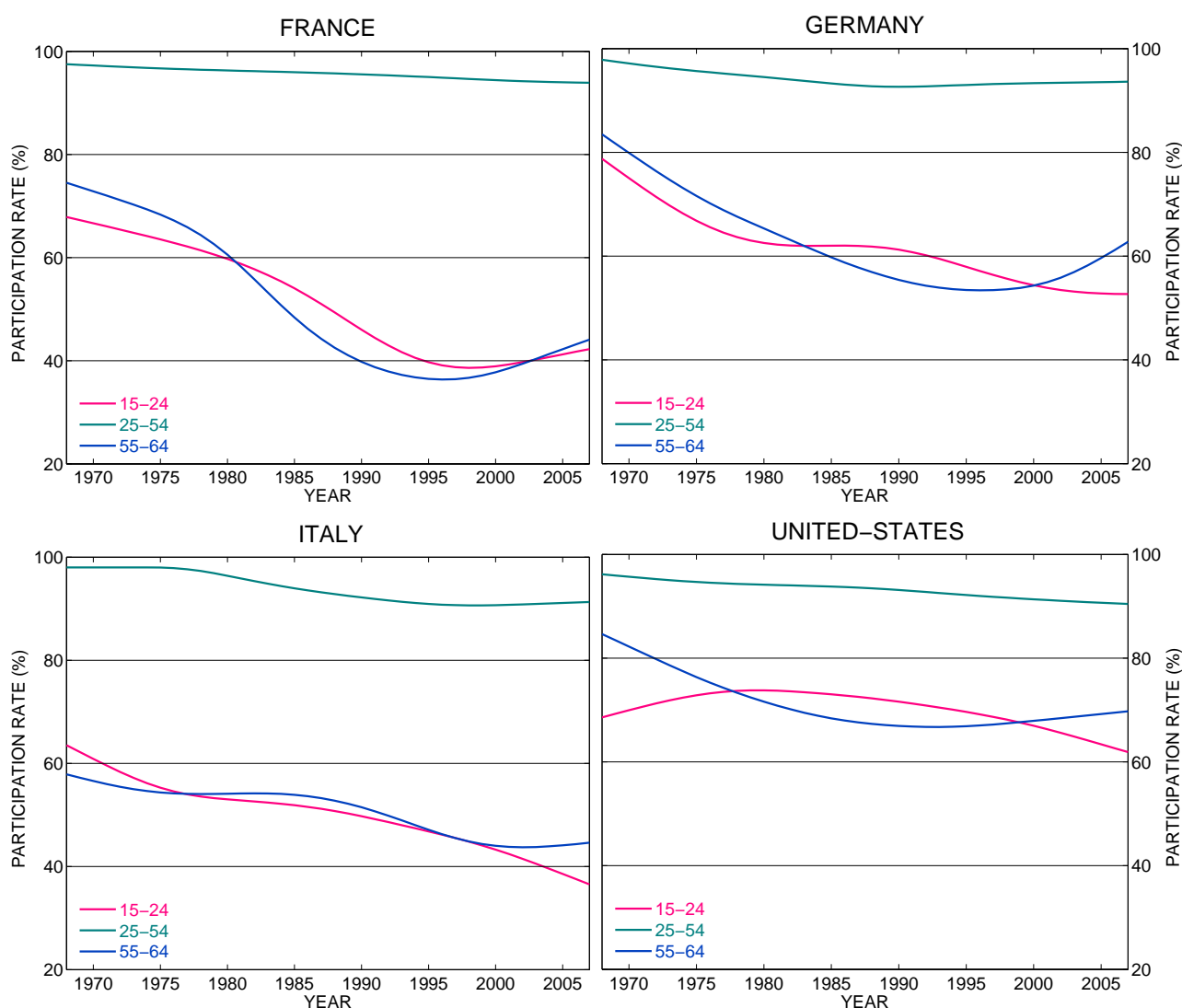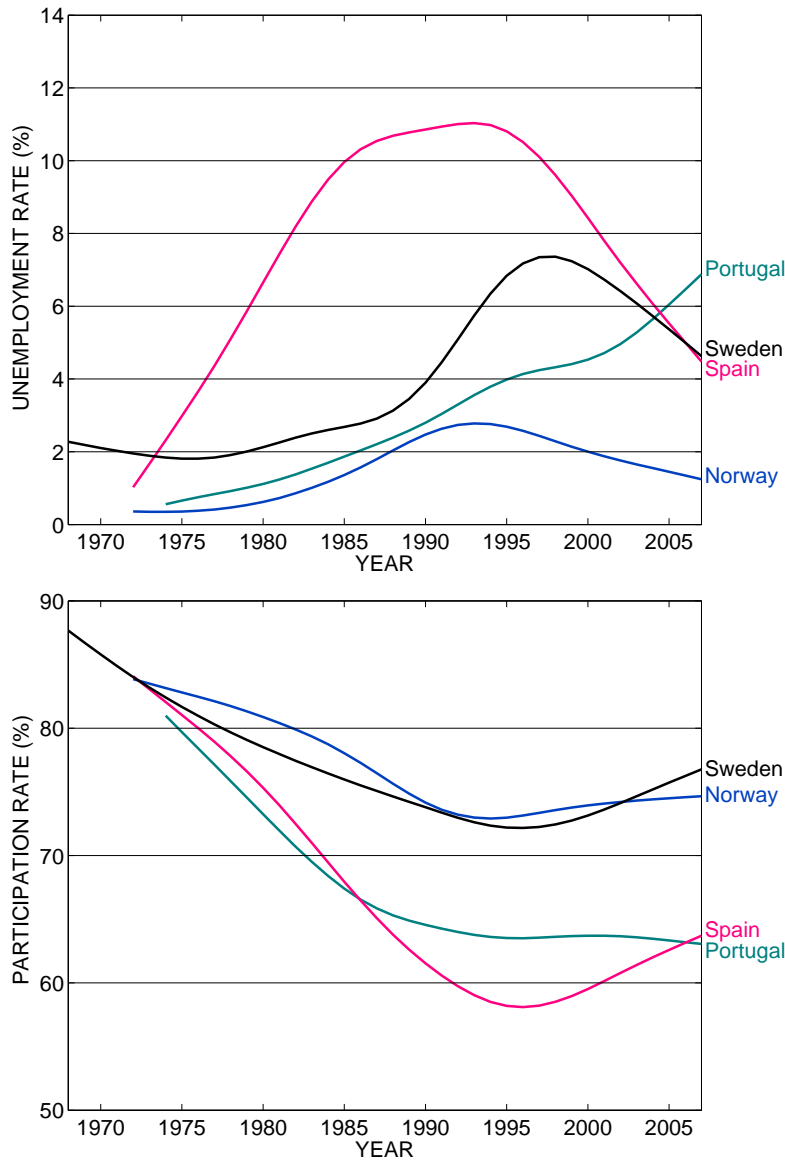
Figure C1. Labor force participation of male workers in different age groups

NOTE: Own calculations based on data from the OECD labour force database for male workers. Data for Germany refers to Western Germany prior to 1991. Each line shows the Hodrick-Prescott trend component with a value of the smoothing parameter equal to 100. The lines in magenta refer to workers aged 15-24. The lines in green refer to workers aged 25-54. The lines in blue refer to workers aged 55-64.

concentrated on workers aged 15 to 24 and 55 to 64. A supplemental file to this paper contains several charts that illustrate this point. Like France, Germany and Italy, the employment rates of prime-age workers in the four European countries of Figure C2 are in the same ballpark of those in the U.S. Finally, compared to France, Italy and Germany, there is more asymmetry between the relative contribution of younger and older workers to the aggregate employment rate in Portugal, Spain and Sweden. Portugal and Spain are most similar to Italy: a lower aggregate employment rate in these countries is associated with a substantially lower employment rate of workers aged 15 to 24. In Sweden the aggregate employment rate is higher on average compared to those countries, and the employment rate of older workers is only slightly lower than the aggregate employment rate. At the same time, the employment rate of workers aged 15 to 24 in Sweden is sometimes 60 percent lower than the aggregate employment rate.

Figure C2. Unemployment and labor force participation among older male workers

C.3 Contribution to aggregate male employment

We complement the analysis of the counterfactual employment rates in Section 2 with the following accounting exercise. As in Section 2, denote by $e_{a,t}$, $u_{a,t}$ and $p_{a,t}$ the employment, unemployment and participation rates of male workers, respectively, for age group a in year t. In addition, denote by $\omega_{a,t}$ the size of age group a in year t relative to the population of male individuals of working age in year t.[44] The aggregate employment rate of male workers is given by

$$e_t = \sum_a \omega_{a,t} p_{a,t} (1 - u_{a,t}) \tag{25}$$

Let us construct two counterfactual time-series based on equation (25) by holding either $u_{55-64,t}$ or $p_{55-64,t}$ constant to the initial period t_0, where $u_{55-64,t}$ and $p_{55-64,t}$ refer to workers aged 55 to 64 (the

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[44]That is, $\sum_a \omega_{a,t} = 1$ for all t: we normalize the size of the population of working-age men to one.

online file contains a set of plots showing these counterfactual time series). Since both unemployment and participation rates deteriorate after t_0, these two counterfactual employment rates are higher than the actual employment rate. Thus, the difference between each counterfactual time series and e_t gives the decrease in aggregate employment that can be attributed (in an accounting sense) to changes in $u_{55-64,t}$ or changes in $p_{55-64,t}$. Table C1 reports the counterfactual-actual difference measured at various time periods. The results are expressed in percentage points.

Table C1. Contribution of unemployment and participation to changes in male employment

Contribution to changes in e_t explained by:		Percentage point difference, 1970s	1980s	1990s	2000s
France	$u_{55-64,t}$	0.21	0.35	0.31	0.26
	$p_{55-64,t}$	0.78	4.89	5.12	5.21
Germany	$u_{55-64,t}$	0.36	0.64	1.45	1.19
	$p_{55-64,t}$	1.98	3.68	5.13	3.15
Italy	$u_{55-64,t}$	0.04	0.11	0.23	0.13
	$p_{55-64,t}$	0.88	1.11	2.53	2.44
Norway	$u_{55-64,t}$	-0.00	0.14	0.13	0.11
	$p_{55-64,t}$	0.25	1.12	1.18	1.66
Portugal	$u_{55-64,t}$	0.04	0.18	0.41	0.67
	$p_{55-64,t}$	0.51	2.64	2.39	2.61
Spain	$u_{55-64,t}$	0.29	0.88	0.69	0.34
	$p_{55-64,t}$	0.66	3.04	3.33	2.90
Sweden	$u_{55-64,t}$	-0.12	-0.05	0.66	0.38
	$p_{55-64,t}$	1.54	2.08	2.41	2.24
United-States	$u_{55-64,t}$	0.12	0.15	0.08	0.14
	$p_{55-64,t}$	1.54	2.20	1.99	2.26

NOTE: Own calculations based on data from the OECD labour force statistics database for male workers. Data for Germany refers to Western Germany prior to 1991. For each country, the first (resp. second) row reports the percentage point difference between the counterfactual time series holding $u_{55-64,t}$ (resp. $p_{55-64,t}$) constant to its late 1960s level and the actual employment rate of male workers, e_t. The figures for each decade are computed by averaging values for the last 3 years of the decade, except for the 2000 decade which use the average value for 2005 to 2007 to avoid confounding effects from the Great Recession. For Norway, Portugal and Spain, the counterfactual time series are computed using the first available data point for these country.

In the eight countries considered, the effect on aggregate employment of changes in labor force participation among older workers is larger compared to the effect of changes in their unemployment rates. Male employment rates in France and in Germany would have been higher by 5 percentage points at the end of the 1990s if $p_{55-64,t}$ had remained unchanged. The corresponding figure is 3 pp. for Portugal, Spain, Sweden, the U.S., and 1 pp. for Norway. These are large deviations in absolute as well as relative terms. For example, the employment rate of male workers in France at the end of the 1990s was 67 percent. Therefore it would have been higher by 7.5 percent if labor force participation among older workers had remained constant. In Table C1, we also see that unemployment among

older male workers is of lesser importance to explain the long-run evolution of aggregate employment. In Germany, where unemployment among older workers mattered most, Table C1 indicates a 1.5 pp effect on the employment rate measured in the late 1990s. This is less than a third of the effect of labor force participation. In the other countries, the effect of unemployment among older workers is less than a 1 pp. difference.

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