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ABSTRACT

European Unemployment and Turbulence Revisited in a Matching Model*

We recalibrate den Haan, Haefke, and Ramey's matching model to incorporate our preferred specification of 'turbulence' as causing distinct dynamics of human capital after voluntary and involuntary job losses. Under our calibration, with high unemployment benefits, an increase in turbulence increases the unemployment rate and the duration of unemployment while leaving the inflow rate into unemployment roughly unchanged, mirroring features of European data in the 1980s and 1990s. The essential issue is that den Haan, Haefke, and Ramey specify that in turbulent times workers experiencing layoffs and quits are *both* subject to instantaneous skill losses, while we restrict instantaneous skill losses to laid off workers.

JEL Classification: E24 and J64
Keywords: European unemployment and turbulence

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1. Introduction

den Haan, Haefke and Ramey (2001) (hereafter referred to as dHHR) used a matching model to study the effects of interest rates, TFP growth and taxes on unemployment rates and rates of job creation and destruction. While their main purpose was to focus on the effects of interest rates, TFP growth and taxes, they also used their model to reexamine our hypothesis that increased microecononomic turbulence interacted with generous European unemployment benefits to raise equilibrium unemployment in the 1980s and 1990s. Here we focus only on this interesting ancillary aspect of dHHR's paper.

We inject Ljungqvist and Sargent's (1998) hypothesis of increased microeconomic turbulence into dHHR's matching model, recalibrate it in what we think is an appropriate way, and show how boosting turbulence increases equilibrium unemployment, just as it does in Ljungqvist and Sargent's (1998) search model. Our findings differ substantially from those of dHHR, who used their model to challenge the robustness of our attribution of high European unemployment to the conjunction of generous unemployment benefit systems with increased microeconomic turbulence in the 1980s and 1990s. Wrestling with dHHR's challenge clarifies the economic forces driving our earlier results, illustrates how they come through in either a matching or a search environment, and shows how dHHR disrupted those forces by making a very different assumption than we did about the dynamics of human capital deterioration in turbulent times.

In both the search environment of Ljungqvist and Sargent (1998) and dHHR's matching environment, we make the key assumption that in the 1980s and 1990s laid off workers were subject to greater shocks to their earnings potential than they had been earlier. dHHR's inability to reproduce our findings in their matching framework hinges on their specifying that in turbulent times, layoffs *and* voluntary job moves are *both* subject to instantaneous skill loss, while we specify that only layoffs are. In dHHR's analysis, skill losses at the time of *voluntary* job terminations play a key role in making an increase in economic turbulence reduce the unemployment rate. High-skill workers' concerns about the skill losses associated with both voluntary and involuntary job separations depress the inflow rate into unemployment.

If we take dHHR's model but restore our original assumption that layoffs and not quits trigger possible instantaneous skill losses, then the matching framework supports our explanation for high European unemployment. Further, our calibration of dHHR's model under our version of the turbulence assumption is consistent with a roughly constant inflow rate into unemployment, a dramatic increase in the average duration of unemployment, and a hazard rate of leaving unemployment that falls with the duration of unemployment, all of which are features of the European data.

2. Setup

In dHHR's environment, time is discrete. Workers have either high ($j = h$) or low ($j = \ell$) skill. Each previously employed low skill worker faces a probability γ^U of an upgrade to the high skill level. Worker-firm pairs produce output z each period. At formation, a skill-j worker and newly matched firm jointly draw z from c.d.f. $\nu_j(z)$ where $\nu_h(z) < \nu_\ell(z)$ for z in the interior of its support (so that z_h first-order stochastically dominates z_ℓ). For an ongoing match, with switch probability γ^S, the match takes a new draw of z from ν_j. If no switch occurs, z remains unchanged. With probability ρ^x, the match exogenously breaks up. Workers face a probability ρ^r of expiring (or euphemistically, 'retiring'), and a measure ρ^r of new workers arrives each period. Bargains maximize the joint surplus (they are efficient). Nash bargaining with weight π on the worker determines the division of the match surplus. New matches are formed according to a standard matching function that is homogeneous of degree one in measures of unemployed workers and firms posting vacancies. Since the total measures of workers and firms are both assumed to be exogenously given and equal to one, it follows that the ratio of the measure of unemployed to the measure of vacancies is also fixed at unity and hence, the matching probability λ^w is a constant.[1] Each period, unemployed workers of skill j receive unemployment benefits $b_j = \phi \overline{p}_j$, where $\overline{p}_j$ denotes the mean wage payment of all workers of skill class j. Key objects in a stationary equilibrium of the model are $\underline{z}_j(b)$, the reservation productivity of a skill-j worker who is entitled to unemployment benefits b; $w_j(b)$, a skill-j worker's future value from entering the

[1] It is implicitly assumed that the calibration of the model is such that all the exogenously given firms find it profitable to remain active in an equilibrium.

unemployment pool in the current period when he receives unemployment benefit of b; w^f, the firm's future value from entering the vacancy pool in the current period; $\tau_e(x)$, the tax rate on income earned in a match when income is x; and $\tau_u(x)$, the tax on unemployment benefits of x. Table 1 contains alternative settings of key parameters, which we discuss next.

2. Reproduction of dHHR's counterexample

The first column of Table 1 contains the calibration of the welfare state that dHHR use to study the potential role of turbulence in explaining high European unemployment. The first three columns of Table 2 reproduce dHHR's numerical findings on how the equilibrium unemployment rate varies with turbulence and the discount factor.[2] In their model, the unemployment rate falls rather than rises with economic turbulence. As shown in panel (a) of Figure 1, the falling unemployment rate is due to the declining share of unemployed workers who entered unemployment from high-skill employment. In turbulent times, high-skilled workers are reluctant to seek better jobs in response to productivity shocks because they fear becoming unskilled if they quit. In fact, when the turbulence parameter γ^D exceeds 0.44, high-skill workers never enter unemployment. (Recall that dHHR set $\rho^x = 0$ as shown in our Table 1, i.e., there are no exogenous layoffs.)

Panel (a) of Figure 2 shows how the inflow rate into unemployment plummets in response to turbulence in dHHR's model while the average duration of unemployment remains approximately constant. But the European data described by Layard, Nickell, and Jackman (1991) and Ljungqvist and Sargent (1998) display a constant inflow rate and a rising duration of unemployment. Our recalibration of dHHR's model will revise its implications about these features of the data as well as about the effects of turbulence.

[2] Because we corrected what we believe are errors in dHHR's computer code, the numbers computed for the original model in our Table 2 differ from the numbers reported by dHHR in their Table 6, part A. See our appendix for details on those corrections, none of which affected the qualitative findings of dHHR.

3. Modified model

We now replace dHHR's assumption with our preferred assumption that laid off workers but not quitters are subject to the risk of instantaneous skill loss upon job separation. This reflects our vision that victims of layoffs, not quitters, are the unlucky ones. We see quitters as people who are secure in their skills and inspired to change jobs to take advantage of evident opportunities to make better use of their current skills. Hence, in our modification of dHHR's model, degradations in skills happen only in connection with exogenous job breakups that occur with probability ρ^x.

Instead of dHHR's equations (15) and (18), our specification makes the joint surplus for a high-skilled worker become

$$s_h(z, b_h) = (1 - \tau_e(z))z + g_h(z) - (1 - \tau_u(b_h))b_h - w_h(b_h) - w^f,$$

while the continuation value of a match involving a high-skilled worker becomes

$$\begin{aligned} g_h(z) = \beta\Big\{(1-\rho^x)\Big[(1-\gamma^S)s_h(z,b_h) + \gamma^S \int_{\underline{z}_h(b_h)}^{\infty} s_h(y,b_h)\, d\nu_h(y)\Big] \\ + (1-\tau_u(b_h))b_h + \big(1-\rho^x\gamma^D\big)w_h(b_h) + \rho^x\gamma^D w_l(b_h) + w^f\Big\}. \end{aligned}$$

To study the effects of turbulence in the modified model where only laid off workers are exposed to the risk of instantaneous skill loss, we must change dHHR's calibration that has no layoffs in the welfare state ($\rho^x = 0$). In choosing a parameter value for ρ^x, we follow dHHR when they postulate quarterly layoff rates of around 1% for the laissez-faire economy. Given the modified model with $\rho^x = 0.01$ and otherwise a calibration identical to dHHR's original values in Table 1, the last three columns of Table 2 report how the equilibrium unemployment rate varies with turbulence and the discount factor. Now increases in turbulence no longer reduce unemployment. Thus, dHHR's result about how turbulence *decreases* unemployment comes completely from their having locked high-skilled workers into their jobs through their fear of losing skills whenever they voluntarily quit to seize other jobs.

Nevertheless, the last three columns of Table 2 still do *not* show any significant positive relationship between turbulence and unemployment, as the model of Ljungqvist and

Sargent (1998) implies. Why not? The answer is to be found in dHHR's calibrations of skills and earnings, to which we turn next.

4. Calibration of skills and earnings

First recall some things about the calibrations of skills and earnings in Ljungqvist and Sargent (1998) and compare them with those of dHHR. It takes a long time to build up the highest level of skills in our model, but not in dHHR's. In our model, it takes on average 7 years and 8 months to make the transition from the lowest to the highest skill level, conditional upon no job loss. We assume that the highest skill level has twice as much human capital as the lowest skill level.[3] The earnings of an employed worker are the product of his wage and his current skill level. At the beginning of each job, the wage is drawn from a wage offer distribution that is common to all workers. A laid off worker receives generous unemployment compensation that is equal to 70% of his lost earnings. A feature that was absent from Ljungqvist and Sargent (1998) is the probability of a productivity switch on the job. However, Ljungqvist and Sargent (2002) extend the framework to include this dimension and they choose this probability so that the average time between new productivity draws on the job is 1.9 years.

The calibration of dHHR is quite different. Transitions from low to high skills take on average only 1 year and 8 months, conditional upon no job loss, $\gamma^U = 0.15$. Moreover, the differences in parameter values between the two skill groups reported in Table 1 and portrayed in panel (a) of Figure 3 are quite small. Both skill groups draw productivities from uniform distributions with only a minor difference in means, $E(z_l) = 0.8$ and $E(z_h) = 1.0$, and with the same high standard deviation, $\sigma^z = 3.818/\sqrt{12}$. New productivities on the job are also drawn from those distributions, and this can be expected to happen very frequently, more often than every four months, $\gamma^S = 0.8$. That is, the reward to staying unemployed and holding out for a good job are dubious under dHHR's calibration, since a

[3] We thank Dan Hamermesh for conversations about his data explorations of wage-experience profiles. Our assumption that work experience alone can double a worker's earnings seems to line up well with data for full-time male workers in the U.S. manufacturing industry. But the time required to attain such earnings gains are longer than what we assume and hence, much longer than dHHR assume.

productivity draw will on average last less than four months. Unemployed workers receive unemployment compensation equal to 50% of the average wage in their skill category.

The second column of Table 1 contains our proposal for bringing the calibration of the matching model more into line with the calibration of Ljungqvist and Sargent (1998). We choose a quarterly probability of upgrading skills $\gamma^U = 0.025$ so that it takes on average 10 years to move from low skills to high skills, conditional upon no job loss. High-skill workers draw productivities from a distribution with a mean that is twice as high as that for low-skill workers. The standard deviation of the uniform distributions remains identical across skill groups, but now at the lower level $\sigma^z = 1/\sqrt{12}$. Panel (*b*) of Figure 3 depicts our choice of distributions; it clearly separates the skill groups. We reduce the probability of a productivity switch on the job to $\gamma^S = 0.1$, so that a worker on average keeps his productivity 2.5 years. We increase the replacement rate to 70% but keep dHHR's assumption that benefits are calculated on the basis of the average wage in a skill category.

5. Turbulence revisited

Using the modified model and the new parameter values in Table 1, we compute how the equilibrium unemployment rate varies with turbulence and the discount factor. Table 3 shows that with our calibration of parameters, the matching model delivers our positive relationship between the unemployment rate and the amount of turbulence. The explanation is the same as in Ljungqvist and Sargent (1998), namely that high-skilled workers who have been laid off and suffered a skill loss find it difficult to find jobs that they would like to accept. Table 4 reports that their hazard rate of gaining employment falls to 10% as compared to 25–28% for other workers. As a result, in panel (*b*) of Figure 1, the proportion of these long-term unemployed workers among all of the unemployed (the dotted line) swells. This explains the surge in the unemployment rate. Other manifestations of this outcome are that the average duration of unemployment increases sharply in panel (*b*) of Figure 2, and the hazard rate of gaining employment falls with the duration of unemployment in Figure 4. Meanwhile, the *voluntary* reallocation of workers in response to changing job opportunities is not much affected by turbulence, keeping the total inflow rate into unemployment roughly constant in panel (*b*) of Figure 2. Qualitatively, these outcomes are consistent with Layard, Nickell and Jackman's (1991, p. 4) account of the outbreak of high European unemployment,

> "The rise in European unemployment has been associated with a massive increase in long-term unemployment. In most European countries the proportion of workers entering unemployment is quite small: it is much lower than in the USA and has risen little. The huge difference is in the duration of unemployment: nearly half of Europe's unemployed have now been out of work for over a year."

It is instructive to return to why the original analysis of dHHR cannot reproduce these results. Outcomes hinge on their assumption that *both* layoffs and voluntary job moves are subject to the risk of instantaneous skill loss. Turbulence then closes down the voluntary reallocation of high-skilled workers because of their fear of losing skills if they quit to look for better jobs. As can be seen in Table 4, the job destruction rate among high-skilled workers falls to zero in turbulent times for dHHR's original model while the destruction rate is largely unaffected by turbulence in our modified model.

To consider some further aspects of dHHR's model and ours, the destruction rate among low-skilled workers increases sharply in dHHR's model, much more than in our modified version of their model. The reason is that in dHHR's framework the value of becoming a high-skilled worker diminishes in turbulent times and low-skilled workers choose to seek better jobs in response to productivity switches rather than "sitting out" and hoping for an upgrade to the high-skill level. An obvious manifestation of the lower return to skill upgrades in the dHHR model is that the average wage of high-skill workers is approximately the same as the average wage of low-skill workers in turbulent times, 0.56 versus 0.53. But of course, high-skill workers are still better off because they never experience any unemployment, while low-skill workers circle in and out of unemployment, with unemployment benefits equal to 50% of their average wage. It should be noted that the total unemployment rate in dHHR's analysis is not much affected by variations in the incidence of unemployment among low-skilled workers, since these workers constitute only 3–4% of total employment because of the assumed high probability of skill upgrades ($\gamma^U = 0.15$).

This returns us to our second criticism of the dHHR's analysis, namely, that their calibration of skills and earnings does not capture the long-term aspect of skill investments and fails to reflect plausible differences in earnings potentials between skill groups.

6. Concluding comments

Our idea that the higher European unemployment of the 80s and 90s came from increased microeconomic turbulence seems robust to the choice of theoretical framework. In the search model of Ljungqvist and Sargent (1998, 2002) and in our recalibrated version of dHHR's matching model, high unemployment erupts in a welfare state with generous benefits when laid off workers are subject to increased turbulence with respect to their earnings potential. Both models attribute the increase in equilibrium unemployment to an increase in the average duration of unemployment but keep the inflow rate into unemployment roughly unchanged – features that also characterize the European unemployment experience in the 1980s and 1990s.

The idiosyncracies of individual workers are at the core of our analyses. Heterogeneity is manifested by a hazard rate of leaving unemployment that falls with the duration of unemployment, a salient feature of European labor markets. dHHR somewhat limit individual heterogeneity when they make their assumptions that the job offer arrival rate is the same for all of unemployed workers and that unemployment benefits are based on the average wage within a skill class. Besides letting benefits be a replacement rate times an individual's own lost earnings, Ljungqvist and Sargent (1998, 2002) let individuals choose the search intensities that affect job offer arrival rates and thereby generate discouraged workers who withdraw from labor market participation. We believe that incorporating a richer structure of *ex post* heterogeneity among workers would improve the ability of dHHR's framework to account for the European unemployment experience. For a discussion of why the aggregate unemployment rate in Europe seems to require focusing on the idiosyncracies of individual workers and a critical assessment of alternative theories based on "representative families", see Ljungqvist and Sargent (2002).

Appendix

We believe that we have corrected for a number of errors in dHHR's original computer code by implementing the following changes.

1. **Continuation values**

   dHHR's original computation of the continuation value of an unemployed high-skilled worker imposed a probability γ^D of becoming low-skilled in the next period if unemployment persists. This is incorrect because the parameter γ^D refers to skill shocks at the time of a job loss. We have therefore made the change that an unemployed high-skilled worker retains his skills if he does not encounter an employer. However, we have kept dHHR's implicit assumption that an unemployed high-skilled worker who turns down a job offer faces the probability γ^D of losing skills. This assumption is needed to support dHHR's wage calculations where both new and old employees with high skills receive the same wage as a function of the current productivity level z, i.e., both new and old employees with high skills have the same threat point that includes the potential loss of skills if the worker leaves the firm.

2. **Transition equations**

i) We have removed the probability $(1-\rho^x)$ from flows out of unemployment pools. dHHR (page 8) make the explicit assumption that "exogenous separations cannot occur in the period that a relationship is newly formed" which is also reflected in dHHR's transition equations (8) and (9) for the model without different skill levels.

ii) The computer code contains three temporary pools: (a) hired new entrants who are not entitled to benefits and are therefore willing to work below the reservation wage of a low-skilled worker entitled to benefits, (b) new hires of low-skilled workers who had been receiving high benefits as unemployed because of their earlier skill status, and (c) low-skilled workers who have just experienced a skill upgrade on the job. These groups are correctly treated separately because the first one must work one period to become entitled to benefits, the second one has a better threat point than other low-skilled workers in the first period of employment because of high benefits, and the third one must work one period in order to actualize the skill upgrade. But what is incorrect in dHHR's computer code is that surviving workers in these pools after one period flow deterministically into the pools of low-skilled unemployed entitled to benefits, employed low-skilled workers entitled to low benefits, and high-skilled workers entitled to high benefits, respectively. This is wrong because these workers face the same potential shocks of switches in productivity levels and skill upgrades as other workers. Hence, we have changed the transition equations so that workers from these temporary pools might flow into other relevant pools. For example, hired new entrants who are not entitled to benefits and are working at subpar wages might draw a high productivity level in the second period and choose to remain with their firms.

iii) In dHHR's computer code, the only attrition from the pool of unemployed high-skilled workers arises from retirement and workers accepting jobs. As noted under item 1 above, this is inconsistent with the calculation of continuation values in both dHHR's code and in our corrected version. We have now made the amendment that unemployed high-skilled workers who turn down job offers become low-skilled with probability γ^D.

3. **Wage computations**

Wage computations involve both a worker's current threat point and the expectation of his next period's threat point and any realized outside option, as indicated by dHHR's equations (4) and (5) for the model without different skill levels. The wage calculations in the original computer code set the current threat point equal to the expectation of next period's threat point and any realized outside option. However, this is not correct for the three temporary pools of workers that were described under item 2.ii) above. Specifically, next period's threat points improve both for hired new entrants who then become entitled to benefits and for the workers who experienced a skill upgrade and then become vested at the higher skill level, while the threat point deteriorates for members of the pool of newly hired low-skilled workers who had been collecting high benefits as unemployed but have now lost that entitlement. The wage calculations in the computer code have been corrected to reflect the changing future circumstances of these three pools of workers.

4. **Tax calculation**

   The algorithm for the equilibrium tax rate has been corrected in a step that calls for computing the aggregate tax base but where dHHR's original computer code erroneously computed after-tax income.

None of these corrections altered dHHR's qualitative finding of a negative relationship between turbulence and unemployment but the single most important correction with a large quantitative impact is the correction under item 1 above. This correction mainly explains the difference between Table 6, part A, in dHHR and the correct calculations in our Table 2 under the "Original model." After we correct the computation of the continuation value of an unemployed high-skilled worker so that skill loss can only happen when a worker leaves a firm, it takes a higher degree of turbulence in order to generate the same fall in equilibrium unemployment as found by dHHR.

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Table 1: Calibration (one period is a quarter)

	Original†	**Modified**
Probability of exogenous breakup, ρ^x	0	0.01
Probability of upgrading skills, γ^U	0.15	0.025
Uniform productivity distribution		
mean for low-skilled workers, $E(z_l)$	0.8	1.0
mean for high-skilled workers, $E(z_h)$	1.0	2.0
standard deviation, σ^z	$3.818/\sqrt{12}$	$1/\sqrt{12}$
Probability of productivity change, γ^S	0.8	0.1
Replacement rate, ϕ	0.5	0.7
Retirement probability, ρ^r	0.005	0.005
Matching probability, λ^w	0.3	0.3
Worker's bargaining weight, π	0.5	0.5
Tax on unemployment benefits, τ_u	0	0
Tax on labor income, τ_e	Endogenous tax rate that finances the unemployment benefit system	

† The original calibration refers to Table 6, part A, in dHHR. We think that we have corrected for three typos in the authors' account of the parameter values. The authors write, seemingly erroneously, that $\lambda^w = 0.5$, $E(z_h) = 0.8$ and $\sigma^z = 3.81$. But only when we use our corrected values of those parameters are we able to reproduce dHHR's Table 6, part A.

Table 2: Equilibrium unemployment rates (per cent)

	Original model[†]			**Modified model**[‡] **with original calibration except for** $\rho^x = 0.01$		
Turbulence, γ^D	*Discount factor*			*Discount factor*		
	0.97	*0.98*	*0.99*	*0.97*	*0.98*	*0.99*
0.0	27.3	25.5	23.7	31.5	29.9	28.5
0.1	21.2	18.0	14.5	31.5	30.0	28.5
0.2	15.3	10.8	7.1	31.6	30.0	28.5
0.3	8.6	5.2	3.5	31.7	30.1	28.5
0.5	2.9	2.6	2.4	31.7	30.2	28.5
0.7	2.7	2.6	2.4	31.8	30.3	28.7
1.0	2.7	2.6	2.4	31.9	30.5	28.8

[†] The original model refers to Table 6, part A, in dHHR. The calibration is given in the first column of our Table 1. The reason that our computed unemployment rates differ from the numbers reported by dHHR is that we have corrected for what we believe are errors in dHHR's computer code. For further details, see our appendix.

[‡] The modified model refers to the framework where laid off workers but not quitters are subject to instantaneous skill loss. The calibration remains the original one, as given in the first column of Table 1, except that we now set $\rho^x = 0.01$.

Table 3: Equilibrium unemployment rates (per cent)

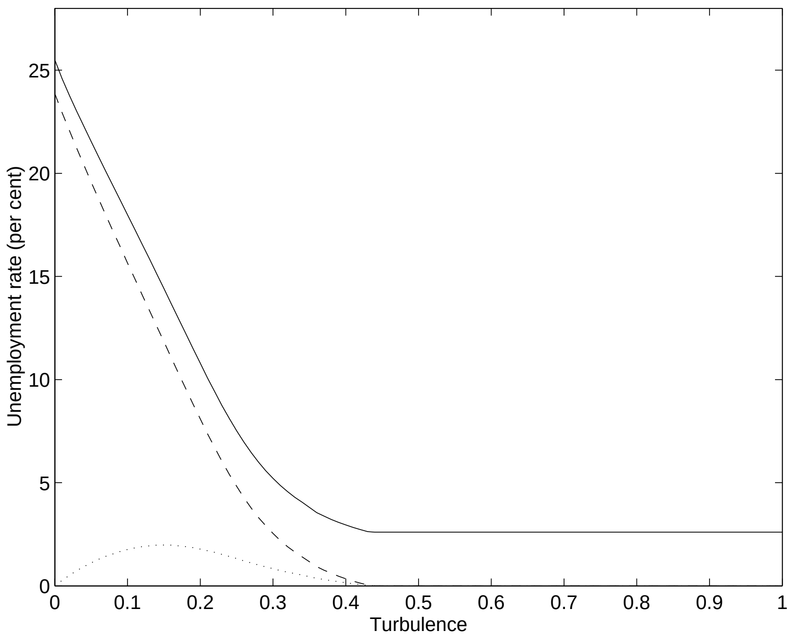
Turbulence, γ^D	**Modified model† with new calibration**		
	Discount factor		
	0.97	*0.98*	*0.99*
0.0	9.4	9.6	9.9
0.1	10.1	10.0	10.2
0.2	10.6	10.4	10.5
0.3	11.1	10.8	10.7
0.5	11.9	11.5	11.3
0.7	12.6	12.1	11.9
1.0	13.5	12.9	12.7

† The modified model refers to the framework where laid off workers but not quitters are subject to instantaneous skill loss. The calibration is given in the second column of Table 1.

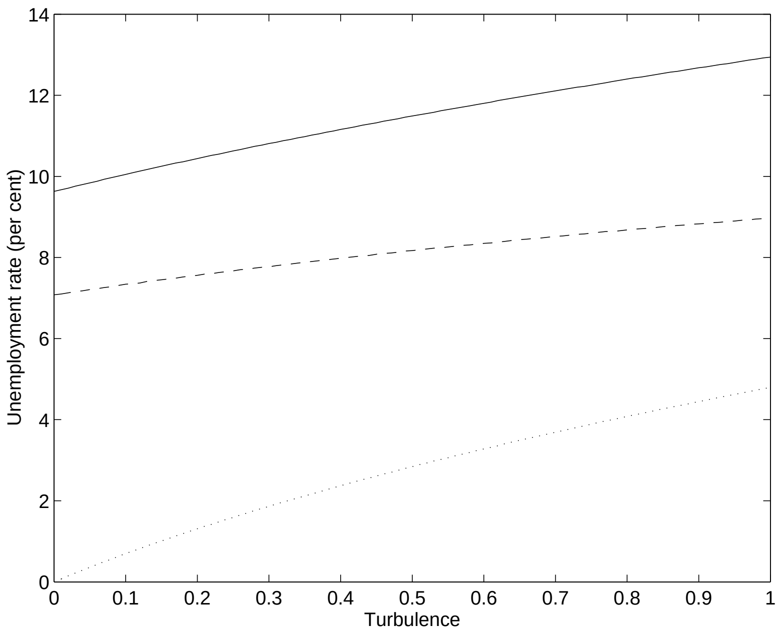
Table 4: Equilibrium outcomes for the original and modified model under tranquil and turbulent economic times†

	Tranquility, $\gamma^D = 0$		**Turbulence,** $\gamma^D = 0.5$	
	Original	*Modified*	*Original*	*Modified*
Unemployment rate (per cent)	25.5	9.6	2.6	11.5
thereof low-skilled / "high benefits"	n.a.	n.a.	0	2.8
Hazard rate of gaining employment (per cent)				
low-skilled / "low benefits"	30.0	28.6	26.6	27.9
low-skilled / "high benefits"	n.a.	n.a.	26.0	10.4
high-skilled	26.6	25.5	30.0	24.9
Job destruction rate in response to productivity shock (per cent)				
low-skilled	0	4.8	11.5	7.1
high-skilled	11.3	15.0	0	16.9
Unskilled fraction of all employed	4.3	18.2	3.2	29.7
Average wage				
low-skilled	0.51	0.71	0.53	0.82
high-skilled	0.71	1.37	0.56	1.41
Tax rate on labor income (per cent)	9.2	4.3	0.2	5.7

† The original and the modified calibration are both given in Table 1 and $\beta = 0.98$.

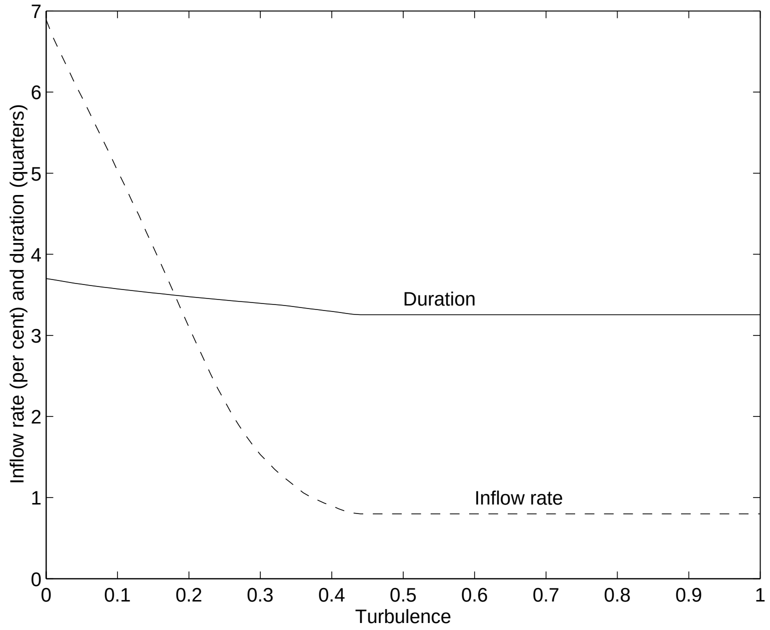


(a) Original model.

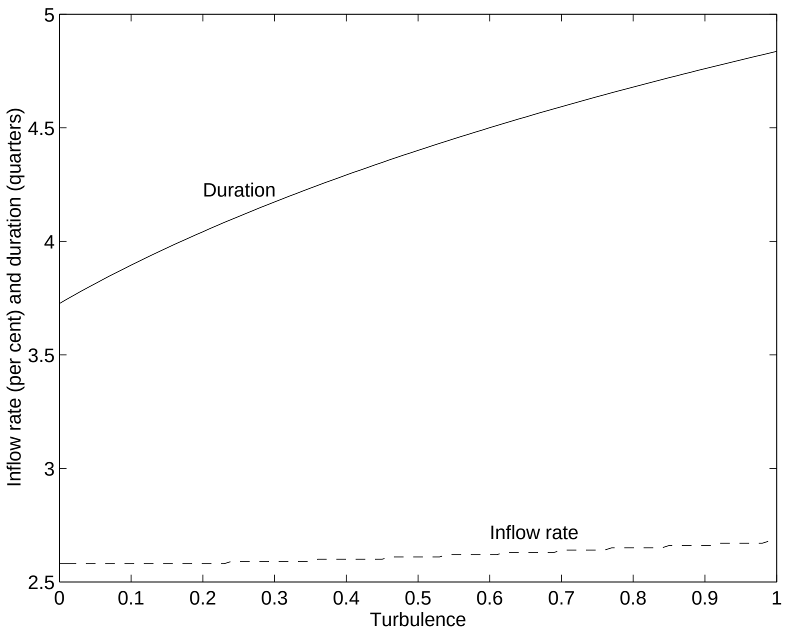


(b) Modified model.

Figure 1. Unemployment rates. The solid line is total unemployment. The dashed line shows the unemployed who have originated from high-skill employment and the dotted line depicts the portion of these workers who have suffered skill loss. (The original and the modified calibration are both given in Table 1 and $\beta = 0.98$.)

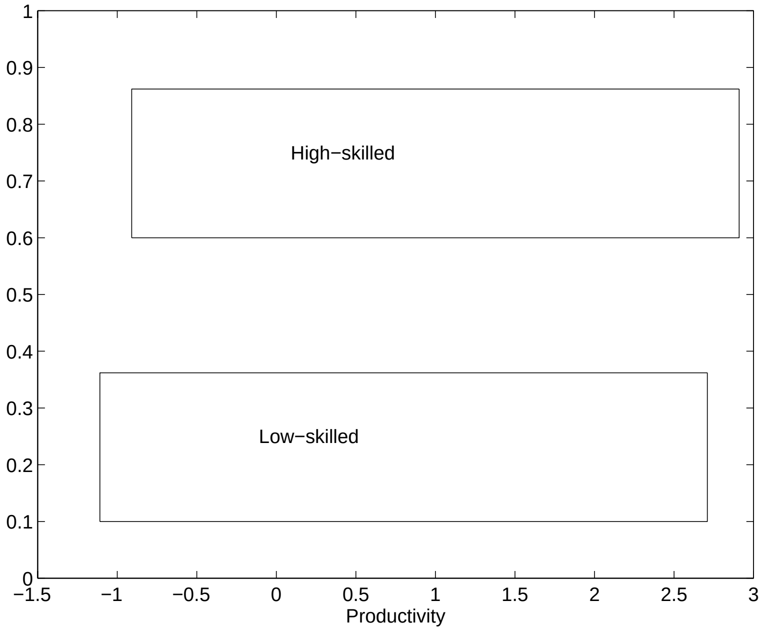


(a) Original model.

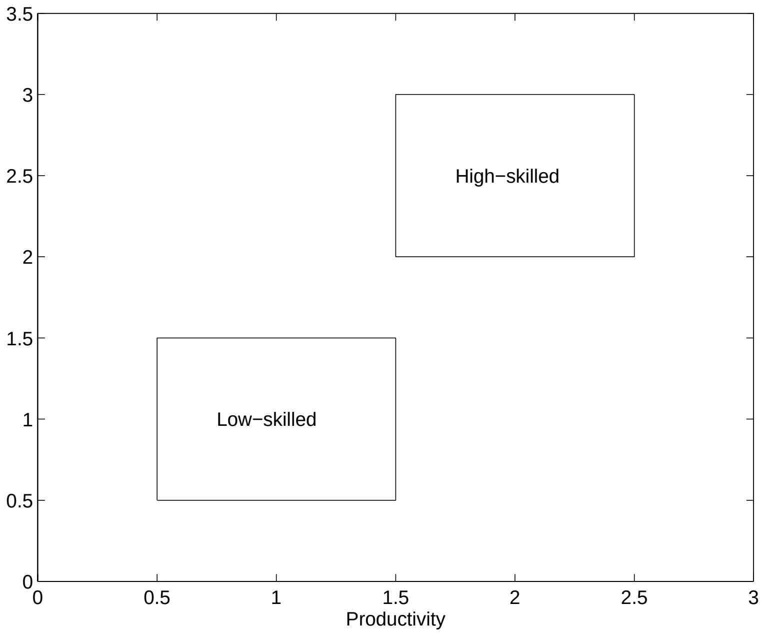


(b) Modified model.

Figure 2. Inflow rate and average duration of unemployment. The solid line is the average duration of unemployment in quarters. The dashed line depicts the quarterly inflow rate into unemployment as a per cent of the labor force. (The original and the modified calibration are both given in Table 1 and $\beta = 0.98$.)



(a) Original calibration.



(b) Modified calibration.

Figure 3. Productivity distributions. Uniform distributions from which productivities are drawn by low- and high-skilled workers, respectively. (The original and the modified calibration are both given in Table 1.)

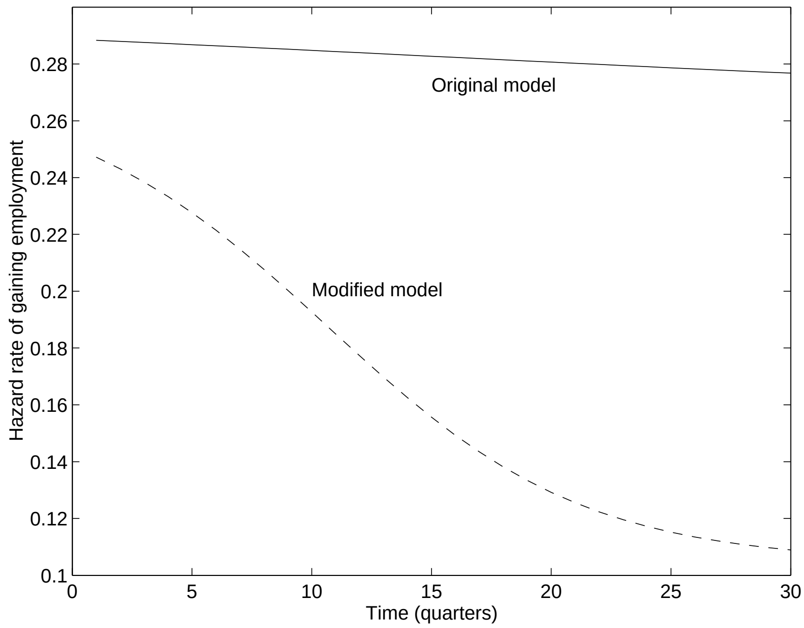


Figure 4. Hazard rates of gaining employment in turbulent economic times, $\gamma^D = 0.5$. (The original and the modified calibration are both given in Table 1 and $\beta = 0.98$.)