

# **A Theory of Slack**

## **How Economic Slack Shapes Markets, Business Cycles, and Policies**

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## **CHAPTER 11.**

# **A unified theory of unemployment**

We now apply the slackish market model to the labor market. We devote an entire part to the labor market because from a social perspective, unemployment is the most costly form of slack, so precisely understanding it is important. We will see that the slackish labor market model offers a unified theory of unemployment—blending frictional unemployment and job rationing. The slackish model is therefore appropriate to describe both good times and bad times and to capture the influence on unemployment of both labor demand and labor supply factors and policies.

In this chapter, we start by presenting the slackish labor market model. We describe the the origins of unemployment and the sources of its fluctuations. We also use the richness of US labor market data to calibrate the slackish labor market model and compare its quantitative behavior with real-world patterns.

### **11.1. Slackish labor market model**

In this section we apply the slackish market model of chapter 9 to the labor market. The mapping between the generic market model and the labor market model is described in table 11.1. Most of the notation remains the same, but some notation is adjusted to respect conventions. We do not repeat the derivations here: we only summarize the main equations and results, and we provide some interpretation.

TABLE 11.1. Application of the slackish market model to the labor market

Generic market			Labor market		
Symbol	Name	Definition	Symbol	Name	Definition
$k$	Market capacity	-	$h$	Labor force	-
$V$	Visits	-	$V$	Job vacancies	-
$U$	Unsold goods	-	$U$	Job seekers	-
$v$	Visit rate	$v = V/k$	$v$	Vacancy rate	$v = V/h$
$u$	Slack rate	$u = U/k$	$u$	Unemployment rate	$u = U/h$
$m(u, v)$	Matching function	-	$m(u, v)$	Matching function	-
$\theta$	Market tightness	$\theta = v/u$	$\theta$	Labor market tightness	$\theta = v/u$
$f$	Selling rate	(4.4)	$f$	Job-finding rate	(4.4)
$q$	Buying rate	(4.5)	$q$	Job-filling rate	(4.5)
$k$	Matching cost	-	$k$	Recruiting cost	-
$\tau$	Matching wedge	(9.13)	$\tau$	Recruiting wedge	(11.3)
$y$	Output	-	$l$	Employment	-
$y^s$	Market supply	(9.9)	$l^s$	Labor supply	(11.1)
$y^d$	Market demand	(5.15)	$l^d$	Labor demand	(11.6)
$c$	Consumption	-	$n$	Producers	-
$u$	Utility function	(5.10)	$y$	Production function	(11.4)
$a$	Demand shifter	-	$a$	Labor productivity	-
$\alpha$	Diminishing marginal utility of consumption	-	$\alpha$	Diminishing marginal productivity of labor	-
$\lambda$	Buyer-seller separation rate	-	$\lambda$	Job-separation rate	-
$p$	Market price	-	$w$	Real wage	-
$p^n$	Price norm	(7.1)	$w^n$	Wage norm	(11.8)
$\rho$	Price norm level	-	$\omega$	Wage norm level	-
$\gamma$	Price rigidity	-	$\gamma$	Wage rigidity	-

### 11.1.1. Matching function and labor market tightness

The labor market is composed of a labor force of size  $h$  and a mass 1 of firms, each indexed by  $j \in [0, 1]$ .

The labor force comprises  $l$  employed workers and  $U = h - l$  unemployed workers.

Each firm  $j$  posts  $V_j$  job vacancies to hire job seekers. The reason why firms must constantly recruit new workers is that they constantly lose existing workers—who retire, quit, or are dismissed. Formally, each firm faces a job-separation rate  $\lambda > 0$ . The aggregate number of vacancies is  $V = \int_0^1 V_j dj$ .

From the unemployment level  $U$  and vacancy level  $V$ , we also define the unemployment rate  $u = U/h$  and the vacancy rate  $v = V/h$ .

The rate at which job vacancies and job seekers match is given by a matching function  $m(U, V)$  that satisfies the assumptions laid out in chapter 4.

The labor market tightness is the ratio of the two arguments in the matching function:  $\theta = V/U = v/u$ .

The labor market tightness determines the rate at which job seekers find jobs,  $f(\theta) = m(1, \theta)$ , and the rate at which job vacancies are filled,  $q(\theta) = m(1/\theta, 1)$ .

### 11.1.2. Equilibrium labor supply

The equilibrium labor supply is the employment level when labor market flows are balanced:

$$(11.1) \quad l^s(\theta) = [1 - u(\theta)] h,$$

where the equilibrium unemployment rate is given by

$$(11.2) \quad u(\theta) = \frac{\lambda}{\lambda + f(\theta)}.$$

On the labor market, the number of job seekers who remain unemployed and that of workers who are employed are determined by how quickly job seekers find jobs and how long employed workers hold on to their jobs. With a fixed job-separation rate  $\lambda$ , these numbers are determined by the job-finding rate  $f(\theta)$  and therefore labor market tightness  $\theta$ . From any initial division of the labor force between employed and unemployed workers and a given tightness, the unemployment rate converges to the equilibrium unemployment rate given by (11.2) and the employment level converges to the equilibrium labor supply given by (11.1).

As we saw in chapter 9, the convergence to the equilibrium unemployment rate is rapid: in the US labor market, the convergence process has a half-life of about 1 month. As a result, in practice, the actual and equilibrium unemployment rates are indistinguishable

(Michaillat and Saez 2021, figure A3). This is why we can abstract from the law of motion of the unemployment rate (given by (9.3)) and consider the unemployment rate as a function of tightness (given by (11.2)).

When labor-market flows are balanced, at any point in time, equally many people lose their job and find a job; equally many employment relationships are created and dissolved. Thus, employment and unemployment remain constant over time, so we can work with static supply and demand relationships instead of differential equations, greatly simplifying the analysis.

### 11.1.3. Equilibrium labor demand

Because it takes time to fill vacancies and each vacancy requires the attention of a recruiter, firms must allocate a share of their workforce to recruiting. Not all workers can be employed at producing goods and services that can be sold to customers. Instead, each firm  $j$  employs two types of workers:  $n_j$  producers and some recruiters. Because each job vacancy requires  $\kappa > 0$  recruiters, the total number of recruiters in firm  $j$  is  $\kappa V_j$  and the total number of workers is  $l_j = n_j + \kappa V_j$ . Because of the recruiters, a wedge appears between the number of employees in the firm and the number of producers:

$$(11.3) \quad l_j = [1 + \tau(\theta)] n_j \quad \text{where} \quad \tau(\theta) = \frac{\kappa \lambda}{q(\theta) - \kappa \lambda}.$$

On the labor market the wedge  $\tau(\theta)$  corresponds to the ratio between the number of recruiters in the firm,  $\tau(\theta)n_j$ , and the number of producers,  $n_j$ . This recruiting wedge  $\tau(\theta)$  is an equilibrium object because it is computed under the assumption that labor market flows are balanced.

Next, each firm  $j$  produces goods or services using the concave production function

$$(11.4) \quad y(n_j) = a \cdot n_j^{1-\alpha},$$

where  $a$  governs labor productivity,  $n_j$  is the number of producers in the firm, and  $\alpha \in (0, 1)$  governs the concavity of the production function, which determines diminishing marginal product of labor. Recruiters are busy recruiting, so only producers participate in the production process. This explains why the production function takes the number of producers  $n_j$  and not the number of employees  $l_j$  as an argument.

Why might the production function exhibit diminishing instead of constant marginal product of labor? A basic reason is that in the short run, capital and land (and other natural resources) are fixed. For instance, if production is given by a Cobb-Douglas function of labor and capital, but capital is fixed in the short run, then the short-run production function takes the form that we use here.

Each firm chooses the size of their workforce to maximize the flow of real profits:

$$(11.5) \quad y(n_j) - wl_j = a \cdot n_j^{1-\alpha} - w[1 + \tau(\theta)] n_j,$$

where  $w > 0$  is the real wage paid by the firm to all its workers. The firm's real profits are solely determined by the firm's number of producers,  $n_j$ , so the firm chooses that number to maximize profits.

In principle, because the model is dynamic, firms should maximize the discounted sum of flow real profits, subject to the law of motion of employment. But because firms operate in a balanced-flow environment, they can pick the number of producers that they employ at any point in time by posting the appropriate number of vacancies. So firms are not subject to any intertemporal constraints, and maximizing the discounted sum of flow real profits is equivalent to maximizing the flow of real profits at any point in time.

The nice thing about the firm's profit function (11.5) is that it is isomorphic to the buyer's objective function (5.12) that we derived in the generic market model, up to a constant. The constant is the endowment of money balances ( $B_j$ ), which appears in the buyer's problem but not in the firm's problem. Obviously, the constant has no effect on the first-order condition and demand curve. The market demand (5.15) can therefore be applied to the labor market, giving us the following labor demand:

$$(11.6) \quad l^d(\theta, w) = \left[ \frac{(1-\alpha)a}{w} \right]^{1/\alpha} \cdot \frac{1}{[1 + \tau(\theta)]^{1/\alpha-1}}.$$

The labor demand gives the firm's profit-maximizing employment level for any labor market tightness  $\theta$ , real wage  $w$ , and productivity  $a$ . The labor demand reflects the property that when profits are maximized, the marginal product of labor equals the marginal cost of labor, which includes both real wage and recruiting costs:

$$(11.7) \quad (1-\alpha)an_j^{-\alpha} = w[1 + \tau(\theta)].$$

The first-order condition of the firm problem (11.7) allows us to derive the labor share in the model, which is quite helpful. The first-order condition implies that firm  $j$ 's real wage bill is

$$wl_j = w[1 + \tau(\theta)]n_j = (1-\alpha)an_j^{1-\alpha} = (1-\alpha)y(n_j).$$

Accordingly, for all firms, their wage bill is a share  $1-\alpha$  of their output, which implies that the economy's labor share—the aggregate wage bill as a share of aggregate output—is just  $1-\alpha$ . And since firms' profits are their output minus their wage bill, firms' profits amount to a share  $\alpha$  of their output, and the economy's profit share is  $\alpha$ . These profits represent broadly operating profits, calculated before incorporating payments to capital and land.

#### 11.1.4. Wage norm

Just as in chapter 7, we assume a rigid wage norm. This means that the real wage depends on labor productivity  $a$  and on the size of the labor force  $h$ , but the response to shocks to  $a$  and  $h$  is muted.

Accordingly, we assume that the real wage norm depends on labor productivity and the labor force, just as in the price norm (7.1):

$$(11.8) \quad w^n = \omega \cdot (a \cdot h^{-\alpha})^{1-\gamma}.$$

The parameter  $\gamma \in (0, 1]$  determines the amount of wage rigidity. At  $\gamma = 1$ , the real wage is fixed at  $w^n = \omega$ . At  $\gamma = 0$ , the real wage would be flexible (we do not consider this case here because we focus on somewhat-rigid wages). Finally, the parameter  $\omega > 0$  determines the level of the wage norm.

Once we incorporate the wage norm (11.8), the labor demand takes the form of the market demand (7.2):

$$(11.9) \quad l^d(\theta) = \left[ \frac{(1-\alpha)a^\gamma}{\omega} \right]^{1/\alpha} \cdot \frac{h^{1-\gamma}}{[1+\tau(\theta)]^{1/\alpha-1}}.$$

#### 11.1.5. Solution of the model

The labor market tightness that solves the model is given by a supply-equals-demand condition:

$$(11.10) \quad l^d(\theta) = l^s(\theta)$$

where the labor demand incorporates the wage norm and is given by (11.9), and the labor supply is given by (11.1).

In the slackish labor market model, the wage is given by the wage norm  $w^n$ , so it is tightness that equalizes labor demand and labor supply. As we showed in chapters 5 and 7, the supply-equals-demand equation admits a unique solution  $\theta$ , and all the other variables in the model can be computed from tightness.

The solution of the model is represented graphically in figure 11.1 in a tightness-employment plane. The solution is at the intersection of the labor demand and supply curves. The intersection directly gives labor market tightness but also employment and unemployment in the model.

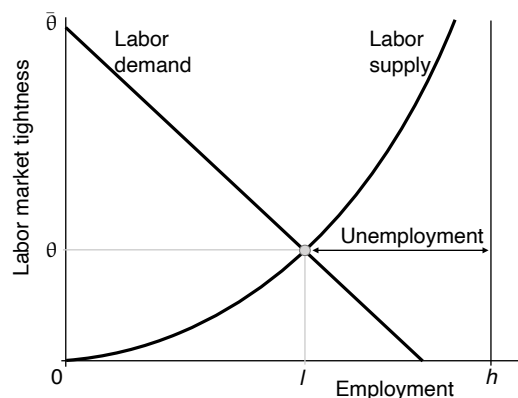


FIGURE 11.1. Solution of the slackish labor market model

The labor supply curve is given by (11.1). The labor demand curve is given by (11.9). The solution of the model is at the intersection of the labor demand and supply curves.

## 11.2. Calibration of the model

In this section, we calibrate the model to the US labor market. As much as possible, we use evidence from the 1948–2019 period. During this period, the labor market operated in a consistent fashion. We omit earlier and later evidence because the monumental disruptions imposed by the Great Depression, World War 2, and the coronavirus pandemic are not representative of the typical behavior of the US labor market.

The calibrated values of the model parameters are summarized in table 11.2. Throughout the rest of the chapter, we will compare the quantitative behavior of the calibrated model with patterns observed in the US labor market. For completeness, the table also summarizes the calibrated values of the main model variables.

The calibration proceeds in two steps. We calibrate as many parameters as possible by directly measuring their values in US data. Then, parameters for which we do not have direct measurements are calibrated to match select, important facts about the US labor market and economy—such as the average unemployment rate and elasticity of the Beveridge curve.

### 11.2.1. Baseline labor productivity and labor force

In the labor market model, labor demand shocks are represented by variations in labor productivity,  $a$ , and labor supply shocks are represented by variations in labor force,  $h$ . Nevertheless, for the calibration, we need to set the two parameters to baseline values. We will then explore how the model responds to changes in these values.

As usual, we normalize the baseline productivity level to  $a = 1$ . We also normalize the baseline labor force to  $h = 1$ , which conveniently equalizes the employment, unemploy-

TABLE 11.2. Calibrated values of the parameters and variables of the slackish labor market model

Value	Description	Source	Reference
A. Normalized parameters			
$a = 1$	Labor productivity	Normalization	Baseline
$h = 1$	Labor force	Normalization	Baseline
B. Parameters calibrated from direct measurement			
$\kappa = 1$	Recruiting cost	Borgschulte and Martorell (2018)	Section 2.7.3
$\gamma = 0.5$	Wage rigidity	Haeflke, Sonntag, and van Rens (2013)	Section 6.4.3
$\lambda = 3.6\%$	Monthly job-separation rate	BLS (2025d)	Section 2.5.1
C. Parameters calibrated to match target			
$\alpha = 0.35$	Diminishing marginal returns to labor	Labor share = 65%	Autor et al. (2020)
$\sigma = 0.47$	Matching elasticity	Beveridge elasticity = 1	Figure 2.8
$\mu = 0.75$	Monthly matching efficacy	Unemployment rate = 5.7%	Equation (11.11)
$\omega = 0.65$	Wage level	Labor market tightness = 0.65	Equation (11.12)
D. Variables calibrated from historical evidence			
$\theta = 0.65$	Labor market tightness	Average over 1948-2019	Figure 4.5
$u = 5.7\%$	Unemployment rate	Average over 1948-2019	Figure 2.1
E. Other variables			
$\nu = 3.7\%$	Vacancy rate	$\nu = \theta \cdot u$	
$f(\theta) = 0.60$	Monthly job-finding rate	$f(\theta) = \mu\theta^{1-\sigma}$	
$q(\theta) = 0.92$	Monthly job-filling rate	$q(\theta) = \mu\theta^{-\sigma}$	
$\tau(\theta) = 4.1\%$	Recruiting wedge	$\tau(\theta) = \kappa\lambda/[q(\theta) - \kappa\lambda]$	
$l = 0.943$	Number of employees	$l = (1 - u)h$	
$n = 0.906$	Number of producers	$n = l/[1 + \tau(\theta)]$	
$y = 0.938$	Output	$y = an^{1-\alpha}$	
$w = 0.65$	Real wage	$w = \omega a^{\lambda} l^{1-\gamma}$	

ment, and vacancy rates and levels at the baseline.

### 11.2.2. Recruiting cost

We argued in section 2.7.3 that it takes about 1 full-time worker to service a job vacancy. Accordingly, we set the recruiting cost to  $\kappa = 1$ .

### 11.2.3. Job-separation rate

We found in section 2.5.1 that between 2001 and 2019, the monthly job-separation rate averages 3.6%. Hence we set  $\lambda = 3.6\%$ .

### 11.2.4. Concavity of the production function

Accordingly, we set the concavity parameter in the production function (11.4) to  $\alpha = 0.35$ , which produces a labor share of  $1 - \alpha = 65\%$ . This value corresponds to the typical, historical US labor share, before it started falling in the 1990s (Autor et al. 2020, figure 1).

### 11.2.5. Matching function

We showed in section 4.9 that a Cobb-Douglas matching function describes the US labor market well, so we use this functional form:  $m(U, V) = \mu U^\sigma V^{1-\sigma}$ .

Next, we set the parameter  $\sigma$  in the matching function to obtain a Beveridge elasticity of 1, as observed in the US (section 2.4.2). In a dynamic slackish model like here, and with a Cobb-Douglas matching function, the Beveridge elasticity  $\beta$  is directly linked to  $\sigma$ , as (10.10) shows:

$$\beta = \frac{1}{1-\sigma} \left( \sigma + \frac{u}{1-u} \right) \quad \text{so} \quad \sigma = \frac{1}{1+\beta} \left( \beta - \frac{u}{1-u} \right).$$

Compared to (10.10), we replace the matching elasticity  $\eta$  by the parameter  $\sigma$  since both are the same when the matching function is Cobb-Douglas.

We target a Beveridge elasticity of  $\beta = 1$ . We set the unemployment rate to its average value between 1948 and 2019:  $u = 5.7\%$  (section 2.2.3). Plugging these numbers in the expression above, we obtain a matching elasticity of  $\sigma = 0.47$ .<sup>1</sup>

Finally, we calibrate the parameter  $\mu$  in the matching function so the unemployment rate takes its average value when labor market tightness is at its average value. Unemployment rate and labor market tightness are related by (11.2). Using the expression for the

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<sup>1</sup>We could also have calibrated  $\sigma$  by using the elasticity of the job-finding rate with respect to labor market tightness, as we discussed in chapter 4. This alternative approach yields a value of  $\sigma = 0.6$ . We prefer to target the elasticity of the Beveridge curve because it is a key sufficient statistic determining the efficient unemployment rate. So by targeting it, we ensure that the calibrated model's welfare properties are realistic. Because the two calibration strategies do not yield exactly the same value of  $\sigma$ , we realize that the model does not perfectly describe the data: it cannot match both the elasticity of the Beveridge curve and the elasticity of the job-finding rate simultaneously.

matching function, this gives  $u = \lambda/(\lambda + \mu\theta^{1-\sigma})$  so

$$(11.11) \quad \mu = \lambda\theta^{\sigma-1} \cdot \frac{1-u}{u}.$$

Between 1948 and 2019, the unemployment rate averages 5.7% (section 2.2.3), while labor market tightness averages 0.65 (section 4.9). Setting unemployment and tightness to their average levels, and setting  $\lambda = 3.6\%$  and  $\sigma = 0.47$ , we obtain  $\mu = 0.75$ .

### 11.2.6. Wage norm

We first calibrate the wage-rigidity parameter in the wage norm (11.8). We showed in section 6.4.3 that the elasticity of real wages with respect to labor productivity is about 0.5. Thus, we set the wage-rigidity parameter to  $\gamma = 0.5$ , which ensures that the elasticity of real wages with respect to productivity is  $1 - \gamma = 1 - 0.5 = 0.5$ .

Next, we calibrate the wage-level parameter  $\omega$  in the wage norm so that the tightness takes its average value at the baseline. Through the labor demand (11.9), the parameter  $\omega$  is related to various other parameters and to labor market tightness. At the tightness that solves the model, the labor demand just gives the employment level, which here is also the employment rate, which is  $1 - u$ , where  $u$  is the unemployment rate. Next, note that we can express the term  $1 + \tau(\theta)$  as a function of the model parameters and tightness. Starting from (9.13) and using (4.13), we obtain

$$1 + \tau(\theta) = \frac{q(\theta)}{q(\theta) - \lambda\kappa} \quad \text{so} \quad \frac{1}{1 + \tau(\theta)} = 1 - \frac{\lambda\kappa}{\mu} \cdot \theta^\sigma.$$

Combining these results with the labor demand (11.9), and setting  $a = h = 1$ , we obtain

$$(11.12) \quad \omega = (1 - \alpha)(1 - u)^{-\alpha} \left(1 - \frac{\kappa\lambda}{\mu} \cdot \theta^\sigma\right)^{1-\alpha}.$$

Setting  $u = 5.7\%$ ,  $\theta = 0.65$ ,  $\alpha = 0.35$ ,  $\kappa = 1$ ,  $\lambda = 3.6\%$ ,  $\mu = 0.75$  and  $\sigma = 0.47$ , the equation gives  $\omega = 0.65$ .

## 11.3. Fluctuations in unemployment

In this section we use our labor-market model to explain the fluctuations in unemployment and other variables observed on the US labor market.

### 11.3.1. Sources of fluctuations

The first question is: what is the main source of labor market fluctuations? The key insight to answer this question is that labor demand shocks produce a positive correlation between

TABLE 11.3. Comparative statics in the slackish labor market model

	Employment $l$	Tightness $\theta$	Wage $w$	Unemployment rate $u$	Vacancy rate $v$
A. Negative labor demand shock					
Decrease in labor productivity $a$	-	-	-	+	-
B. Negative labor supply shock					
Decrease in labor force $h$	-	+	+	-	+

The comparative statics are obtained from equation (7.3) and are illustrated in figure 11.2. A variable's increase is denoted by "+" and a decrease by "-".

employment and labor market tightness, while labor supply shocks produce a negative correlation (figure 11.2). This insight can be used to distinguish demand and supply shocks on any slackish market, and especially in the labor market.

In the model, a labor demand shock is a shock that impacts worker productivity,  $a$ . If there is a decrease in productivity, the labor demand decreases for any level of tightness (equation (11.9)). Indeed, if workers suddenly become less productive, it is less profitable for firms to hire workers—as wages are rigid ( $\gamma > 0$ ) and therefore do not decrease as much as productivity. In the labor market diagram of figure 11.2A, the labor demand curve shifts inward. At the new solution, the tightness is lower. The employment level decreases as well, as the market slides down along the labor supply curve.

A labor supply shock is a shock to the size of the labor force,  $h$ . After a decrease in labor force, the labor supply mechanically decreases for any level of tightness (equation (11.1)). The real wage increases slightly when the labor force decreases, as labor becomes scarcer (equation (11.8)). As a result, the labor demand is slightly depressed by a decrease in the labor force (equation (11.9)). In the labor market diagram of figure 11.2B, the labor supply curve shifts inward, and the labor demand moves inward slightly as well. As we established using equation (7.3), the shift in labor supply dominates, so at the new solution labor market tightness is higher. In contrast, the employment level decreases as both labor supply and demand are lower.

Table 11.3 summarizes the comparative statics. The main takeaway is that fluctuations in labor demand—which stem from labor productivity shocks—lead to positive comovements between employment level and labor market tightness. By contrast, fluctuations in labor supply—which stem from labor force shocks—lead to negative comovements between employment level and labor market tightness.

To determine the main source of labor market fluctuations, we therefore examine the correlation between employment and labor market tightness in the US labor market. Labor market tightness was constructed in section 4.9. Employment simply is the employment level computed by the BLS (2025a) from CPS data. Just like in figure 2.8, we stop the analysis

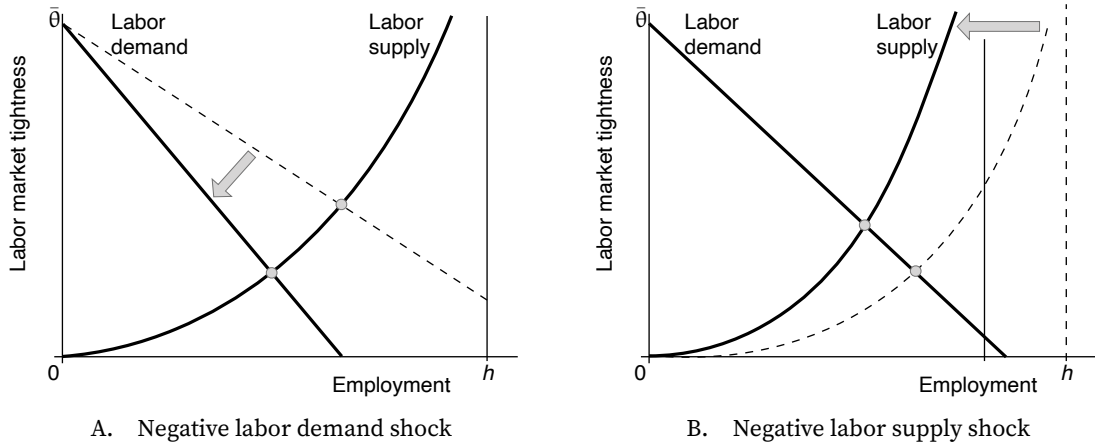


FIGURE 11.2. Comparative statics in the slackish labor market model

The labor supply is given by (11.1). The labor demand, including the wage norm, is given by (11.9). A negative labor demand shock is a reduction in labor productivity  $a$ . A negative labor supply shock is a reduction in labor force  $h$ .

in 2019 to concentrate on the 1948–2019 period so the analysis is not unduly influenced by the dislocation of the US labor market caused by the coronavirus pandemic.

We first look at the comovements of employment and labor market tightness by superimposing cyclical fluctuations in employment with those in tightness (figure 11.3A). It is clear that fluctuations in employment and tightness are positively correlated. The correlation between the two series is substantial, at 0.85. The two series appear especially strongly positively correlated after 1970—when they track each other very closely. Such positive correlation indicates that labor demand shocks, not labor supply shocks, are the main source of labor market fluctuations.

In figure 11.3B we recast the results from figure 11.3A in scatter form. We see again that employment and labor market tightness are positively correlated: an increase in tightness by 10% is associated with an increase in employment by about 0.3%. We also see that employment fluctuations are for the most part explained by tightness fluctuations: the least-squares regression has an  $R^2$  of 0.89.

To conclude in the slackish labor market model, labor demand shocks produce the sort of comovements between employment and tightness observed in reality. Labor supply shocks would produce opposite comovements. In the rest of the chapter, we therefore use labor demand shocks to generate labor market fluctuations. The labor demand equation (11.9) shows that labor demand is increasing in labor productivity. So good times are represented by a high labor productivity and bad times by a low labor productivity. A higher productivity could reflect higher technology in good times, or more realistically, a higher utilization rate of employed labor—as displayed in figure 2.3.

It is unsurprising that we find that changes in the size of the labor force do not explain

short-run labor market fluctuations. We saw in chapter 2 that the labor force participation rate is moving quite slowly over time, compared to the pace of business cycles, so changes in labor force were always unlikely to explain cyclical labor market fluctuations. Instead, changes in labor force participation are likely to have medium run effects on the labor market—as the labor force participation rate evolves in the medium run.

### 11.3.2. Amplitude of fluctuations

A more quantitative question arises next: can the model actually match the amplitude of the fluctuations we see in the data? That is, can the calibrated model generate an elasticity of labor market tightness with respect to labor productivity that we see in US data?

First, we need to measure labor productivity. We simply measure labor productivity  $a$  as a Solow residual:  $\ln(a) = \ln(y) - (1 - \alpha) \cdot \ln(n)$  where  $y$  is real output in the nonfarm business sector and  $n$  is employment in the nonfarm business sector, both constructed by the BLS (2025c,b).<sup>2</sup> Labor productivity incorporates both technology and labor utilization—this is by design since both affect labor demand. Here we treat labor utilization as exogenous; we will endogenize it in chapter 15.

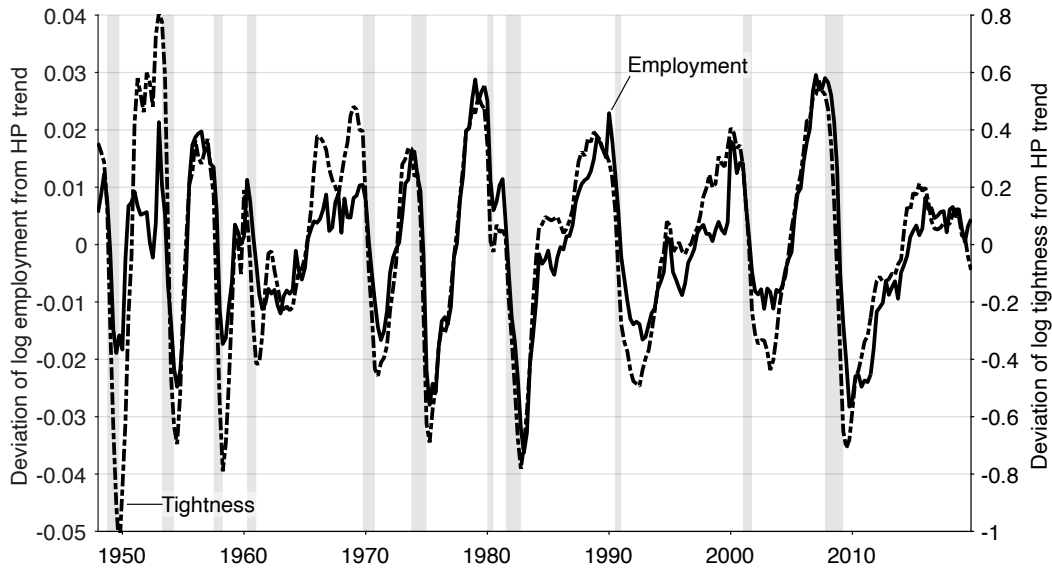
To estimate elasticity of labor market tightness with respect to labor productivity, we regress log tightness on log productivity, after detrending them with our HP filter (figure 11.4). We continue to focus on the 1948–2019 period. We see that labor market tightness rises when labor productivity rises, with an elasticity estimated at  $\epsilon_a^\theta = 12.8$ : an increase in productivity by 1% generates an increase in tightness by 12.8%.

We are interested in reaching the target for the elasticity of tightness with respect to productivity:  $\epsilon_a^\theta = 12.8$ . Can we generate such an elasticity for a plausible amount of wage rigidity? To answer this question, we exploit the elasticity of labor market tightness with respect to labor productivity, which is given by equation (7.14), but adjusted for the fact that in a dynamic model the elasticity of labor supply with respect to tightness is given by (9.14). Applying this equation here, with a Cobb-Douglas matching function, we get the elasticity of tightness with respect to productivity:

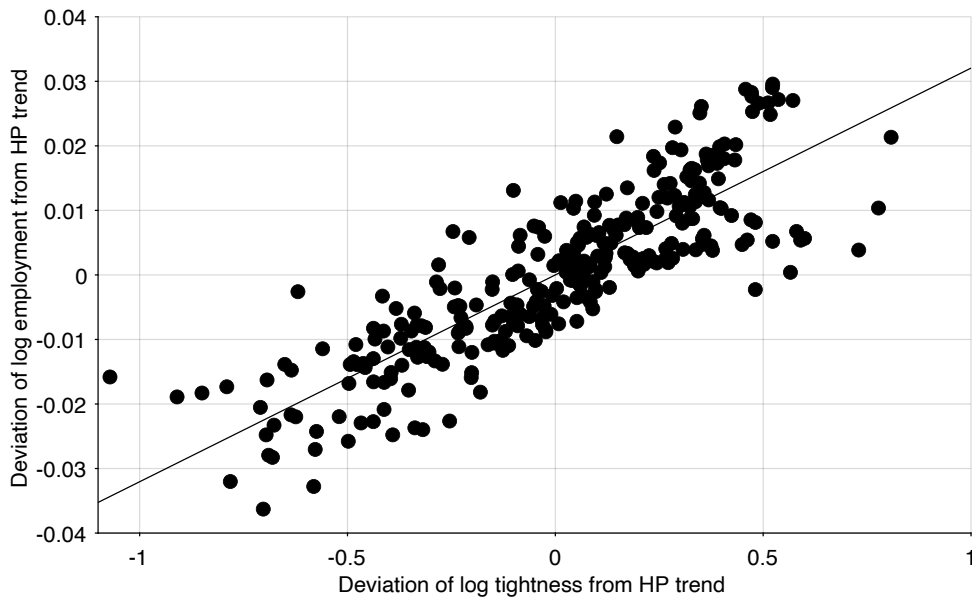
$$(11.13) \quad \epsilon_a^\theta = \frac{\gamma}{(1 - \sigma)\alpha u + (1 - \alpha)\sigma\tau}.$$

First, as we saw in chapter 7, if the wage is flexible ( $\gamma = 0$ ), then there are no fluctuations in tightness with changes in productivity ( $\epsilon_a^\theta = 0$ ). If the wage is flexible, it moves in proportion with productivity, so it absorbs any changes in productivity, which leaves firms no incentives to change the size of the firm when productivity varies. Thus, the only way to produce fluctuations in the model ( $\epsilon_a^\theta > 0$ ) is if the wage is somewhat rigid ( $\gamma > 0$ ).

<sup>2</sup>According to the model,  $n$  should be the number of producers in the nonfarm business sector—the number of employees net of the number of recruiters. Because the number of recruiters is not available, we simply use the number of employees for  $n$ .



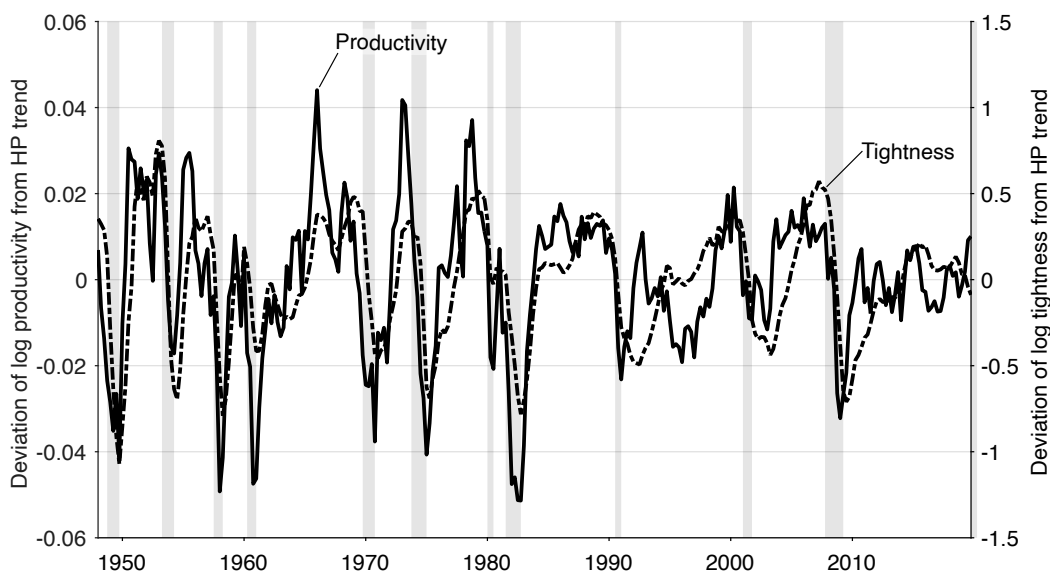
A. Correlation: 0.85



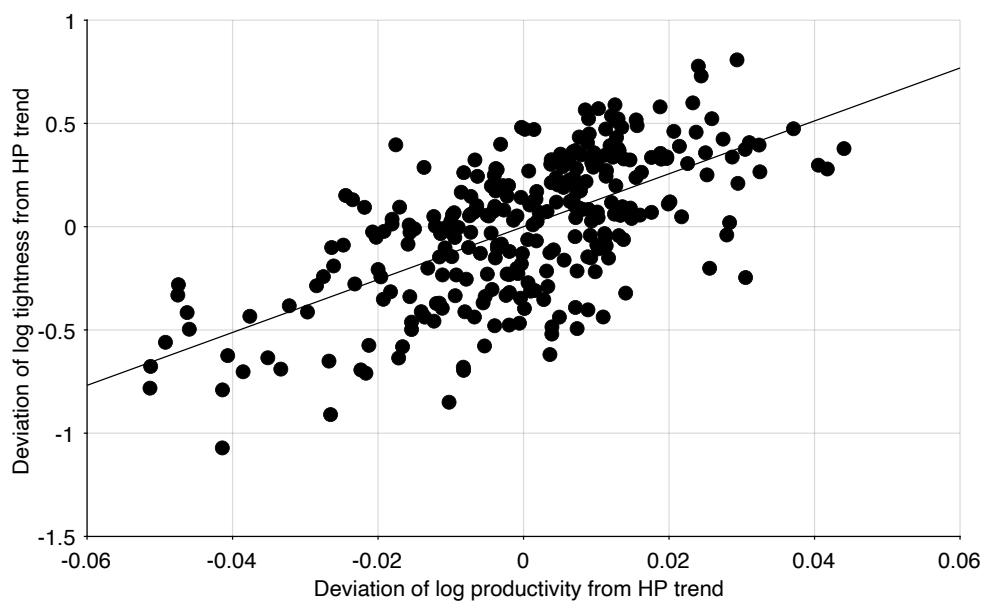
B. Estimated slope: 0.032

FIGURE 11.3. Correlation between employment and labor market tightness in the United States, 1948–2019

The employment level is the quarterly average of the monthly, seasonally adjusted series computed by the BLS (2025a). Labor market tightness comes from figure 4.5. Both series are detrended by applying a HP filter with smoothing parameter of 10,000. Shaded areas indicate recessions dated by the NBER (2023).



A. Correlation: 0.64



B. Estimated elasticity: 12.8

FIGURE 11.4. Response of labor market tightness to labor productivity in the United States, 1948–2019

Labor productivity is computed as the residual  $\ln(a) = \ln(y) - (1 - \alpha) \cdot \ln(n)$  where  $y$  is quarterly, seasonally adjusted real output in the nonfarm business sector and  $n$  is quarterly, seasonally adjusted employment in the nonfarm business sector, both constructed by the BLS (2025c,b). Labor market tightness comes from figure 4.5. Both series are detrended by applying a HP filter with smoothing parameter of 10,000. Shaded areas indicate recessions dated by the NBER (2023).

We can now calibrate the elasticity of tightness with respect to productivity by plugging in values for the parameters and variables of the model listed in table 11.2. Setting the production-function shape to  $\alpha = 0.35$ , the matching-function shape to  $\sigma = 0.47$ , the unemployment rate to  $u = 5.7\%$ , and the recruiting wedge to  $\tau = 4.1\%$ , we find  $\epsilon_a^\theta = 43.3 \times \gamma$ .

The last parameter that we need to calibrate is the wage-rigidity parameter  $\gamma$ , which is critical. We have set  $\gamma = 0.5$ , based on the rigidity of real wages of new hires observed by Haefke, Sonntag, and van Rens (2013). This gives us  $\epsilon_a^\theta = 43.3 \times 0.5 = 21.7$ : significantly higher than the elasticity of tightness with respect to productivity observed in the data.

Of course, we do not yet have a precise estimate of the wage-rigidity parameter. The best available evidence suggests that it is in the 0.2–0.7 range. How much of that range is rigid enough to produce the fluctuations in tightness observed in reality? To obtain an elasticity of at least 12.8, the wage rigidity must be at least  $12.8/43.3 = 0.30$ . Hence any wage rigidity in the 0.3–0.7 range is both realistic in itself and sufficient to amplify productivity shocks as much as in the data. Wage rigidity in the 0.2–0.3 range is slightly too low to amplify productivity shocks sufficiently. Overall, except at the most flexible end of the range, the small amount of wage rigidity observed in real wages for new hires is sufficient to amplify productivity shocks as much as observed in labor market data.

For completeness, we can also compute the elasticities of the unemployment rate  $u$ , vacancy rate  $v$ , and employment level  $l$  with respect to productivity  $a$ . This is very easy to do in the model. First, using the Beveridge curve  $v(u)$ , we have  $v(a) = v(u(a))$  so  $\epsilon_a^v = (-\beta) \cdot \epsilon_a^u$ , where  $\beta = -\epsilon_u^v$  is the Beveridge elasticity. Second, by definition of tightness,  $\theta(a) = v(a)/u(a)$  so that  $\epsilon_a^\theta = \epsilon_a^v - \epsilon_a^u = -(1 + \beta)\epsilon_a^u$ . In other words, the Beveridge elasticity distributes the fluctuations in tightness between fluctuations in unemployment and fluctuations in vacancies:

$$\epsilon_a^u = \frac{-1}{1 + \beta} \cdot \epsilon_a^\theta \quad \text{and} \quad \epsilon_a^v = \frac{\beta}{1 + \beta} \cdot \epsilon_a^\theta.$$

Finally, the employment level is simply given by  $l(a) = [1 - u(a)]h$  so  $\epsilon_a^l = -[u/(1 - u)]\epsilon_a^u$ , which gives

$$\epsilon_a^l = \frac{1}{1 + \beta} \cdot \frac{u}{1 - u} \cdot \epsilon_a^\theta.$$

We have calibrated the model to match the empirical observation that the Beveridge curve is a rectangular hyperbola, so the Beveridge elasticity is just  $\beta = 1$ . Hence, in the calibrated model,  $\epsilon_a^v = \epsilon_a^\theta/2 = 10.9$  and  $\epsilon_a^u = -\epsilon_a^\theta/2 = -10.9$ . This means that fluctuations in unemployment and vacancies contribute equally to fluctuations in labor market tightness. We have also calibrated the model so  $u = 5.7\%$ , which gives  $u/(1 - u) = 0.060$  and  $\epsilon_a^l = \epsilon_a^\theta \times 0.03 = 0.65$ . We notice also that under productivity shocks, the observed elasticity of employment with respect to tightness is  $\epsilon_\theta^l = \epsilon_a^l/\epsilon_a^\theta = 0.030$ , which is exceedingly close to the elasticity of 0.032 estimated in figure 11.3B.

Finally, figure 11.5 displays labor market tightness, unemployment rate, vacancy rate, and employment as a function of productivity to illustrate the quantitative properties of the calibrated model. The figure also shows the Beveridge curve: the negative relationship between unemployment rate and vacancy rate traced as productivity varies.

### 11.3.3. Shimer puzzle

By looking closely, we see that our calibration solves the famous Shimer (2005) puzzle.

The Shimer puzzle says—broadly—that in a labor market model built around a matching function, and with bargained wages, productivity shocks are not amplified enough to produce realistic fluctuations in labor market tightness, unemployment, and vacancies.

We can see the Shimer puzzle in the present analysis, because the bargained wage is flexible, in the sense that it can be represented by the wage norm (11.8) with  $\gamma = 0$ . And as we have just seen in (11.13), if  $\gamma = 0$ , tightness does not respond to productivity shocks at all, so unemployment rate and vacancy rate do not respond either.

Are we entirely sure that the bargained wage is flexible? Well yes: we established that result in chapter 9 in the case of a generic dynamic market, but the result directly applies to this chapter's labor market. In fact, an interesting result from section 9.9 is that the bargained wage is set at a markdown below the marginal product of labor:

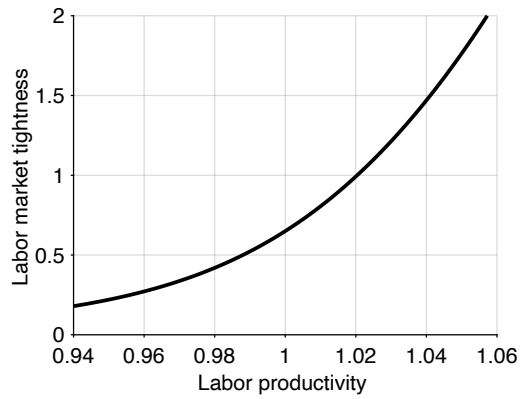
$$(11.14) \quad w = \frac{(1 - \alpha)an^{-\alpha}}{1 + \frac{1-\chi}{\chi} \cdot u}.$$

If the worker bargaining power  $\chi$  is 0, the markdown becomes infinite and the wage falls to 0. If the worker bargaining power is 1, the markdown vanishes and the wage rises to the marginal product of labor. Interestingly, the markdown increases with the unemployment rate. If the unemployment rate was 0, the markdown would vanish and the wage would reach the marginal product of labor. When the unemployment rate reaches 1, the markdown reaches  $1/\chi$ , which implies that the wage is just a fraction  $\chi$  of the marginal product of labor. This property appears because workers' outside option is worse when the unemployment rate is higher: if they do not agree to the wage offer, they are forced to remain jobless for a longer time. Workers must therefore settle for lower wages when the unemployment rate is higher—which allows firms to impose a higher markdown.

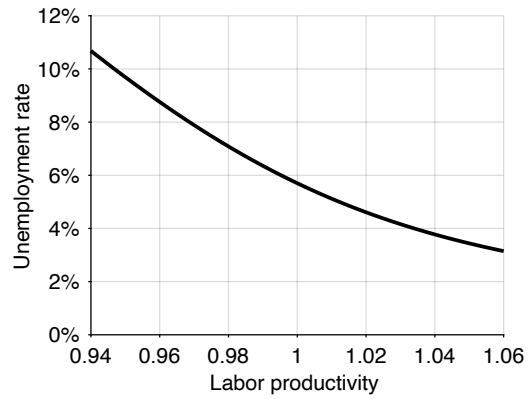
Just as we did in the generic dynamic market, we can plug the wage expression into the labor demand equation (11.7). We find that the labor demand is degenerate under wage bargaining, in the sense that it does not involve quantities:

$$(11.15) \quad \frac{\tau(\theta)}{u(\theta)} = \frac{1 - \chi}{\chi}.$$

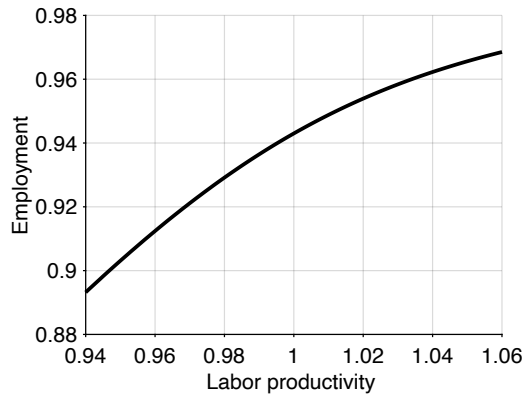
In the tightness-quantity diagram, the labor demand is therefore horizontal, pinning



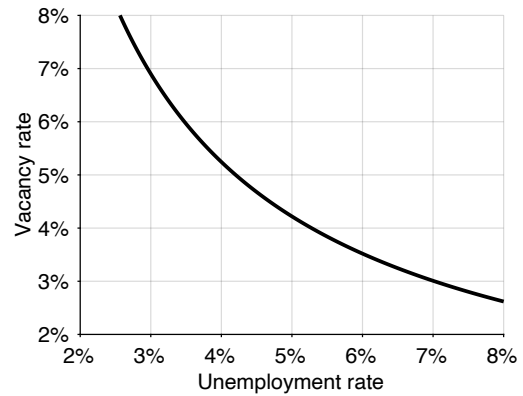
A. Labor market tightness



B. Unemployment rate



C. Employment



D. Vacancy rate

FIGURE 11.5. Response to productivity fluctuations in the slackish labor market model

Labor market tightness  $\theta$  is given by (11.10). The unemployment rate  $u$  is given by (11.2). The employment level is given by  $l = (1 - u)h$ . The vacancy rate is given by  $v = \theta u$ . The calibration of the model is described in table 11.2.

down a unique labor market tightness:

$$(11.16) \quad \theta = (\tau/u)^{-1} \left( \frac{1-\chi}{\chi} \right).$$

From this equation and the underlying structure of the matching wedge  $\tau(\theta)$  and slack rate  $u(\theta)$ , we infer that labor market tightness is solely determined by the worker bargaining power  $\chi$ , the recruiting cost  $\kappa$ , the job-separation rate  $\lambda$ , and the matching function. The Shimer puzzle is directly visible in the labor demand (11.16), as labor market tightness does not depend in any way on labor productivity  $a$ . This means that productivity shocks have no effect on tightness, and therefore no effect on unemployment, employment, or vacancies.

#### 11.3.4. Mechanism behind fluctuations

A common idea is that unemployment goes up in recessions because firms lay off a large number of workers. However, this is not what happens in the model, and this is not what happens in the data.

In the model, the pool of unemployment grows in bad times because it takes a longer time for people to find a job, not because employed workers lose their jobs at a higher pace. Formally, when labor demand drops, labor market tightness falls, so the job-finding rate plummets, and job seekers get stuck in unemployment. Conversely, the pool of unemployment shrinks in good times because it is much quicker for unemployed workers to find a job, not because employed workers keep their jobs longer.

This is also what appears in the data. As we see in figures 4.6A and 2.9A, the job-finding rate is sharply procyclical, while the job-separation rate is acyclical. It is true that the layoff rate was countercyclical in the past (Akerlof, Rose, and Yellen 1988, figure 2). But it's less true now, and the increase in layoffs in recessions is offset by a simultaneous drop in quits, as figure 2.9B shows. As Hall (2005, p. 397) eloquently puts it,

In the modern US economy, recessions do not begin with a burst of layoffs. Unemployment rises because jobs are hard to find, not because an unusual number of people are thrown into unemployment.

More formally, Shimer (2012, p. 128) shows that the job-finding rate explains 77% of unemployment fluctuations over 1948–2010, while the job-separation rate explains only 23%. Over 1987–2010, the share explained by the job-finding rate rises to 90%, and the share explained by the job-separation rate declines to 10%.

## 11.4. Origins of unemployment

Although the slackish model is built around a matching function, not all unemployment is frictional in it. In fact, part of unemployment is due to job rationing, and part to matching frictions. Moreover, in bad times, when total unemployment is high, frictional unemployment is low: job rationing accounts for almost all of unemployment.

In that way the slackish model unifies two theories of unemployment that have coexisted for a long time but have always only been applied to different contexts. Before the Great Depression people were working on frictional unemployment, caused by matching and recruiting (Reder 1969). But the Great Depression and the *General Theory* killed that theory and replaced it with one explaining unemployment from a lack of jobs due to low labor demand combined with a wage floor (Okun 1981, figure 1-2). In the 1970s, researchers started asking: Why should nominal wages be sticky? This led to the development of efficiency-wage models, which aimed to complete the *General Theory* by providing a justification for the wage floor (Akerlof and Yellen 1986). However, the emergence of the DMP model put a stop to the efficiency-wage literature, and once again researchers started focusing solely on frictional unemployment.

The slackish framework allows us to blend both sources of unemployment, offering a unified way to study the labor market in good and bad times. In this section, we establish that the slackish model incorporates both rationing and frictional unemployment, and we study the cyclical nature of the two components. We also show that the DMP model can be seen as a special case of the slackish model without rationing unemployment.

### 11.4.1. Why is a unified theory of unemployment beneficial?

A common view among New Keynesian macroeconomists is that a market-clearing model—or a model with frictional unemployment—is accurate enough to describe good times. Of course, they also realize that such a model doesn't work in bad times—market failures are just too prevalent. As Mankiw and Romer (1991) wrote at the onset of their text on *New Keynesian Economics*:

Perhaps, the invisible hand guides the economy in normal times, but events like the Great Depression require different theories.

We can see that there's this idea that it is acceptable to have separate models to describe bad times and good times. But surely we can do better. A good model of the labor market should capture both good times and bad times. The labor market and its participants are the same in good times and bad, so shouldn't we aim for a unified treatment of the labor market over the business cycle? Shouldn't we be able to use a common theory to think about bad times, when there is high unemployment, and good times, when there is low unemployment? Scientifically, it seems like the right thing to do.

Practically, the coronavirus pandemic demonstrates why it's very helpful to have a labor market model that describes both good and bad times. Initially, when the pandemic started, there was a vast increase in unemployment, so we needed a model that could help us think about that. In the US, unemployment rose to almost 15%, which we hadn't seen since the Great Depression. However, the labor market recovered rapidly. Suddenly, we were in a very tight labor market, with a vast amount of vacancies posted, and low unemployment. It was important to have a model that could help us understand this situation.

So it is evident that the labor market can move quickly from a situation with a massive amount of slack to a situation that is massively tight. We need to be able to think about these two things simultaneously; this is what the model developed in this chapter aims to do. We don't want to have two separate models to think about good times and bad times, but rather one model that captures both. This is one of the motivations for the model: to offer a unified treatment of unemployment that applies at all times. The unified treatment captures both the lack of jobs that we observe in slumps as well as the matching frictions especially visible in booms.

#### **11.4.2. Job rationing in the real world**

Why is it a quality that the slackish model features job rationing—unlike the DMP model? It is because we know that when matching frictions vanish—when workers are desperate to work so recruiting for firms is costless—unemployment does not disappear. This means that some unemployment must be caused by a lack of jobs: it cannot all be due to matching frictions.

How do we know this? It is because whenever a significant recession occurs, people queue for jobs at factory gates, in front of firms, at job bureaus, and job fairs. Many people want to work so recruiting is essentially costless, and yet, there is still some unemployment—so unemployment cannot possibly all be frictional.

The photos collected in figure 11.6 illustrate this phenomenon. These are classical pictures from the Great Depression across the United States, mostly by Dorothea Lange. They show queues of workers who are patiently waiting to apply for jobs, or waiting to be hired. From these photos and others it is clear that queues were everywhere—a clear manifestation of job rationing.

#### **11.4.3. Job rationing in the model**

We are interested in the following question: Can the slackish model still have some unemployment when the recruiting cost goes to zero? The key finding is that, if the labor demand is low enough, it is possible that some unemployment remains although the recruiting cost is zero.



A. Howard Street, known as “Skid Row,” the district of the unemployed (San Francisco, CA, 1937)



B. Unemployed men sitting on the sunny side of the San Francisco Public Library (San Francisco, CA, 1937)



C. Part of the daily lineup outside the State Employment Service Office (Memphis, TN, 1938).



D. Typical scene reflecting large population of unemployed in desperate need of work and looking for jobs (Camden, NJ, 1935)

### FIGURE 11.6. Job rationing in the Great Depression

Sources. A: Dorothea Lange, available at <https://www.loc.gov/pictures/item/2017769707/>. B: Dorothea Lange, available at <https://www.loc.gov/pictures/item/2017769687/>. C: Dorothea Lange, available at <https://lccn.loc.gov/2017770574>. D: Franklin D. Roosevelt Library Public Domain Photographs, available at <https://catalog.archives.gov/id/195658>.

We define rationing unemployment as the amount of unemployment that prevails when the recruiting cost is 0. Rationing unemployment comes from the fact that even when recruiting is free, firms do not want to hire all workers in the labor force. This means that there just are not enough jobs for everyone.

To see that rationing unemployment exists in the slackish model, and to study its properties, let's first compute the labor demand when the recruiting cost is set to  $\kappa = 0$ . In that case, the recruiting wedge  $\tau(\theta)$  becomes 0, so the labor demand does not depend on tightness anymore. The labor demand reduces to the Walrasian labor demand, which equalizes marginal product of labor to the real wage:

$$(11.17) \quad l^d(w, \kappa = 0) = \left[ \frac{(1 - \alpha)a}{w} \right]^{1/\alpha}.$$

Then the rationing unemployment rate is defined as

$$u^r = \max\left(0, 1 - \frac{l^d(w, \kappa = 0)}{h}\right).$$

A natural question is whether rationing unemployment always exists in our slackish model. The answer is no. There are certain situations in which jobs are lacking and other situations in which jobs are plentiful. Rationing unemployment exists whenever  $l^d(w) < h$ , which can be rewritten

$$w > (1 - \alpha)ah^{-\alpha}.$$

Thus, rationing unemployment exists whenever the real wage is higher than the marginal product of labor of the last worker in the labor force—who is the least productive worker in the labor force by diminishing marginal returns to labor under a concave production function. The logic is simple. If the wage the firm has to pay is above the marginal product of the least productive worker in the labor force, then no firm wants to hire that worker. This scenario leads to job rationing because some workers are less productive than what they are paid. Essentially, job rationing arises in any situation in which the wage is too high.

Are we sure that for some level of productivity there is some job rationing? The answer is yes. Given the wage norm assumed here, the labor demand in the absence of recruiting cost can be expressed as a function of model parameters:

$$(11.18) \quad l^d(a, h, \kappa = 0) = \left[ \frac{(1 - \alpha)a^\gamma}{\omega} \right]^{1/\alpha} \cdot h^{1-\gamma}.$$

Job rationing occurs whenever  $l^d(a, h, \kappa = 0) < h$ , which can be rewritten

$$(11.19) \quad a < \left( \frac{\omega}{1 - \alpha} \right)^{1/\gamma} h^\alpha.$$

This gives us a threshold of productivity below which job rationing appears.

Finally, we represent rationing unemployment graphically (figure 11.7). With our Cobb-Douglas matching function, when  $\theta \rightarrow 0$ ,  $q(\theta) \rightarrow \infty$  so  $\tau(\theta) \rightarrow 0$ . From this, we learn that the labor demand when  $\theta = 0$  is the same as the labor demand when the recruiting cost is 0. This means that the position of the vertical, zero-recruiting-cost labor demand corresponds to the x-intercept of the regular, positive-recruiting-cost labor demand with the x-axis. Hence, when the recruiting cost goes to zero, the labor demand curve rotates clockwise around the fixed x-intercept. And for our purpose, this means that rationing unemployment is measured by the distance between the x-intercept of the labor demand and the labor force.

There are several possible situations, depending on the value of labor productivity. If labor productivity is above the threshold described in (11.19), the x-intercept of the labor demand occurs farther to the right than the labor force  $h$ , so there is no rationing unemployment (figure 11.7A). If labor productivity is below the threshold, the x-intercept of the labor demand occurs within the labor force  $h$ , so there is some rationing unemployment (figure 11.7B). If labor productivity is even lower, the x-intercept is even closer to the origin so rationing unemployment is larger (figure 11.7C).

#### 11.4.4. Frictional unemployment in the model

We now complete the decomposition of unemployment into two parts: rationing unemployment  $u^r$  and frictional unemployment  $u^f$ . Frictional unemployment is the extra unemployment that exists beyond that caused by the lack of jobs in the economy:

$$u^f = u - u^r.$$

We next express frictional unemployment as a function of the parameters and tightness. We focus on the situations in which productivity is low enough so that rationing unemployment prevails. Without rationing unemployment, all unemployment is frictional, so there is no special expression for frictional unemployment. With rationing unemployment,  $u = 1 - l^d(\theta)/h$  and  $u^r = 1 - l^d(\kappa = 0)/h$  so

$$u^f = \frac{l^d(\kappa = 0)}{h} - \frac{l^d(\theta)}{h}.$$

Using the expressions (11.9) and (11.18) for the labor demands, we find that frictional

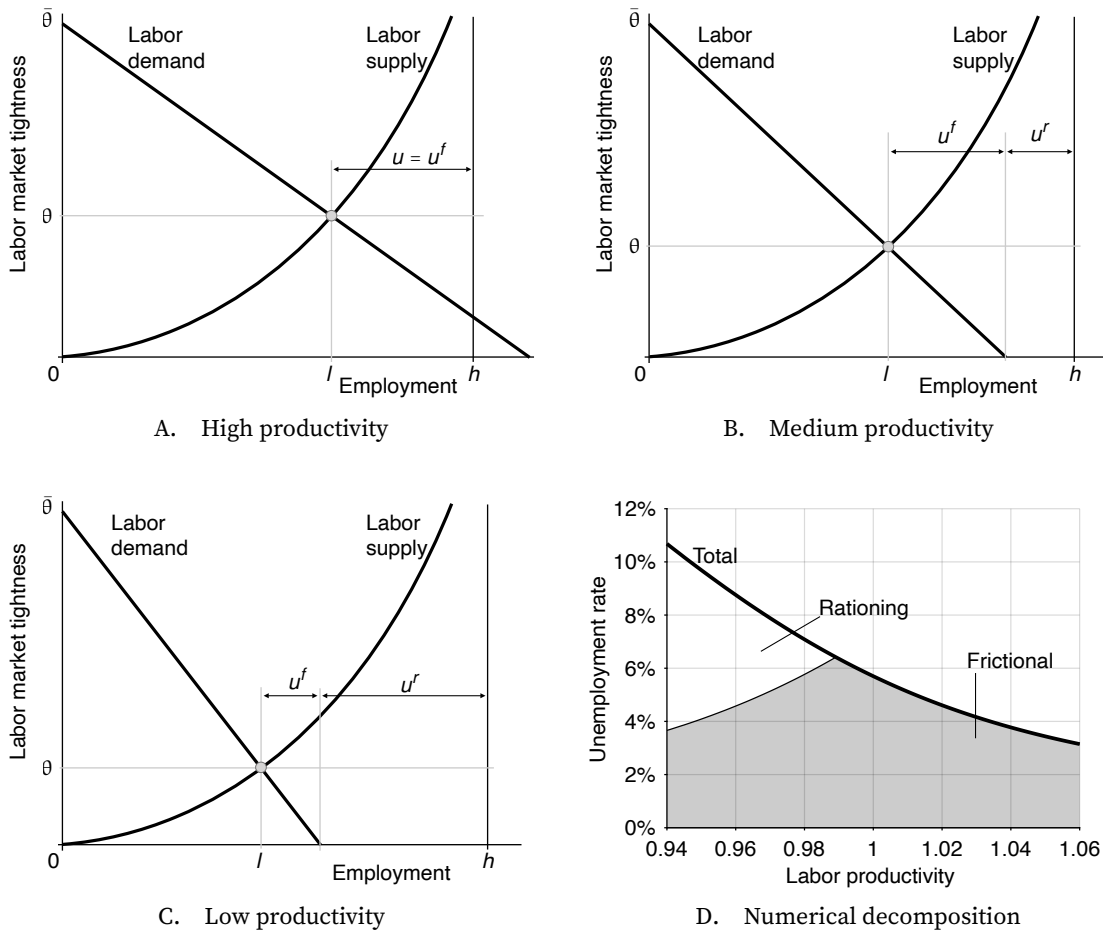


FIGURE 11.7. Rationing and frictional unemployment in the slackish labor market model

In panels A–C, the labor supply is given by (11.1) and the labor demand, including the wage norm, is given by (11.9). In panel D, the calibration of the model comes from table 11.2.

unemployment satisfies

$$(11.20) \quad u^f = \left[ \frac{1-\alpha}{\omega} \right]^{1/\alpha} h^{-\gamma} a^{\gamma/\alpha} \left[ 1 - \frac{1}{(1+\tau(\theta))^{1/\alpha-1}} \right].$$

We graphically decompose unemployment in figure 11.7. In figure 11.7A, productivity is high, so all unemployment is frictional. In figures 11.7B and 11.7C, labor productivity is below the threshold (11.19), so there is some rationing unemployment. However, total unemployment is greater than this amount. Indeed, tightness is strictly positive so firms hire fewer workers than at the point where tightness is zero. Thus, there is more unemployment than when tightness is zero and this extra unemployment corresponds to frictional unemployment. Frictional unemployment corresponds to the horizontal distance covered as we move along the labor demand from the x-intercept to the supply-demand intersection.

#### 11.4.5. Fluctuations in rationing and frictional unemployment

It is interesting to study how rationing and frictional unemployment vary when the labor market fluctuates. From this we will see how the sources of unemployment change as the state of the labor market evolves. We would presume that the tide lifts all boats: that when unemployment is high, all types of unemployment are high. It turns out that this is not what happens. In very good times, all unemployment is frictional, so of course total and frictional unemployment move together. But then a divergence occurs. As rationing unemployment becomes larger, overall unemployment grows, but frictional unemployment shrinks. So in bad times, rationing unemployment is large but frictional unemployment is low.

It is easy to establish these results from the expressions that we derived for frictional and rationing unemployment. We only consider situations where labor productivity is below the threshold in (11.19) so rationing unemployment exists. From expression (11.18), we see that as labor productivity  $a$  drops, the zero-recruiting-cost labor demand  $l^d(\kappa = 0)$  shrinks, so rationing unemployment  $1 - l^d(\kappa = 0)/h$  grows.

What happens to frictional unemployment at the same time? In expression (11.20) for frictional unemployment, we see that as labor productivity drops, the term  $a^\gamma$  drops. We have also seen earlier (see table 11.3) that when productivity drops, tightness drops, which means that the recruiting wedge  $\tau(\theta)$  decreases, and implies that the term in square brackets in (11.20) decreases. Accordingly, frictional unemployment decreases when labor productivity falls, just as total unemployment increases.

We can also see these movements graphically (figure 11.7). As labor productivity drops, the labor demand curve shifts inward, so rationing unemployment and total unemploy-

ment grow. The economic mechanism is the following: in bad times, productivity falls, wages do not fall as much, so the profitability of workers falls and firms do not want to hire as many workers. This reduces the number of jobs in the economy, which boosts unemployment. Since labor demand is weaker, tightness falls.

What happens to frictional unemployment as the labor market cools? Tightness is much lower as the economy moves down the labor supply curve, so the amount of employment that has been reduced due to recruiting costs is very small. This leads to less frictional unemployment. The general intuition is that in bad times it is easy for firms to recruit workers since labor is readily available. The total increase in unemployment due to the negative productivity shock is dampened by the reduction in frictional unemployment.

Overall, in bad times there is high rationing unemployment and low frictional unemployment. A natural question is how big the fluctuations in rationing and frictional unemployment might be. Figure 11.7D shows what happens in the calibrated version of the slackish model. For any unemployment rate below 6.4% (which is slightly above the average unemployment rate of 5.7%), all unemployment is frictional. Once unemployment rises further, above 6.4%, job rationing appears, and frictional unemployment starts declining. When unemployment reaches 7%, rationing unemployment is 1.2% and frictional unemployment falls to 5.8%. When unemployment rises further to 8% and then 9%, rationing unemployment reaches 2.9% and then 4.6% and frictional unemployment declines to 5.1% and 4.4%. Finally, when unemployment reaches 10%, rationing unemployment reaches 6.0% and frictional unemployment declines to 4.0%.

#### **11.4.6. Absence of job rationing in the DMP model**

The idea of job rationing—the idea that irrespective of recruiting costs firms do not want to hire everyone because there is not enough demand for labor—is absent from the DMP model. This means that when the recruiting cost goes to zero, unemployment disappears in the DMP model. All DMP unemployment is frictional. As we discussed in chapter 3, the DMP model is the workhorse model of unemployment in macroeconomics and labor. But it provides an excessively supply-centric view of the labor market because its labor demand is degenerate—it is perfectly elastic. In the DMP model, the labor supply is the main hindrance to employment; the labor demand is never the issue. As we will see in the rest of the chapter, this property colors our understanding of how the labor market operates and all the policy implications from the model.

The DMP model is a special case of the slackish labor market model with a linear production function and a bargained wage. So we can use the analysis above to show quickly that there is no job rationing in that model.

Let's first gather the labor demand and supply in the DMP model. The labor supply is the same as in the generic model, given by (11.1). The labor demand follows from the

first-order condition (11.7) with  $\alpha = 0$ , so it is perfectly elastic:

$$(11.21) \quad [1 + \tau(\theta)] w = a.$$

Given that the labor demand is perfectly elastic, it is horizontal in our usual tightness-employment plane (figure 11.8A).

To completely specify the DMP model, we need to specify the wage norm. The wage norm imposes that wages are determined through Nash bargaining, so that the employment surplus is shared between worker and firm. Specifically, the worker keeps a share  $\chi$  of the surplus and the firm keeps a share  $1 - \chi$ , where  $\chi \in (0, 1)$  is the worker's bargaining power. Using equation 9.18, with  $\alpha = 0$ , we see that the wage in the DMP model is a markdown below productivity:

$$(11.22) \quad w = \frac{a}{1 + \frac{1-\chi}{\chi} \cdot u(\theta)}.$$

With wage bargaining, as we saw in (9.19), the labor demand equation becomes

$$(11.23) \quad \frac{\tau(\theta)}{u(\theta)} = \frac{1-\chi}{\chi}.$$

The labor demand pins down a unique labor market tightness, determined by the bargaining power  $\chi$ , the matching function, as well as the parameters underlying the functions  $\tau(\theta)$  and  $u(\theta)$ : job-separation rate  $\lambda$  and recruiting cost  $\kappa$ .

Since we perform an experiment where the recruiting cost  $\kappa$  goes to 0, it is good to spell out what the recruiting wedge  $\tau(\theta)$  is, since it depends on the recruiting cost. Using the expressions (11.3) and (11.2) for the functions  $\tau(\theta)$  and  $u(\theta)$ , we rewrite the labor demand as

$$\kappa \cdot \frac{f(\theta) + \lambda}{q(\theta) - \kappa\lambda} = \frac{1-\chi}{\chi}.$$

Multiplying both sides by  $\chi[q(\theta) - \kappa\lambda]$ , and collecting terms, we obtain

$$\lambda\kappa + \chi\kappa f(\theta) = (1-\chi)q(\theta).$$

Finally, dividing both sides by  $q(\theta)$  to keep all the terms with  $\kappa$  and  $\theta$  together, and using again (4.6), we find that the DMP model's labor demand is

$$(11.24) \quad (1-\chi) - \kappa \left[ \chi\theta + \frac{\lambda}{q(\theta)} \right] = 0.$$

The left-hand side of the equation is continuous and strictly decreasing from  $1 - \chi > 0$  to  $-\infty$  when  $\theta$  goes from 0 to  $\infty$ . Indeed,  $q(\theta)$  is strictly decreasing in  $\theta$  so  $-\lambda/q(\theta)$  is

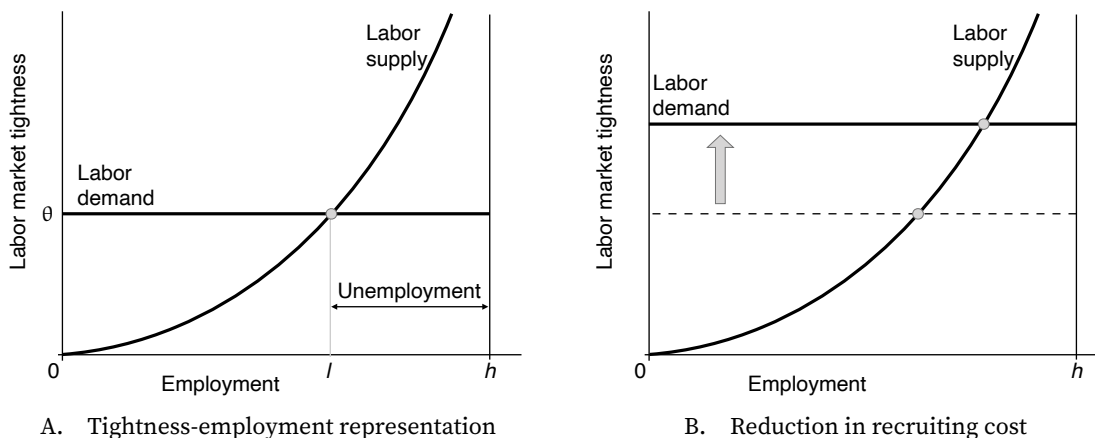


FIGURE 11.8. Solution of the DMP labor market model

The labor supply is given by (11.1) and the labor demand, including the wage norm, is given by (11.23).

also strictly decreasing. Furthermore, with the Cobb-Douglas matching function, when  $\theta \rightarrow 0$ ,  $q(\theta) \rightarrow \infty$  so  $\lambda/q(\theta) \rightarrow 0$ . Hence, the DMP model's labor demand defines a unique tightness.<sup>3</sup>

To conclude, we want to know what happens when the recruiting cost  $\kappa$  goes to 0. As  $\kappa \rightarrow 0$ , the term in square brackets in (11.24) goes to 0 for any finite  $\theta$ , and the left-hand side goes to  $1 - \chi$ , so the equation is violated. The equation can only continue to hold if tightness becomes arbitrarily large. Hence, in the DMP model,  $\theta \rightarrow \infty$  when  $\kappa \rightarrow 0$ . The economic intuition is that with bargaining, the wage is strictly below productivity, so if there are no recruiting costs, firms are willing to hire everyone and post an arbitrarily large number of vacancies. This drives tightness to infinity. The movement of the labor demand as the recruiting cost falls is depicted in figure 11.8B, showing how tightness rises as the recruiting cost dwindles.

What happens to employment and unemployment? Well, employment is determined by the labor supply, so it is the limit of the labor supply when  $\theta \rightarrow \infty$ . Given that the labor supply is given by (11.1), and that  $f(\theta) \rightarrow \infty$  when  $\theta \rightarrow \infty$  with the Cobb-Douglas matching function, we learn that the labor supply asymptotes to the labor force  $h$  as tightness becomes infinite. This means that everyone in the labor force has a job when tightness is infinite. Thus, when the recruiting cost vanishes, unemployment disappears. From this we can conclude that there is no job rationing in the DMP model and all unemployment is frictional. The only reason there is unemployment in the DMP model is because there is a recruiting cost.

<sup>3</sup>The labor demand is the same as the job-creation curve in Pissarides (2000, equation (1.24)), once we set unemployment benefits to  $z = 0$  and the interest rate to  $r = 0$  in Pissarides' model.

### 11.4.7. Another definition of job rationing based on infinite job-search effort

We now introduce a parameter  $e > 0$  for job-search effort by unemployed workers. In the previous specification we effectively set  $e = 1$ ; here we ask what happens when  $e$  changes, and in particular when  $e$  goes to infinity—when people are really desperate to work, what happens to unemployment? We will see that the limit of the unemployment rate when job-search effort is infinite is just rationing unemployment.

To allow for job-search effort, the matching function becomes  $m(e \cdot u, v)$ : total search input on the worker side is  $e \cdot u$ , with  $u$  the number of job seekers, while  $v$  continues to capture recruiting effort on the firm side. Labor market tightness is the ratio of the two arguments,  $\theta = v/(e \cdot u)$ . By constant returns to scale, the job-filling rate is still  $q(\theta)$  with the same properties as before. But the job-finding rate becomes  $e \cdot f(\theta)$ —so it depends on both tightness and effort. This is because  $f(\theta)$  is the rate at which one unit of effort is successful, so  $e \cdot f(\theta)$  is the rate at which  $e$  units of effort are successful. We can quickly formally see this, as the job-finding rate is

$$\frac{m(e \cdot u, v)}{u} = e \cdot \frac{m(e \cdot u, v)}{e \cdot u} = e \cdot m\left(1, \frac{v}{e \cdot u}\right) = e \cdot m(1, \theta) = e \cdot f(\theta).$$

Because the job-filling rate is unchanged, nothing on the firm side moves at given  $\theta$ : labor demand is unaffected by  $e$  and still given by (11.9).

Only labor supply changes. Since the job-finding rate is altered from  $f(\theta)$  to  $e \cdot f(\theta)$ , the labor supply becomes

$$(11.25) \quad l^s(\theta, e) = \frac{e \cdot f(\theta)}{\lambda + e \cdot f(\theta)} \cdot h.$$

The properties with respect to tightness  $\theta$  are as before. For effort, labor supply is 0 when effort is 0, labor supply is strictly increasing with effort, and the limit of the labor supply is  $h$  when effort is infinite. So raising effort is like raising tightness—if people search more, more people have jobs.

The easiest way to see what happens in the model when the job-search effort goes to infinity is to use the tightness-employment diagram (figure 11.9). We know that the labor demand is unaffected by search effort, while the labor supply shifts out when the search effort increases. In the limit with infinite search effort, the labor supply curve becomes rectangular with a right angle at  $l = h$ . Using this, we can see what happens when search effort goes to infinity.

In a generic slackish model, when search effort goes to infinity, unemployment still does not disappear when jobs are rationed. The economy converges to the same point as in the limit of zero recruiting cost, to the x-intercept of the labor demand curve. The unemployment that remains at that stage is rationing unemployment. The condition for

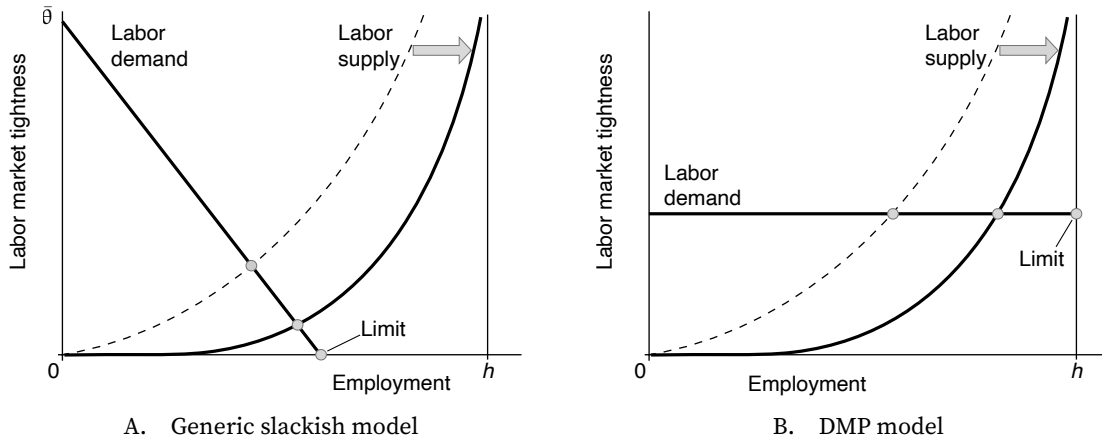


FIGURE 11.9. Limit of the labor market models when job-search effort becomes infinite

The labor demand is given by (11.9) in panel A and by (11.23) in panel B. The labor supplies are given by (11.25), for a lower job-search effort (dashed line) and a higher job-search effort (solid line).

it to exist is unchanged: the intercept must lie below  $h$ , equivalently productivity must be low enough as in (11.19). Whether search effort goes to infinity or recruiting cost goes to 0, the same amount of rationing unemployment prevails.

Hence, even infinitely intense job search does not eliminate unemployment. This is because even if it is immensely easy for firms to find workers, firms do not want to hire these workers when their wage exceeds their marginal product. This is what happened during the Great Depression: people were desperate to work but unemployment did not vanish, and queues formed at factory gates.

In the DMP model, unemployment disappears as job-search effort goes to infinity. As search effort rises, the labor supply curve shifts out and the labor market moves along the horizontal labor demand curve. When effort becomes infinite, all workers in the labor force find a job, and no unemployment remains. So we confirm that there is no job rationing in the DMP model.

## 11.5. Summary

In this chapter, we apply the slackish market model of chapter 9 to the labor market. We derive equilibrium labor supply from balanced flows on the labor market, equilibrium labor demand from profit maximization by firms, and close the model with a rigid wage norm. The solution of the model is found at the intersection of the labor supply and demand curves in a tightness-employment diagram. We then calibrate the model to the US labor market over 1948–2019 and use the calibration to connect the model’s quantitative properties to evidence on unemployment, vacancies, tightness, and the Beveridge curve.

We find that the main driver of labor market fluctuations in the United States is a

labor demand shock moving labor productivity, not short-run movements in labor force: employment and tightness comove positively, as the model predicts under productivity shocks but not under labor force shocks. A modest amount of wage rigidity is enough to amplify productivity shocks into realistic movements in tightness, unemployment, and vacancies. We also emphasize that fluctuations in the model—and in modern US data—work primarily through fluctuations in the job-finding rate rather than fluctuations in job separations.

Finally, we show that although matching frictions are central to the framework, not all unemployment is frictional in the slackish model. That is, unemployment would not disappear if recruiting costs vanished or unemployed workers searched infinitely hard for jobs. While all unemployment is frictional in good times, frictional unemployment falls as rationing unemployment grows in bad times. In the calibration, when total unemployment reaches 10%, rationing unemployment amounts to 6.0% while frictional unemployment is only 4.0%.

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