Labor Force Participation, Wages and Turbulence (preliminary and incomplete draft)

Francesc Obiols-Homs   Virginia Sánchez-Marcos*

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Abstract

Participation of middle aged men with upper secondary education or less has decreased over the last two decades in the US. This comes together with wage stagnation for this demographic group. In this paper we use a general equilibrium model of the labor market with frictions, participation decisions and endogenous accumulation of skills through a learning by doing technology in order to understand these facts. We quantitatively assess the implications of an increase in the probability of skills loss during non-employment spells (*turbulence*, after Ljungqvist and Sargent, 1998) and show that non-participation increases and wages of more experienced workers fall because with increased turbulence their outside option worsens.

1 Introduction

It is a well known fact that the US has experienced a decrease in the participation rate in the labor market at least over the last three decades. To some extent this is related to the aging of the population, but the decline observed among prime-age men (25 to 54 years old) is specially notorious (see for instance, Krueger 2017). Some additional insight can be gained by looking at participation across education levels. Figure 1 offers a representation using data from the OECD and reveals that the size of the decrease is far from being uniform: the first and second panels of Figure 1 show that there is a persistent decrease in the participation of workers with at most upper secondary education, with a remarkable drop of about 6 percentage points from 1997 to 2017 of the workers aged 25 to 34 and of those aged 45 to 54. This decline is in sharp contrast

*Obiols-Homs, Universitat Autònoma de Barcelona, Sánchez-Marcos, Universidad de Cantabria (email: sanchezv@unican.es). Obiols acknowledges financial support from the Spanish Ministry of Science, Innovation and Universities and FEDER through grant PGC2018-094364-B-I00, and Sánchez acknowledges financial support from Spanish Ministry of Science and Innovation through grant PID2019-108087RB-I00. We thank Mridula Duggal for excellent research assistance with the data. We thank comments of participants at the online meeting of the European Economic Association in 2021.

with the much smaller decrease observed among tertiary educated workers (in the lower panel of Figure 1). According to the Brooking Institution (2017) in 1968 prime-age men with a high school degree or less participated similarly to college, however, in 2015 there is a gap between the two groups of about 11 percentage points.

What is driving the decrease in participation of prime-age low educated workers? The abundant literature about the labor market has mainly focus on unemployment and wages and its dynamics over the cycle, yet important issues related to participation have not received much attention. We contribute to fill this gap by formulating an equilibrium model of the labor market and by using it to conduct a quantitative exploration of the ability of several potential drivers suggested in the literature.

Our main hypothesis behind the reduction in the participation rate in recent times is that it is caused by a higher probability of skill loss during periods of non-employment. This is the *increased turbulence* hypothesis in Ljungqvist and Sargent (1998).[1] We rely on the evidence presented in Davis and von Watcher (2011) to argue that in recent years skill losses during non employment spells are larger. In particular, these authors show that, conditioning on the unemployment rate the earnings loss in the third year of job displacement is larger in the 2000s than in the 1990s (see their Figure 5, p. 19). For an unemployment rate of 5 to 6% they estimate an earnings loss of about 10% in the mid nineties and about 30% in the beginning 2000s.[2]

We also consider two additional facts discussed in the empirical literature and that could be related to the decline in participation. First, Autor et al. (2014) finds evidence that workers with increased exposure to trade experienced lower cumulative earnings over 1992 to 2007, and Acemoglu and Restrepo (2020) finds that an additional robot per thousand workers reduces the employment-to-population ratio by 0.2 percentage points and wages by 0.42%.[3] Second, Abraham et al. (2018) argues that the increase in the generosity of safety net assistance, such as disability insurance programs, may have contributed to the decline in employment over this

[1] In a series of papers Ljugqvist and Sargent (1998, 2004, 2007, 2008) and Baley, Ljugqvist and Sargent (2018) (BLS from now on) explore the combination of *layoff* and of *quit* turbulence (respectively, human capital loss due to involuntary and to voluntary quits) together with the generosity of a welfare state to explain the differences in the unemployment rate level in Europe and in the US. This interesting line of research was partly stimulated by the challenging views in Den Haan, Haefke and Ramey (2001, 2005)(DHHR from now on).

[2] More recent evidence of an increase in earnings loss after displacement is reported in Braxton et al. (2021).

[3] These phenomena are responsible to some extent for the increase in wage inequality and, as argued by Hall (2015), the widening of the earnings distribution may play a role in discouraging participation. Furthermore, Moffit (2012) finds that changes in wages account for half of decline of men participation rate during the period 1999 to 2007.

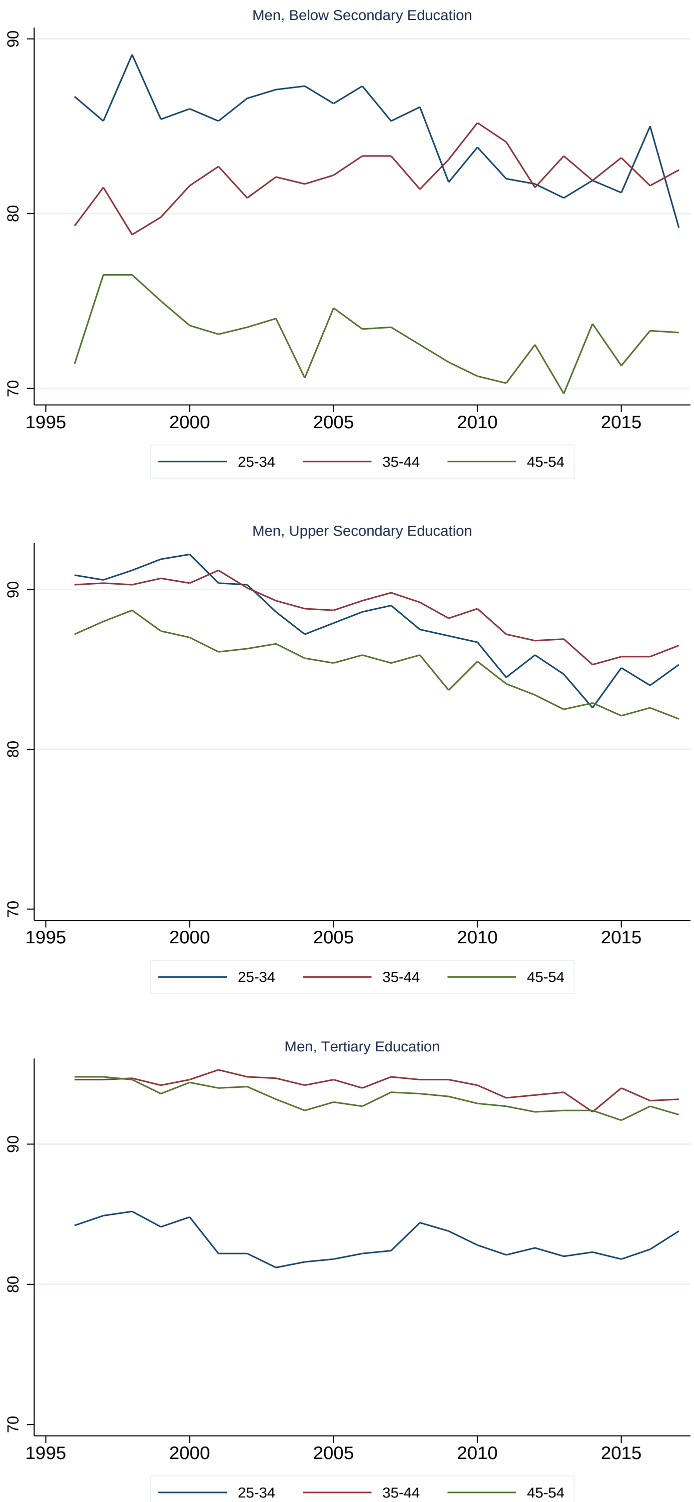

Figure 1: Participation Rate

period.[4]

Our model builds on the search and matching tradition and it embeds the usual features (search frictions, wage bargaining, shocks to non market income, etc.). An innovative characteristic of our model is that it considers the endogenous evolution of human capital as a result of the participation decisions. That is, individuals may accumulate experience while they work, whereas non-employment spells may result in the loss of worker's human capital (in the rest of the paper we refer to experienced workers as high skill or simply *high type* workers, and to inexperienced workers as low skill or *low type* workers). In our quantitative investigation we use the data from SIPP (the 1996 and 2014 panels) to calibrate our model and we investigate the effects of the three counterfactuals discussed above. Specifically, we introduce the increase in turbulence as an increase in the probability of skill loss, we study the effect of a decrease in the productivity of low-skill workers and we finally consider the effect of an increase in the value of not working.

We find that an empirically plausible increase in the probability of skill loss during displacement can account for the increase in non participation that we observe in the data for low educated workers. Of course, a larger turbulence mechanically produces an increase in the number of low type workers for whom leaving the labor market becomes a better option than paying the search cost. There is however a more subtle effect which is the one we wish to emphasize: the increase in turbulence erodes the bargaining power of high skilled workers and thus these workers end up accepting lower wages as a strategy to protect their human capital. It is also worth to emphasize that with increased turbulence the wage of low skill workers tends to *increase*, not to decrease. The reason is that from the firm perspective hiring one of these workers is now more profitable than before: their probability of becoming skilled remains unchanged, and once this happens their wage will be lower than before. Furthermore, the reservation wage of low type workers increases with turbulence due to the lower expected earnings. Therefore, in our model the increase in turbulence results in a reduction in the premium to experience.[5] This

[4]Krueger (2017) argues that the declining participation is related to widespread prescription of opioid pain medication. However, according to Abraham et al. (2018) pain and opioid use and enhanced value of leisure time (as suggested by Aguiar et al. 2017) play a residual role in accounting for declining participation. Finally, Abraham et al. (2018) disregard an increase in spousal income as a driver of declining participation over this period.

[5]This is an interesting dynamic effect that complements the effect identified in Pries and Rogerson (2009): increasing the probability of high search costs (as well as a lower probability of low search cost) may lead to higher transition rates from participation to non participation and to a lower participation. These dynamic effects are useful to account for the differences in the participation rates of different groups of agents and across countries.

relates our analysis to Jeong et al. (2015) where this important empirical fact is documented. Their explanation for the decline in the return to experience is based on population aging and it is independent of the change in participation. Hence, our work suggests that increased turbulence can account for the decrease in the participation rate and, simultaneously, it may be a complementary channel to explain the decline in the return to experience.[6] Regarding the alternative explanations that we explore, they have similar implications for unemployment and transition rates to those of increased turbulence. Interestingly, however, they do not seem to deliver noticeable changes in the premium to experience.

Our paper is related to several papers that with different purposes study the importance of skill depreciation during unemployment. Cairó and Cajner (2018) show that higher firm-specific human capital of educated workers reduces the job separation rate of these workers. Ortego (2018) studies the effect on TFP of skill depreciation during unemployment. In a recent paper Heathcote et al. (2020) find that recessions cause persistent increases in inequality. Workers that experience unemployment tend to lose skills relative to their counterparts that remain employed. As a consequence, periods of unemployment can have a persistent scarring effect and some low skill workers who experience unemployment might decide to stop participating. There are a few papers that explicitly model the participation decision within an otherwise standard labor-macro model. Saint-Paul (2015) studies the effect of a subsidy to job search, in a static model of matching with heterogeneous workers. Our approach is closer to that in Garibaldi and Wasmer (2005) (GW from now on). These authors model the participation decision but do not consider the endogenous evolution of skills. Our work is also related to Pries and Rogerson (2009) where it is considered a model with random participation (search) costs and random separation shocks. These authors show that agents facing the greatest flows between participation and non-participation also have the lowest participation rates. That is, there is a dynamic effect of the expected duration of a participation spell on the participation decision which is in contrast to standard textbook treatments that emphasize static costs and benefits of participation. Finally, our work is also related to Fujita (2018), where the author proposes increased turbulence as a way to explain the observed declining labor turnover in a model in which separations are endogenous.

[6] As explained is Section 2 we use the SIPP data to compute the ratio of monthly earnings of workers with more than 10 years of tenure relative to that of workers with shorter tenure and find that between 1996 and 2014 the premium has decreased about 11%, from 1.43 to 1.27.

The paper is organized as follows. In section 2 we introduce the data that we use to describe both the facts and in the calibration of the model economy, which we introduce in section 3. The results of the quantitative exercises are presented in section 4. Finally, in section 5 we conclude and for the sake of completeness we include a few additional data details, results and solution algorithm in the Appendices.

2 Data

In this section we use the 1996 and 2014 Panels of the Survey of Income and Program Participation to describe both the facts and the hypotheses that motivate our analysis.

In Table 1 we report the change in participation for different age groups and different education categories (the numbers are consistent with OECD data which for completeness we report in table 8 in the Appendix). According to the SIPP data, in 1996 13% of men 25-54 have below upper secondary education, 49% upper secondary education and 37% have tertiary education. The fraction with the lowest level remained constant in 2014, but the fraction of tertiary educated individuals increased up to 49%. All education groups exhibit a decrease in the participation rate, that, as we argued in the Introduction, it is more pronounced for individuals with at most upper secondary education. For this reason we restrict our analysis to middle aged men with less than tertiary education, whom we refer to as *low educated individuals*.

Table 1: Percentage Points Change in Male Labor Force Participation Rate, 1996-2015

	25-34	35-44	45-54
Below Upper Secondary Education	-6.1	0.4	-4.9
Upper Secondary Education	-6.8	-6.7	-8.9
Tertiary Education	-2.9	-2.3	-4.3

Source: SIPP 1996 and 2014 panels.

Overall, according to the SIPP data the participation rate of our group of interest decreased by 6 percentage points, from 89.2% in the 1996 panel (covering 1996 to 1999[7]) to 83.0% in the 2014 panel (covering years 2013 to 2016). The unemployment rate for this demographic group doubles from 4.1% to 8.2% in the same time period, as reported in the top panel of Table 2. Finally, we observe an increase in the duration of unemployment and of the non-participation spells. In order to provide a comprehensive description of the changes in the labor market, the last six rows

[7] We ignore 1995 and 2000 due to the small number of available observations.

of the first panel in Table 2 report the transition rates across labor market status. There is a very clear decline in the transition from unemployment to employment and from unemployment to non-participation. The transitions out of non-participation also declined. Finally, the transition from employment to unemployment exhibits a moderate reduction whereas the transition from employment to non-participation remains stable.

Table 2: Labor Market Statistics

	1996	2014
Participation Rate	89.2	83.0
Unemployment Rate	4.1	8.1
Duration Unemployment (months)	3.31	5.26
Duration Non-employment (months)	6.43	8.64
Monthly Transition Employment to Unemployment	0.74	0.61
Monthly Transition Employment to Non-participation	0.51	0.49
Monthly Transition Unemployment to Employment	19.89	8.73
Monthly Transition Unemployment to Non-participation	6.83	3.59
Monthly Transition Non-participation to Employment	3.79	2.03
Monthly Transition Non-participation to Unemployment	2.43	1.58
Monthly Real Earnings	2513	2397
Monthly Real Earnings if Tenure ≤120 moths	2226	2214
Monthly Real Earnings if Tenure >120 months	3147	2819
Tenure Premium	1.41	1.27
Fraction receiving public transfers if non-employed	0.11	0.23
Fraction married	0.65	0.48
Fraction Spouse Employed/Married	0.67	0.48
Spouse Earnings if Spouse Employed	1667	1998

Source: SIPP 1996 and 2014 panels. After we restrict to middle aged men with less than tertiary educations the number of observations is 429,881 in 2996 and 234,221 in 2014. Monthly real earnings are for the main job, dollars of 2014.

In the second panel of Table 2 we report average monthly real earnings in the main job.[8] Average real earnings exhibit a slight decrease from the 1996 panel to 2014, which is consistent with wage stagnation that has been reported elsewhere in the literature for this demographic group (see for instance Ngai and Sevic, 2021). Since our model features heterogeneity in human capital through a learning by doing technology, we also report real earnings for two type of workers:

[8] We define the main job as the one in which the individual reports to work the largest number of hours per week.

those with firm tenure lower than 10 years and those with larger tenure. The earnings of those with shorter tenures remained stable. In clear contrast, however, the earnings of workers with 10 or more years of tenure decreased over the period.

Table 3: Returns to Firm Tenure

	1996	2014
Upper Secondary Education	0.307***	0.275***
	(0.00602)	(0.00673)
Age	0.0350***	0.0403***
	(0.00366)	(0.00337)
Age Sq	-0.000386***	-0.000407***
	(0.0000473)	(0.0000428)
Tenure	0.00309***	0.00183***
	(0.0000780)	(0.0000983)
Tenure Sq	-0.00000466***	-0.00000253***
	(0.000000260)	(0.000000305)
Constant	0.838***	1.223***
	(0.0694)	(0.0646)
Observations	82391	46748
Adjusted R^2	0.106	0.084

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

We further explore this fact in the regression reported in Table 3 where the log of earnings is regressed against tenure and tenure squared and having an education dummy, and age and age squared as control variables. The estimated coefficients on tenure are consistent with a decrease in the return to tenure. This is in line with the results in Jeong et al. (2015) that we mentioned in the Introduction.[9] Overall, the firm tenure premium (as measured by the ratio of earnings of those with 10 or more years of tenure to the earnings of those with 1ess than 10 years) decreases from 1.41 to 1.27 over this period.

Finally, in the third panel of Table 2 we report several statistics that are relevant to assess various supply factors as potential drivers of the increase in non-participation. First, public transfers and other sources of household's income affect the outside option of working. As shown in the Table, the fraction of non-employed individuals receiving public transfers is larger in the 2014

[9] The fact that the average earnings for all workers in our sample decreased slightly reflects that the distribution of tenure has shifted towards individuals with higher tenure, as shown in Hyatt and Spletzer (2016). This prevents a stronger decrease in the earnings of low educated individuals.

panel than in the 1996 panel. This is consistent with the facts described by Abraham et al. (2018) and therefore the hypothesis of more generous benefits as a driving force of the decrease in participation seems reasonable also in the SIPP data. We also find that in our sample, the fraction of individuals reporting to be married is lower in 2014 (0.48) than in 1996 (0.65) and that the fraction of those with a working spouse (conditioning on being married) goes down from 0.67 in 1996 to 0.60 in 2014. The real earnings of working spouses are slightly larger in 2014 than in 1996. Overall, these figures do not offer a solid support to the hypothesis that the lower participation rate of men is driven by a higher labor market participation of their spouses.

3 Model Economy

Time is discrete and there is a unit mass of infinitely lived agents. Agents are risk neutral and discount the value of future consumption at a rate $\beta \equiv \hat{\beta}(1-\rho^r)$, where $\hat{\beta} \in (0,1)$ is the subjective time discount factor and where $\rho^r \in (0,1)$ is a constant probability of retirement. Retired agents are replaced by newborn agents so that the population remains constant over time.

With respect to the labor market agents can be employed (actively working in the market), unemployed (mainly searching for a job and with a small home production), or not participating (not looking for a job but actively producing at home). There are two levels of experience or skills denoted $s = l, h$ (low and high) that are valuable in market production but irrelevant for home production. The productivity at home is given by b which can take a continuum of values. This means that in addition to the status in the labor market agents will be heterogeneous in their current (s, b) pair.[10]

Labor productivities may change over time. In particular, during non employment (i.e., unemployment and non participation) a high type worker may become low type with probability γ^l, and during employment a low type worker may become high type with probability γ^h ($\gamma^s \in (0,1)$ for $s = h, l$). We follow BLS in that a low type worker that becomes high type retains these skills even if she chooses no to continue employed. We also let the productivity at home to change with probability ρ^b. In case a new b is obtained it is drawn from a distribution with cdf $F(b)$ which has a compact support B (notice therefore that the realizations of b are independent of

[10]Having a discrete number of states for one of the productivities and a continuum for the other is similar to GW, DHHR and BLS, for instance.

the experience level of the worker).

There are frictions in the labor market such that unemployed workers and firms need to spend time in order to form a productive match. These frictions are captured by a matching function and as a result of them unemployed workers find a job with probability λ^w and vacancies are filled with probability λ^f. Finally, active matches may be terminated endogenously (when the worker/firm choose not to continue producing together), and exogenously, which happens with probability ρ^x. Our model therefore encompasses a general notion of turbulence but does not distinguish between "quits" and "layoffs" as BLS, that is, γ^l is the same in a quit and in a layoff and during non employment.

A summary of the timing of events is as follows: in the beginning of a period agents learn whether they have an employment opportunity (i.e., keep their previous job or found one if they were unemployed), or if the employment opportunity is unavailable (when they lost the previous job or did not find one from unemployment/non participation). Low type agents with an employment opportunity may obtain a skill upgrade. Likewise, high type workers without a job opportunity may suffer skill deterioration. Some agents will also draw a new realization of b. Once shocks are realized all agents with an employment opportunity will chose whether to accept the job or to leave it to be unemployed or non participants, and all agents without an employment opportunity will choose either to be unemployed or not to participate. Hence at the end of each period agents know their current status in the labor market and their skills and labor productivity at home.[11] These are the states with which they will start in the next period, when a new realization of shocks will be obtained.

For simplicity we introduce below the value functions for workers and firms written in a compact notation. We include in the Appendix fully explicit versions of these equations.

3.1 Workers

The value of employment for a type s worker with current productivity b at home is

$$W_s(b) = w_s(b) + \beta \left\{ (1-\rho^x) E_{s'b'}[\max(W,U,N)] + \rho^x E_{s'b'}[\max(U,N)] \right\}, \tag{1}$$

where $w_s(b)$ is the wage rate and where $E_{s'b'}$ represents the expectations operator with respect to future values of s and b. The max operator inside the expectations reflects the fact that an

[11] The retirement shock occurs also at the end of the period. In that event the agent starts the following period as unemployed with low experience and receives a new realization of b.

employed worker may reevaluate her status in the labor market whenever there is a change in her skills in the market and productivity at home and when there is an exogenous separation. The value of unemployment is similarly defined

$$U_s(b) = \alpha b + \beta \left\{ \lambda^w E_{s'b'}[\max(W, U, N)] + (1 - \lambda^w) E_{s'b'}[\max(U, N)] \right\}, \tag{2}$$

where λ^w is the probability of receiving a job offer, b is labor productivity at home and $\alpha \in (0, 1)$. The interpretation is that α captures the cost of search in the labor market. Finally, the value of no participation is given by

$$N_s(b) = b + \beta E_{s'b'}[\max(U, N)]. \tag{3}$$

Notice that there are no transitions from N to W as in the current formulation agents that do not participate in the labor market observe a zero probability of a match with a vacancy. Notice also that since $\alpha \in (0, 1)$ then it is possible that some non employed workers find optimal to stop participating in the labor market. Thus α is a way to capture the idea that unemployed agents differ from non participants mainly in that the former spend time and resources looking for jobs in the market, whereas the later do not (Flinn and Heckman, 1983).

Associated to the previous value functions there are decision rules that deliver whether to continue an ongoing employment relationship (accept one if it appears from unemployment), to remain unemployed or to abandon the labor market, as a function of the "state" of the worker, which in addition to the current skill level s it includes whether she has available an employment opportunity and the current productivity at home b. The analysis in GW and in BLS suggests that the decision rules take the form of reservation values for home productivity such that given the level of skills an unemployed worker is indifferent between being unemployed and not participating. This *entry* threshold level is denoted b_s^e and it is such that $U_s(b_s^e) = N_s(b_s^e)$. Intuitively, when the productivity at home is sufficiently low an agent prefers to remain unemployed because at least there is a positive probability of finding a job. Hence non employed agents with skill level s choose to be unemployed when $b \leq b_s^e$. There is another threshold level such that an employed agent is indifferent between continuing being employed and stop participating in the labor market. This *quit* threshold level is denoted b_s^q and it is such that $W_s(b_s^q) = N_s(b_s^q)$. Again, with a sufficiently high productivity at home an employed agent would quit her job, thus agents with skill level s will choose no to participate when $b \geq b_s^q$.

3.2 Firms

A firm and a worker jointly produce output y_s. For simplicity we will assume that y_s is linear in s. The value for a firm of a match with a worker type (s, b) is given by

$$J_s(b) = y_s - w_s(b) + \beta \left\{(1-\rho^x)E_{s'b'}[\max(J, V)] + \rho^x V\right\}, \tag{4}$$

where V is the value of creating a vacancy which satisfies

$$V = -k + \beta \left\{ E_{\lambda_s^f} [\max(J, V)] + (1 - \lambda^f)V \right\}. \tag{5}$$

As usual, we assume there is free entry so in a stationary equilibrium $V = 0$ will hold. In the previous expression k is the cost of creating a vacancy and $E_{\lambda_s^f}$ is the expectation using the probability measure λ_s^f. In particular, $\lambda_s^f(b)$ gives the probability of filling the vacancy with an unemployed worker of type (s, b) and it is explained in more detail below. Associated to the previous value functions there are decision rules which indicate whether the firm forms a productive match when a worker type (s, b) is available, or it leaves the market and creates a new vacancy.

3.3 Frictions in the labor market and matching probabilities

There are frictions in the labor market such that both unemployed workers and firms posting vacancies need some time to form a match. These frictions are captured by the matching technology $M(v, u)$ which delivers the number of matches as a function of the number of vacancies available in the market, v, and the number of unemployed agents, u. The job finding rate for an unemployed worker is given by $\lambda^w = M(v, u)/u$. The probability that a vacancy is filled is analogously defined: $\lambda^f = M(v, u)/v$. Under the usual constant returns to scale assumption about M these two probabilities can be expressed as a function of *market tightness* $\theta = v/u$:

$$\lambda^w = \frac{M(v, u)}{u} = M(\theta, 1) = m(\theta) \text{ and } \lambda^f = \frac{m(\theta)}{\theta}. \tag{6}$$

For the decision of posting a vacancy it is relevant to know how unemployment is distributed over the (s, b) types, which is given by $\lambda_s^f(b)$ we introduced above. All unemployed workers have a $b \leq b_s^e$ $(s = l, h)$ and are equally likely to be met by a firm, irrespectively of their (s, b) type. Furthermore, since for given $s = l, h$ the arrival rate of a new b, the distribution of b and the separation rate are the same for all b, then the density of the unemployed workers over b given

s is given by the population density of b conditional on being unemployed given s. This means that

$$\lambda_s^f(b) = \lambda^f \frac{u_s}{u} \frac{dF(b)\mathcal{I}_{b \leq b_s^e}}{F(b_s^e)}, \tag{7}$$

where u_s is the mass of unemployed workers of type s (thus $u = u_h + u_l$ is the total mass of unemployed agents) and $\mathcal{I}_{b \leq b_s^e}$ is the indicator function with value 1 if $b \leq b_s^e$ and zero otherwise.

3.4 Wages

As usual in the literature wages are obtained as the solution of a generalized Nash bargaining problem between the firm and the worker in which the total surplus created by the match will be split. We assume that in this problem the bargaining power of the workers is η and that of the firms is $(1-\eta)$. The total surplus created in a match involving an (s, b) worker is

$$S_s(b) = (W_s(b) - \max(U_s(b), N_s(b))) + (J_s(b) - V). \tag{8}$$

Let $S_s^w(b)$ denote the surplus of the worker and let $S_s^f(b)$ represent the surplus of the firm. The solution to the bargaining problem is such that $S_s^w(b) = \eta S_s(b)$ and thus $S_s^f(b) = (1-\eta)S_s(b)$. Combining we obtain

$$(1-\eta)S_s^w(b) = \eta S_s^f(b). \tag{9}$$

3.5 Stationary equilibrium

In general it would be necessary to introduce a notion of the distribution of agents over the state space of all possible combinations of status in the labor market, skill levels and home productivities. In the current model in which the distribution of b is exogenous and the same for all agents irrespectively of their status and skill level in the labor market this distribution can be summarized in a vector $\Psi = (e_h, e_l, u_h, u_l, n_l)$ indicating the mass of agents in each possible state and skill level. Hence we have

Definition: A stationary equilibrium consists of a distribution Ψ, a labor market tightness θ, probabilities $\lambda^w(\theta)$ and $\lambda_s^f(\theta)$, value functions for workers $W_s(b)$, $U_s(b)$ and $N_s(b)$ and the corresponding critical values (b_s^e, b_s^q), value functions for firms $J_s(b)$ and the corresponding decision rules and wage functions $w_s(b)$ such that

1. $W_s(b), U_s(b)$ and $N_s(b)$ satisfy Equations (1)-(3) given λ^w and $w_s(b)$; and $U_s(b_s^e) = N_s(b_s^e)$ and $W_s(b_s^q) = N_s(b_s^q)$ hold.

2. $J_s(b)$ satisfy the Equations (4) with $V = 0$ given λ^f, Ψ and $w_s(b)$.

3. $w_s(b)$ satisfies Equation (9) given the value functions of workers and firms.

4. $\lambda^w(\theta)$, $\lambda^f(\theta)$ satisfy the equations in (6).

5. θ is consistent with Equation (5) with $V = 0$ given $\lambda^f(\theta)$ and Ψ.

6. $\lambda^f_s(\theta)$ satisfies Equation (7) given Ψ.

7. The distribution Ψ is consistent with (b^e_s, b^q_s) and $n_h = 1 - (e_h + e_l) - (e_h + e_l) - n_l$ holds.

The consistency of Ψ takes a simple form due the critical values characterized by the value functions. We have in particular that at a steady state with $b^e_l \leq b^e_h \leq b^q_l \leq b^q_h$ the following equations hold:

$$\begin{aligned} e_h = (1-\rho^r) \Big\{ & e_h(1-\rho^x) \left[\rho^b F(b^q_h) + (1-\rho^b)\right] \\ & + e_l(1-\rho^x)\gamma^h \left[\rho^b F(b^q_h) + (1-\rho^b)\right] \\ & + u_h \lambda(\theta)^w [\rho^b F(b^q_h) + (1-\rho^b)] \\ & + u_l \gamma^h \lambda(\theta)^w [\rho^b F(b^q_h) + (1-\rho^b)] \Big\} + \rho^r \gamma^h \lambda(\theta)^w F(b^e_l). \end{aligned} \tag{10}$$

Notice that in the first line all employed agents type high that do not obtain a new b will remain being employed. In the second line we have employed type low that keep their previous job and that upgrade their skills. Some of them will remain employed as type high if their new $b \leq b^q_h$ (or otherwise they would leave the market). All those that do not receive a new b will also remain employed as type high because we assume that $b^q_l \leq b^q_h$. Similar reasoning applies to the rest of stocks:

$$\begin{aligned} e_l = (1-\rho^r) \Big\{ & e_l(1-\rho^x)(1-\gamma^h)[\rho^b F(b^q_l) + (1-\rho^b)] \\ & + u_l(1-\gamma^h)\lambda(\theta)^w \left[\rho^b F(b^q_l) + (1-\rho^b)\right] \Big\} + \rho^r (1-\gamma^h)\lambda(\theta)^w F(b^e_l), \end{aligned} \tag{11}$$

$$\begin{aligned} u_h = (1-\rho^r) \Big\{ & u_h(1-\lambda(\theta)^w)(1-\gamma^l) \left[\rho^b F(b^e_h) + (1-\rho^b)\right] \\ & + e_h \rho^x (1-\gamma^l) \left[\rho^b F(b^e_h) + (1-\rho^b)\frac{F(b^e_h)}{F(b^q_h)}\right] \\ & + n_h(1-\gamma^l)\rho^b F(b^e_h) \Big\}, \end{aligned} \tag{12}$$

$$
\begin{aligned}
u_l = (1-\rho^r)\Big\{ & u_l(1-\lambda(\theta)^w)\left[\rho^b F(b_l^e) + (1-\rho^b)\right] \\
& + e_l \rho^x \left[\rho^b F(b_l^e) + (1-\rho^b)\frac{F(b_l^e)}{F(b_l^q)}\right] \\
& + e_h \rho^x \gamma^l \left[\rho^b F(b_l^e) + (1-\rho^b)\frac{F(b_l^e)}{F(b_h^q)}\right] \\
& + u_h(1-\lambda(\theta)^w)\gamma^l \left[\rho^b F(b_l^e) + (1-\rho^b)\frac{F(b_l^e)}{F(b_h^e)}\right] \\
& + n_l \rho^b F(b_l^e) + n_h \gamma^l \rho^b F(b_l^e)\Big\} + \rho^r F(b_l^e)(1-\lambda(\theta)^w), \qquad (13)
\end{aligned}
$$

$$
\begin{aligned}
n_l = (1-\rho^r)\Big\{ & e_h \rho^x \gamma^l \left[\rho^b(1-F(b_l^e)) + (1-\rho^b)\frac{F(b_h^q)-F(b_l^e)}{F(b_h^q)}\right] \\
& + e_l \rho^x \left[\rho^b(1-F(b_l^e)) + (1-\rho^b)\frac{F(b_l^q)-F(b_l^e)}{F(b_l^q)}\right] \\
& + e_l(1-\rho^x)(1-\gamma^h)\rho^b(1-F(b_l^q)) \\
& + u_h(1-\lambda(\theta)^w)\gamma^l \left[\rho^b(1-F(b_l^e)) + (1-\rho^b)\frac{F(b_h^e)-F(b_l^e)}{F(b_h^e)}\right] \\
& + u_l(1-\lambda(\theta)^w)\rho^b(1-F(b_l^e)) + u_l\lambda(\theta)^w(1-\gamma^h)\rho^b(1-F(b_l^q)) \\
& + n_h\gamma^l\left[\rho^b(1-F(b_l^e)) + (1-\rho^b)\right] \\
& + n_l\left[\rho^b(1-F(b_l^e)) + (1-\rho^b)\right]\Big\} + \rho^r(1-F(b_l^e)) \qquad (14)
\end{aligned}
$$

and

$$
n_h = 1 - (e_h + e_l) - (e_h + e_l) - n_l. \qquad (15)
$$

In the previous equations the term after $(1-\rho^r)$ represents the fraction of the population (irrespectively of the status in the labor market of the workers) that does not retire exogenously. All newborns (a fraction ρ^r) are assumed to be low type and unemployed and each of them receives a realization of b from $F(b)$. Equation (14) makes explicit the rich dynamics when no participation and changes in human capital are possible. The first two lines take into account the effect of exogenous separations for both high and low type workers (in the case of endogenous separations the workers keep their skills). The third line takes into account the endogenous separations of employed "still" low-skilled workers (did not obtain a skill upgrade). The next two lines take into account the direct flow from unemployment. The last two lines take into account the possible flows from non participation and from newborns.

4 Quantitative Analysis

In this section we calibrate our model economy as we explain in section 4.1 and then we assess the implications of an increase in turbulence in section 4.2 and of an increase in the outside value of working and of a lower productivity in section 4.3.

4.1 Calibration

We use data from the Survey of Income and Program Participation (SIPP) 1996, in which individuals are observed between 1995 and 2000 in order to calibrate our benchmark economy. As explained in section 2, we restrict the sample to middle aged men, aged 25 to 54, with upper secondary education or less. This sample restriction leaves aside about 39% of the male population within this age group. We compute several statistics of the labor market to be used in the identification of model parameters and then proceed with the quantitative analysis. As reported in Table 1, using the 1996 panel, non-participation was 0.11 and the average duration of unemployment was 3.3 months. The (monthly) transition probability from employment to unemployment was 0.007 and from employment to non-participation 0.005. The job finding rate for unemployed workers was 0.195 and it was 0.037 for non-participants. Since in our model direct transitions from non-participation to employment are not allowed, we follow GW and we target a probability of transition from unemployment to employment of 0.232 (the sum of the former two probabilities). Consistently, we target a transition from non-participation to unemployment of 0.061, which is the sum of the probability of transition from non-participation to unemployment (0.037) observed in the data and the probability of transition from non-participation to employment (0.024). Finally, in our sample the transition rate from unemployment to non-participation is 0.069.

We proceed under the assumption that $F(b)$ is uniform on $B = [b_{min}, b_{max}]$ and we use the previous statistics to identify b_{min}, b_{max}, the cost of opening a vacancy κ, the cost of searching for a job α, the destruction rate of a match ρ_x and the probability of receiving a new realization of the productivity of being at home ρ_b.

Regarding the parameters that govern the evolution of worker's skills, γ_l and γ_h we pursue the following strategy in order to bring our model to the data. We define a high type worker as someone with 10 years or more of tenure. This is the same assumption made in Ljungqvist and

Sargent (2007), so it takes a long time to acquire the highest skill level. Then we calibrate the value of γ_h so that the average number of periods to become a high type worker is 120 (thus a model period is equivalent to one month). We normalize s_h to 1 and calibrate s_l to target the tenure premium, i.e. the high type worker's wage relative to the low type worker's wage as measured in the SIPP. In our sample this is 1.3. Finally, in order to calibrate γ_l we target the earning loss after six years of displacement as estimated by Couch and Placzek (2010). As in Jacobson, LaLonde, and Sullivan (1993), these authors consider workers who are screened to be continuously employed for at least the first six years of the sample and that may be separated from employment beginning in 1999 as a result of mass layoffs.[12] Couch and Placzek (2010) estimate that during ordinary times (from 1993 through 2004 in their sample), the earnings loss of displaced workers six years later is between 12% and 15%. We assume a 12% earnings loss in our quantitative exercise. In total, then, we have to calibrate 9 parameters by solving the model and targeting the aforementioned data moments.

There are several parameters that we take from the literature. These are parameters that characterize the discount factor $\beta = 0.991$ (at monthly frequency), the matching function such as $A = 0.441$ and $\nu = 0.5$ (with $M = Av^{1-\theta}u^{\theta}$), the worker's bargaining power $\eta = 0.5$ (see for instance GW and BLS) and the probability of retirement $\rho_r = 0.00278$ (which reflects an average age of retirement of 55 years).

There are a few more statistics of interest that are not used in the calibration but that it is worth reporting here and that serve the purpose of assessing the goodness of fit of the model economy. In the model, 0.10 of those who moved out of employment in a period are unemployed 12 months after exiting and 0.24 are out the labor force. These figures are fairly close to the 0.11 and 0.18 that are observed in the data. Regarding the fraction of non-participants who are employed after 3 months, we observe 0.12 in the data, what is slightly higher than the 0.08 implied by the model. Finally, the unemployment rate is 0.061 in the benchmark economy as opposed to 0.042 in the data.

[12]This target is closer to our definition of a high-type worker as someone with at least ten years of experience, hence we disregard the estimates from Davis and Watcher (2011) that consider a less stringent and including workers with at least three years of experience.

Table 4: Calibration

Parameter	Description	Value	Target	Data (Model)
$b_{min} =$	Lower Bound Value at Home	0	Non-Participation Rate	0.113 (0.119)
$b_{max} =$	Lower Bound Value at Home	1.3	Trans E to U	0.007 (0.007)
$\alpha =$	Mean Value at Home if Search	0.05	Trans E to N	0.005(0.005)
$\kappa =$	Vacancy Cost	3.65	Trans U to E	0.232 (0.231)
$\rho_x =$	Separation Rate	0.012	Trans U to N	0.069 (0.058)
$\rho_b =$	Prob. of Updating Val at Home	0.16	Av Duration of Unemp	3.4 (3.4)
$\gamma_l =$	Prob. Skill Loss	0.018	Earning Loss After 6 Years	0.12 (0.117)
$\gamma_h =$	Prob. Skill Increase	0.0083	Av. time to Bec High (mths)	120
$s_l(s_h = 1)$	Low Skill Productivity	0.7	Tenure Premium	1.41 (1.35)
$\eta =$	Worker Barg. Power	0.5	Literature	
$A =$	Matching Function	0.441	Literature	
$\nu =$	Matching Function	0.5	Literature	
$\beta =$	Discount Factor	0.991	Literature	

4.2 Higher Turbulence

We implement an increase in the probability γ_l of skill loss after exiting employment such that the implied increase in non-participation of 5 percentage points, which is what we roughly observe in the data. This involves γ_l going up from 0.018 in the benchmark to 0.072 in the current scenario. As a result of this, the earnings loss after six years of exiting employment goes up from 12% in the benchmark to 19%. In order to assess the empirical plausibility of the increase in the earnings loss implied by this counterfactual, we compute the earnings loss in the third year of displacement in the benchmark, 13.1%, and in the increased turbulence economy, 19.7%. This increase in the earnings loss is modest as compared to the estimates in Figure 5 of Davis and von Watcher (2011). According to their estimates the earnings losses of men in the third year of displacement is between 10% and 15% in the mid-nineties, but about 30% in the mid-2000s (with an unemployment rate of about 5.5% in both time periods).

Why are men less likely to participate in the higher turbulence economy? In order to understand the mechanisms driving the increase in the non participation rate, we disentangle compositional effects from partial equilibrium and general equilibrium effects. First, note that there is a mechanical compositional effect due to the fact that a higher γ_l automatically implies a larger fraction of low type workers in steady state, which are less likely to participate. The non-participation rate would be 0.142 (instead of 0.119 in the benchmark) as a result of the

Table 5: Increased turbulence

	Bench	Higher Turburlence $\gamma_l = 0.072$
Earning Loss After 6 Years	0.117	0.191
Non-Participation Rate	0.119	0.169
Unemployment Rate	0.061	0.071
Wage Low Type	0.68	0.69
Wage High Type	0.92	0.90
θ	0.2735	0.2599
EU	0.007	0.008
EN	0.005	0.0078
UE	0.231	0.22
UN	0.058	0.069
NU	0.072	0.062

compositional effect alone. Second, in order to isolate the partial equilibrium effects, we compute the distribution across labor states that would be observed if only workers were allowed to react to the new value of parameter γ_l, but the same finding rate and wages of the benchmark economy were in place. In this case, workers would be less prone to searching because the expected value of participating in the labor market becomes smaller since the skill loss in the event of job destruction is more likely. Note that the entry threshold level for low type workers (see third column of Table 7) declines with respect to the benchmark (second column), implying that there is a larger mass of non-employed agents that prefer to be non-participants rather than unemployed. In clear contrast, the entry threshold of high type workers increases since they are willing to avoid the higher probability of skill loss during non-employment spells. Overall, there is an increase in non-participation that goes up to 0.166 in partial equilibrium. Finally, as reported in Table 5, non-participation is 0.169 when general equilibrium effects are allowed. Therefore general equilibrium effects are small, 0.3 percentage points but go in the direction of reducing participation a bit further. This is because the reduction in γ_l mechanically implies a reduction in the fraction of high type workers which reduces the return of a new vacancy and, as a result, there is a decrease in vacancy creation and an increase of market tightness (θ goes from 0.2735 to 0.2599). In response to the lower finding rate, low type workers are less likely to participate and this amplifies the initial effect on the non-participation rate. However, the bulk of the increase in the aggregate is driven by the change in the distribution of skills and by the partial equilibrium effects. Note finally that there is an increase in the fraction of low type workers which is due to the mechanical compositional effect, but also due to the fact that the increase in non-participation contributes to eroding the skills of the population. This is behind the reduction in vacancies posted by firms.

We discuss now the implications for wages. The increased turbulence implies a 1% increase in the wage of low type workers and a 2% decrease in the wage of high type workers. Overall, there is a decrease in the tenure premium from 1.35 to 1.30, in the direction of what we observe in the data. With increased turbulence the outside option of high type workers worsens and thus they obtain lower wages when employed. The reduction in high type wages, together with the increased turbulence, worsens the value of working for a low type worker (since the present value of accepting a job incorporates the value of becoming high type in the future). This dynamic effect tends to lower the participation of low type workers (hence the supply of labor). From the perspective of the firms, however, it is more profitable than before to hire low skill workers, since their probability of becoming high skill is the same as before and yet the corresponding wages are lower. This is another dynamic effect that increases the demand of labor, and together explain the increase in the wages of low skill workers. Note that this may be attenuating the impact on the number of vacancies in equilibrium.

Finally, beyond the effect on non participation there is an increase in the unemployment rate of 1 percentage point. This occurs in spite of the decrease in the transition NU that we also observe. This is due to the fact that with higher turbulence and lower wages for high type workers they are less willing to start looking for a job from non participation. Actually, the reduction of NU in the model economy brings a reduction in NE at the quarterly frequency to 0.063, from 0.077 in the benchmark, which is consistent with what we observe in the data. There is a decrease in the transition UE that is however mild compared to the data.

4.3 Other Driving Forces

We first consider an increase in the value of non employment, which we implement as an increase in b_{max}. We then consider a decrease in the productivity s_l of low type workers. In both cases, the size of the parameter change is disciplined to increase non-participation in the same magnitude than in the experiment in section 4.2. These experiments are motivated by the empirical evidence we summarized in the Introduction and our purpose is to compare their implications in terms of labor market transitions and wages with the implications of the higher turbulence hypothesis.

It is clear from Table 6 that these alternative counterfactuals share similar effects with the increased turbulence, in terms of the unemployment rate, the tightness of the labor market and in most transition rates. This is not surprising, since, roughly speaking, all counterfactuals represent a deterioration of the pool of unemployed agents from the perspective of the firm: either it becomes more likely to meet a low type worker, a worker that is more expensive -due to a better outside option- or a less productive one, respectively in each counterfactual. Table 7 displays the critical values of entry and quit for high and low type workers in the three exercises and offers a complementary view of the mechanisms at play. Regarding the entry threshold values of low type workers, they decline, as in the case of increased turbulence. In the case of high type workers the increase is rather modest in the case of a reduction in the productivity of low type workers, and it declines in the case of higher value of staying at home. This decline implies that non participation of high type workers increases. It is also clear that the quit threshold level for low type workers also declines, which implies again that there is a smaller mass of low type workers that will remain employed rather than becoming non participants. Since in the current calibration there are no endogenous transitions of high type workers from E to N the reported quit threshold level coincides with b_{max}, the upper limit of the support B.

Table 6

	Benchmark	Higher Val Home $b_{max} = 1.327$	Lower Prod Low Skill $s_l = 0.669$
Earning Loss After 3 Years	0.117	0.146	0.143
Non-Participation Rate	0.119	0.167	0.170
Unemployment Rate	0.061	0.071	0.073
Wage Low Skill	0.68	0.67	0.64
Wage High Skill	0.92	0.92	0.92
θ	0.2735	0.2678	0.2618
EU	0.007	0.007	0.007
EN	0.005	0.008	0.008
UE	0.231	0.227	0.224
UN	0.058	0.064	0.064
NU	0.072	0.066	0.065

The most significant difference among these counterfactuals and the increased turbulence is in the behavior of wages: wages of high type workers decrease in the case of increased turbulence and remain constant in the other cases, and wages of low type workers increase in the case of increased turbulence and decrease in the the other cases. In the counterfactuals studied in this section the dynamic effects on high type wages are missing. However, a lower productivity s_l reduces the incentives to work and the demand for labor. The former is reinforced by the increase of market tightness (θ goes from 0.2735 to 0.2618) that reduces the probability of finding a job. As a result wages of low type workers go down. A higher value of $\bar{b}$ mechanically increases the fraction of workers above b_l^e. At the same time, due to the increase of market tightness (θ goes from 0.2735 to 0.2678), the threshold level b_l^e is smaller than in the benchmark economy (see Table 7). As a consequence, the average value of b among workers is lower than in the benchmark, which is reflected in lower wages for low type workers.[13] For completeness, in Appendix C we report additional results and insights from several counterfactuals in which *i)* we combine the increase in turbulence with the decrease in the productivity of low type workers and *ii)* we consider alternative implementations to increase the value of not participating.

Table 7: Threshold levels for *entry* and *quit*

	Benchmark	Higher Turburlence	Higher Val Home	Lower Prod Low Skill
b_l^e	0.521	0.492	0.502	0.485
b_h^e	0.968	1.157	0.951	0.977
b_l^q	1.287	1.251	1.254	1.222
b_h^q	1.3	1.3	1.327	1.3

Finally, we discuss the impact on the transitions across labor market states. The transition rate employment to non-employment increases across the two new counterfactuals, and in the case of increased turbulence, in the same magnitude (from 0.012 to 0.015). However, in the case of increased turbulence this comes through an increase of both EN and EU, whereas in the other two experiments only EN is larger than in the benchmark, as opposed to EU that remains constant. The reason is related to the fact that in the first scenario high type workers have stronger incentives to stay employed because the probability of losing their skills during non-employment is now larger.

There is small increase in the unemployment rate in all the counterfactuals, of about 1 percentage point. This is in spite of the increase in transition rate from UN and the decrease in the transition rate from NU. The reason for the increase in the unemployment rate in the three counterfactuals is related to the evolution of θ. The increase in the unemployment rate that our model predicts is in contrast to the decrease found in Fujita (2018). There the decrease in the unemployment rate is related to the lower endogenous transition rate EU of high type workers as a way to protect their skills. In our current calibration all separations from employment of high type workers are exogenous, but remaining unemployed is effectively the way to protect the skills.

[13] This is different to what will be observed in an economy in which the participation decision and the heterogeneity in b are ignored. In such a case an increase in b would increase wages.

5 Conclusions

In this paper we use a general equilibrium model of the labor market with frictions, participation decisions and endogenous accumulation of skills to understand the increase in participation of middle aged men with upper secondary education or less observed over the last decades in the US.

We quantitatively assess the implications of a more turbulent environment in recent times in which the probability of skills loss during non-employment spells is larger. We also explore the effects of a decrease in the productivity of workers and an increase in the outside option of employment. We show that in more turbulent times non-participation increases and wages of more experienced workers fall because their outside option worsens. This effect on the wages of experienced workers is not observed with decreased labor productivity of low experienced workers and with improved outside options in case of non employment. Our analysis, therefore, offers a complementary explanation to decrease in the returns to experience documented in Jeong et al. (2015) and explained there as a consequence of demographic changes.

The equilibrium in our model is likely to be inefficient due to the fact that firms do not fully internalize the benefits of hiring low type workers, which from the social perspective would promote human capital accumulation, a higher employment rate and a larger output. With this intuition in mind the increase in turbulence may exacerbate this inefficiency and thus it is necessary to investigate the effect of Welfare-to-Work policies such as the introduction of subsidies. From this perspective, then, an important research question is to understand if the decrease of non-participation in the US, which is at odds with the observations across Europe, is related to differences in labor market policies. These interesting issues are part of our current research agenda.

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7 Appendix A

Table 8: Percentage Points Change in Male Labor Force Participation Rate, 1997-2017

	25-34	35-44	45-54	55-64	All
Below Upper Secondary Education	-6.1	1.0	-3.2	0.2	-2.9
Upper Secondary Education	-5.4	-3.9	-6.1	-2.0	-6.9
Tertiary Education	-2.5	-1.3	-2.7	2.5	-2.8

Source: OECD

8 Appendix B

8.1 Value functions

It is convenient to write explicitly the values associated to each type of firm and of worker in each possible state in the labor market.

8.1.1 Workers

The value of employment for a type h worker with current productivity b at home is

$$\begin{aligned} W_h(b) = w_h(b) + \beta \Bigg\{ (1-\rho^x) \left[\rho^b \int_B \max(W_h, U_h, N_h) dF(b') + (1-\rho^b) W_h(b) \right] \\ + \rho^x \Bigg[\gamma^l \left(\rho^b \int_B \max(U_l, N_l) dF(b') + (1-\rho^b) \max(U_l, N_l) \right) \\ + (1-\gamma^l) \left(\rho^b \int_B \max(U_h, N_h) dF(b') + (1-\rho^b) \max(U_h, N_h) \right) \Bigg] \Bigg\}. \end{aligned} \tag{16}$$

For an employed worker with low skills the corresponding value function reads

$$\begin{aligned} W_l(b) = w_l(b) + \beta \Bigg\{ (1-\rho^x) \Bigg[\gamma^h \left(\rho^b \int_B \max(W_h, U_h, N_h) dF(b') + (1-\rho^b) \max(W_h, U_h, N_h) \right) \\ + (1-\gamma^h) \left(\rho^b \int_B \max(W_l, U_l, N_l) dF(b') + (1-\rho^b) W_l(b) \right) \Bigg] \\ + \rho^x \left(\rho^b \int_B \max(U_l, N_l) dF(b') + (1-\rho^b) \max(U_l, N_l) \right) \Bigg\}. \end{aligned} \tag{17}$$

Likewise, the value of unemployment for a highly skilled worker is

$$\begin{aligned} U_h(b) = \alpha b + \beta \Bigg\{ (1-\lambda^w) \Bigg[\gamma^l \left(\rho^b \int_B \max(U_l, N_l) dF(b') + (1-\rho^b) \max(U_l, N_l) \right) \\ + (1-\gamma^l) \left(\rho^b \int_B \max(U_h, N_h) dF(b') + (1-\rho^b) U_h(b) \right) \Bigg] \\ + \lambda^w \left(\rho^b \int_B \max(W_h, U_h, N_h) dF(b') + (1-\rho^b) \max(W_h, U_h, N_h) \right) \Bigg\}. \end{aligned} \tag{18}$$

The value function for a low skills unemployed worker satisfies

$$
\begin{aligned}
U_l(b) = \alpha b + \beta \Big\{ (1-\lambda^w) \Big[\rho^b \int_B \max(U_l, N_l) dF(b') + (1-\rho^b) U_l(b) \Big] \\
+ \lambda^w \Big[\gamma^h \Big(\rho^b \int_B \max(W_h, U_h, N_h) dF(b') + (1-\rho^b) \max(W_h, U_h, N_h) \Big) \\
+ \ (1-\gamma^h) \Big(\rho^b \int_B \max(W_l, U_l, N_l) dF(b') + (1-\rho^b) \max(W_l, U_l, N_l) \Big) \Big] \Big\}. \qquad (19)
\end{aligned}
$$

Finally, the value functions associated to no participation satisfy

$$
\begin{aligned}
N_h(b) = b + \beta \Big\{ \gamma^l \Big(\rho^b \int_B \max(U_l, N_l) dF(b') + (1-\rho^b) \max(U_l, N_l) \Big) \\
+ \ (1-\gamma^l) \Big(\rho^b \int_B \max(U_h, N_h) dF(b') + (1-\rho^b) N_h(b) \Big) \Big\} \qquad (20)
\end{aligned}
$$

and

$$
N_l(b) = b + \beta \Big\{ \rho^b \int_B \max(U_l, N_l) dF(b') + (1-\rho^b) N_l(b)) \Big\}. \qquad (21)
$$

8.1.2 Firms

A firm and a worker jointly produce output y_s. The value to a firm of a match is given by

$$
\begin{aligned}
J_h(b) = y_h - w_h(b) + \beta(1-\rho^x) \Big[\rho^b \int_B \max(J_h, V) dF(b') + (1-\rho^b) J_h(b) \Big] \\
+ \beta \rho^x V, \qquad (22)
\end{aligned}
$$

when the worker is high type and where V is the value of creating a vacancy. The value of an active match involving a low type worker is given by

$$
\begin{aligned}
J_l(b) = y_l - w_l(b) + \beta \Big\{ (1-\rho^x) \Big[\gamma^h \Big(\rho^b \int_B \max(J_h, V) dF(b') + (1-\rho^b) \max(J_h, V) \Big) \\
+ (1-\gamma^h) \ \Big(\rho^b \int_B \max(J_l, V) dF(b') + (1-\rho^b) J_l(b) \Big) \Big] + \rho^x V \Big\}. \qquad (23)
\end{aligned}
$$

Finally, the value of creating a vacancy is given by

$$
V = -k + \beta \lambda^f \Big\{ \sum_s \Big[\frac{u_s}{uF(b_s^e)} \int_{b_{min}}^{b_s^e} \max(J_s, V) dF(b') \Big] + (1-\lambda^f) V \Big\}, \qquad (24)
$$

where b_{min} is the lower end of B.

8.2 General structure of the solution algorithm

The approach is similar to that in BLS.

1. Fix B, construct a grid $\mathcal{B}$ of size N_b to discretize B and approximate $F(b)$ over $\mathcal{B}$.

2. Guess an initial θ and Ψ and obtain n_h by means of Equation (15).

3. Guess initial values for

   - $\hat{W}_s(b)$, $\hat{U}_s(b)$ and $\hat{N}_s(b)$ for $s = h, l$ and all $b \in \mathcal{B}$
   - $\hat{J}_s(b)$ for $s = h, l$ and all $b \in \mathcal{B}$

4. Given the guesses for the value functions of the worker, determine the threshold levels b_s^e and b_s^q correspondingly to entry and quit using

$$U_s(b_s^e) = N_s(b_s^e) \text{ and } W_s(b_s^q) = N_s(b_s^q) \tag{25}$$

5. Given the guess for θ and $u_s(b)$, obtain $\lambda^w(\theta)$ and $\lambda_s^f(\theta)$ by means of Equations (6) and (7).

6. Given the previous guesses compute the continuation values for workers and firms (the terms after β in Equations (16)-(23)). Denote these values $\tilde{W}_s(b)$, $\tilde{U}_s(b)$ and $\tilde{N}_s(b)$ and $\tilde{J}_s(b)$ (remember that in equilibrium $V = 0$), for $s = h, l$ and all $b \in \mathcal{B}$.

7. Determine wages:

   (a) Use the previous results to obtain expressions for the surplus of workers and firms. In case the outside option is unemployment the surplus for workers is given by

$$S_s^w(b) = w_s(b) + \beta \tilde{W}_s(b) - (\alpha b + \beta \tilde{U}_s(b)), \tag{26}$$

   and if the outside option is no participation we have

$$S_s^w(b) = w_s(b) + \beta \tilde{W}_s(b) - (b + \beta \tilde{N}_s(b)). \tag{27}$$

   The surplus of the firm is given by

$$S_s^f(b) = y_s - w_s(b) + \beta \tilde{J}_s(b). \tag{28}$$

   Notice that in the previous equations the only unknown is the wage rate $w_s(b)$.

   (b) Combine Equations (26)-(28) with Equation (9) to obtain $w_s(b)$.

8. Update value functions of workers and firms using the equilibrium wages and

$$W_s(b) = w_s(b) + \beta \tilde{W}_s(b), U_s(b) = \alpha b + \beta \tilde{U}_s(b) \text{ and } N_s(b) = b + \beta \tilde{N}_s(b) \tag{29}$$

   and

$$J_s(b) = y_s - w_s(b) + \beta \tilde{J}_s(b). \tag{30}$$

   Iterate from 3 to 8 using as initial guesses the results in 8 until convergence in the value functions is achieved.

9. Update market-tightness using Equations (24) and (6). Update the matching probabilities using Equations (6) and (7).

10. Update Ψ. This can be done by computing the corresponding masses using Equations (10)-(14) and Equation (15).

11. If convergence in θ and Ψ is obtained then stop. If convergence is not obtained then go back to step 2 using the last values as initial guesses and repeat the calculations until step 10. Iterate until convergence is obtained.

9 Appendix C

We first investigate the effect of combining an increase in turbulence with a decrease in labor productivity of the low type. In particular, we increase γ_l up to 0.03 and we decrease s_l to 0.68 which achieves an increase in non participation of the same magnitude as in the exercises in the main text (the rest of the parameters are as in the benchmark calibration). We still find that the wages of the high-type decrease (due to the desire of insuring human capital of the high-type workers). However, now also the wages of the low-type workers decrease. That is, the decline in the productivity of low-type workers dominates the positive effect of the larger demand from the firm's side.

We also look at the effect of increasing the value of non-participation via an increase in b_{min} while keeping constant b_{max}. This alternative implementation can be thought of as an improvement of assistance programs oriented to help the less favored agents. An increase in b_{min} achieves again an increase in non participation similar to the previous counterfactuals. We find again that the wages of the high-type workers tend to increase. However, the wages of low-type workers tend to *decrease*. This is at odds with the predictions from search and matching models without participation decisions in which an improvement of the outside option will induce higher equilibrium wages. The increase in b_{min} shifts the mass of agents to the right and this mechanically increases non participation (there are more individuals to the right of the threshold levels for entry and quit). The increase in b_{min} of course represents an improvement of the expected outside option of the workers, which even if wages do not change, implies a shift to the left of these thresholds (i.e., with a better outside option employed workers ask for a larger compensation to stay at work). As a result of this, the probability of receiving a large enough b to quit working increases. Hence, from the firm's perspective investing in hiring a low-type worker is less attractive than before, since it is more difficult that the worker becomes high-type. As a result of this wages of low-type workers decline, which in addition reinforces the decline in the threshold levels for entry and quit. Notice that high type workers are immune to this mechanism because when they are employed they never leave the firm. In Table 9 below we report the results for the combined effect of turbulence and a decrease in labor productivity and for a substantial increase in b_{min}.

Table 9

	Benchmark	Higher γ_l and Lower s_l $\gamma_l = .03$, $s_l = 0.68$	Higher b_{min} $b_{min} = 0.3$
Earning Loss After 3 Years	0.117	0.157	0.185
Non-Participation Rate	0.119	0.168	0.59
Unemployment Rate	0.061	0.072	0.105
Wage Low Skill	0.68	0.66	0.65
Wage High Skill	0.92	0.91	0.94
θ	0.2735	0.2616	0.3707
EU	0.007	0.007	0.005
EN	0.005	0.007	0.022
UE	0.231	0.224	0.259
UN	0.058	0.064	0.101
NU	0.072	0.064	0.029