Practice Problems for the DMP Model*

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*These problems are based on the model presented in our paper *Revisiting Unemployment in Intermediate Macroeconomics: A New Approach for Teaching Mortensen-Pissarides*. Email addresses: arghyab@uci.edu, pjackso1@uci.edu, and bcjenkin@uci.edu.

1 Empirical Problems

The following questions are based on US labor market data available at:

http://www.briancjenkins.com/dmp-model/data/beveridge_curve_data.csv

These questions are designed to be answered using a spreadsheet tool like Microsoft Excel or Google Sheets.

1. The unemployment rate is the ratio of unemployed persons to the labor force. Create a new column containing the unemployment rate expressed as a percentage.[1]
   (a) Construct a well-labeled line plot of the unemployment rate for the US.
   (b) In which month and year was the unemployment rate in the US the highest? What was the value of the unemployment rate in that month?
   (c) In which month and year was the unemployment rate in the US the lowest? What was the value of the unemployment rate in that month?
   (d) What is the average rate of unemployment for the US?
2. Labor market tightness is the ratio of job vacancies to the number of unemployed persons. Create a new column containing labor market tightness expressed as a simple ratio.[2]
   (a) Construct a well-labeled line plot of labor market tightness rate for the US.
   (b) In which month and year was labor market tightness in the US the highest? What was the value of labor market tightness in that month?
   (c) In which month and year was labor market tightness in the US the lowest? What was the value of labor market tightness in that month?
   (d) What is the average labor market tightness for the US?
3. The Beveridge curve I. In this problem, you will look at the long-run behavior of the unemployment rate and labor market tightness in the US.
   (a) Using the unemployment rate and labor market tightness data that you've already constructed, make a well-labeled scatter plot with the unemployment rate on the horizontal axis and market tightness on the vertical axis. Set the limits for the x-axis to $[-0.5, 26]$ and set the limits for the y-axis to $[-0.5, 5]$.

[1] I.e., Unemployment rate $= \frac{\text{Unemployed}}{\text{Labor force}} \times 100$

[2] I.e., Labor market tightness $= \frac{\text{Vacancies}}{\text{Unemployed}}$

(b) Based on the figure that you created in the previous question, describe in words the apparent relationship between labor market tightness and the unemployment rate.

4. The Beveridge curve II. In this problem, you will look at the behavior of the unemployment rate and labor market tightness in the US over the Great Recession of 2007-09 and the subsequent recovery.

   (a) Between December 2007 and August 2016, in which month and year was the unemployment rate in the US the highest? What was the value of the unemployment rate in that month?

   (b) Between December 2007 and August 2016, in which month and year was the unemployment rate in the US the lowest? What was the value of the unemployment rate in that month?

   (c) Make a well-labeled scatter plot with the unemployment rate on the horizontal axis and labor market tightness on the vertical axis using only data from December 2007 through August 2016. Set the limits for the x-axis to $[4, 11]$ and set the limits for the y-axis to $[4, 0.5]$.

   (d) From December 2007 through August 2016, did the plotted unemployment rate-market tightness combinations move in a clockwise or counterclockwise direction?

2 Multiple choice questions

1. If A represents the efficiency of the matching process, U is the number of unemployed, and V is the number of vacancies, then which of the following matching functions is NOT constant returns to scale?

   (a) $H(U,V) = A\min\{U,V\}$ (Leontief)

   (b) $H(U,V) = A\frac{UV}{U+V}$

   ✓(c) $H(U,V) = AUV$ (Quadratic)

   (d) $H(U,V) = A\sqrt{UV}$

2. The Beveridge curve is a(n) ______ relationship between ______ and ______.

   (a) increasing; market tightness (θ), real wage rate (w)

   (b) decreasing; market tightness (θ), real wage rate (w)

   (c) increasing; market tightness (θ), unemployment rate (u)

   ✓(d) decreasing; market tightness (θ), unemployment rate (u)

3. The vacancy supply curve is a(n) ______ relationship between ______ and ______.

   (a) increasing; market tightness (θ), real wage rate (w)

   ✓(b) decreasing; market tightness (θ), real wage rate (w)

   (c) increasing; market tightness (θ), unemployment rate (u)

   (d) decreasing; market tightness (θ), unemployment rate (u)

4. The wage setting curve is a(n) ______ relationship between ______ and ______.

   ✓(a) increasing; market tightness (θ), real wage rate (w)

   (b) decreasing; market tightness (θ), real wage rate (w)

   (c) increasing; market tightness (θ), unemployment rate (u)

   (d) decreasing; market tightness (θ), unemployment rate (u)

5. Which of the following shifts the Beveridge curve?

   (a) Cost of opening a vacancy, κ

   (b) Worker's productivity, y

   ✓(c) Separation rate, λ

(d) Worker's bargaining power, β

6. As the economy grows and occupations become more specialized, matching between workers and firms become less efficient. This affects the parameter ______, which graphically leads to a shift in ______.

   (a) κ; vacancy supply curve and wage setting curve

   (b) κ; vacancy supply curve

   (c) A; Beveridge curve

   ✓(d) A; Beveridge curve and vacancy supply curve

7. If λ is the separation rate and f the job finding rate, then in a steady state equilibrium, the unemployment rate u satisfies

   (a) λ/f

   (b) $\frac{f}{\lambda+f}$

   ✓(c) $\frac{\lambda}{\lambda+f}$

   (d) $\frac{\lambda}{\lambda+1}$

8. Consider a variation of the Diamond-Mortensen-Pissarides model where labor force, L is growing at a constant rate n, with entrants starting off unemployed. In the steady state equilibrium for this model, the unemployment rate, u satisfies

   ✓(a) $\frac{\lambda+n}{\lambda+f}$

   (b) $\frac{\lambda}{\lambda+f+n}$

   (c) $\frac{\lambda}{\lambda+f}$

   (d) $\frac{f}{\lambda+f+n}$

9. If the separation rate is 0.02 and the job finding rate is 0.08 but the current unemployment rate is 0.10, then the current unemployment rate is ______ the equilibrium rate, and in the next period it will move ______ the equilibrium rate.

   ✓(a) above; toward

   (b) above; away from

   (c) below; toward

   (d) below; away from

10. A policy that decreases the job separation rate ______ the vacancy supply curve and ______ the Beveridge curve

✓(a) shifts out, shifts out

(b) shifts out, shifts in

(c) shifts in, shifts out

(d) shifts in, shifts in

11. Suppose that at the time a job is terminated, the firm must pay a *one-time* tax called the *firing tax*. One can think of this tax as severance payment, or it can also comprise of administrative costs to dismiss a worker (forms to fill, advance notice, etc.) Let F denote the firing tax. The equation for the vacancy supply condition of the search-matching model of unemployment becomes:

(a) $\kappa = q\left[\frac{y-w}{s-F}\right]$

✓(b) $\kappa = q\left[\frac{y-w}{s} - F\right]$

(c) $\kappa - F = q\left[\frac{y-w}{s}\right]$

(d) $\kappa = q\left[\frac{y-w-F}{s}\right]$

12. Consider the search-matching model of unemplpyment with efficiency wage considerations. In such a model worker's productivity depends on the wage. For example, to a certain degree better pay might make workers more loyal to their employer, reduce absenteeism and improve their productivity. The labor productivity is expressed as a function of the real wage in the following fashion

$$y(w) = (1+\bar{y})w - w^2/2$$

The profit-maximizing value of w is:

(a) $w^* = 1+\bar{y}$

✓(b) $w^* = \bar{y}$

(c) $w^* = 2\bar{y}$

(d) $w^* = 0$

13. Henry Ford decided to double the wages of Ford Motor Company workers to $5 a day in 1914. Following the wage increase,

- (a) Job turnover and layoffs increased
- (b) Job turnover increased, but layoffs decreased
- (c) Job turnover decreased, but layoffs increased
- ✓(d) Job turnovers and layoffs decreased

14. Any policy aimed at lowering the steady-state rate of unemployment must either ______ the rate of job separation or ______ the rate of job finding

    - (a) reduce; reduce
    - (b) increase; increase
    - ✓(c) reduce; increase
    - (d) increase; reduce

15. In the search-matching model of unemployment, an increase in unemployment benefits shifts the wage-setting curve to the ______, leading to ______ wages ______ unemployment.

    - (a) left; higher; lower
    - (b) right; lower; higher
    - (c) left; lower; lower
    - ✓(d) right; higher; higher

16. In the search-matching model of unemployment, an increase in workers' bargaining power leads to ______, leading to ______ wages, ______ market tightness, and ______ unemployment.

    - ✓(a) higher; lower; higher
    - (b) higher; higher; higher
    - (c) lower; higher; higher
    - (d) lower; higher; lower

17. Suppose that the real wage is equal to $w = \beta y + (1 - \beta)b$. Moreover, unemployment benefits are proportional to wages, $b = \rho w$ with $0 < \rho < 1$. (The coefficient ρ is called the replacement ratio.) Then the closed for expression for the wage is:

    - ✓(a) $w = \frac{\beta}{1-(1-\beta)\rho} y$
    - (b) $w = \frac{\beta}{(1-\beta)\rho} y$

(c) $w = \frac{\beta\rho}{1-(1-\beta)\rho} y$

(d) $w = \beta\rho y$

18. Suppose that the recruiting cost, κ, is proportional to wages, $\kappa = cw$. (This can be justified by the fact that recruiting requires labor.) Suppose that the wage is determined as in the question above. Assuming the matching funcrion, $H(U, V) = A\sqrt{UV}$, equilibrium market tightness is:

✓(a) $\theta = \left[\frac{A(1-\beta)(1-\rho)}{c\beta\lambda}\right]^2$

(b) $\theta = \left[\frac{A\beta(1-\rho)}{c\beta\lambda}\right]^{1/2}$

(c) $\theta = \left[\frac{A(1-\beta)}{c\beta\lambda\rho}\right]^2$

(d) $\theta = \left[\frac{A(1-\beta)(1-\rho)}{c\beta\lambda\rho}\right]^{1/2}$

19. Under the assumptions of Q 18, an increase in labor productivity, y, leads to:

(a) an increase in market tightness and a decrease in unemployment

(b) a decrease in market tightness and a increase in unemployment

(c) no effect on market tightness but a decrease in unemployment

✓(d) no effect on market tightness or unemployment

20. In the search model of unemployment, suppose the government imposes a tax τ on filled jobs, and the wage is fixed at $\bar{w}$. This cases a(n) ______ in θ and a(n) ______ in u.

(a) increase; increase

(b) increase; decrease

✓(c) decrease; increase

(d) decrease; decrease

21. What is the equilibrium market tightness in Q 20?

(a) $\left[\frac{A(y-w)}{\lambda\kappa}\right]^2$

(b) $\frac{A(y-w)}{\lambda\kappa}$

✓(c) $\left[\frac{A(y-\tau-w)}{\lambda\kappa}\right]^2$

(d) $\frac{A(y-\tau-w)}{\lambda\kappa}$

22. In the Diamond-Mortensen-Pissarides model of unemployment equilibrium wage rate is determined by the

   (a) intersection of the labor demand and labor supply curves

   (b) Beveridge curve

   ✓(c) intersection of vacancy supply and wage setting curve

   (d) marginal product of labor

23. Suppose L denotes the size of the labor force, U the number of unemployed people, λ denotes the separation rate and f denotes the job finding rate. The change in number of unemployed over time, ΔU, is equal to

   ✓(a) $\lambda(L - U) - fU$

   (b) $f(L - U) - \lambda U$

   (c) $fU - \lambda(L - U)$

   (d) $\lambda U - f(L - U)$

24. In the steady state of Diamond-Mortensen-Pissarides model of unemployment:

   (a) no hiring or firings are occurring.

   ✓(b) the number of people finding jobs equals the number of people losing jobs

   (c) the number of people finding jobs exceeds the number of people losing jobs

   (d) the number of people losing jobs exceeds the number of people finding jobs

25. Consider a model where $H(U, V) = \sqrt{UV}$. Wages are negotiated between firm and employee. An increase in unemployment benefits will

   (a) Increase wages, decrease unemployment

   (b) Decrease wages, decrease unemployment

   ✓(c) Increase wages, increase unemployment

   (d) Decrease wages, increase unemployment

26. Consider the matching function $H(U, V) = AUV$. The job finding rate is equal to:

   (a) $A\sqrt{V/U}$

   (b) AV/U

   ✓(c) AV

(d) $A\sqrt{U/V}$

27. The urn-ball matching function takes the following form: $H(U, V) = V\left(1 - e^{-\frac{U}{V}}\right)$

✓(a) Yes

(b) No

28. Consider the matching function $H(U, V) = AUV$. Does this function exhibit constant returns to scale?

(a) Yes

✓(b) No

3 Free response questions

1. High unemployment rates in European countries relative to the U.S. are often blamed on the high tax rates that prevail in Europe. Consider the model of unemployment described in the lecture and assume that the real wage w is fixed. The government introduces a tax τ paid by each filled job.

   (i) How does this tax affect the vacancy supply condition?

   (ii) How does it affect equilibrium unemployment? (Justify your answer with a graphical representation of the equilibrium)

2. During the last recession, unemployment insurance (UI) benefits have been extended. In addition to the 26 weeks of UI benefits, up to 73 weeks of additional benefits have been available. The object of this question is to understand the effects of such policy on economic activity and unemployment.

   We adopt the following functional form for the matching function: $H(U, V) = AV$. (In a depressed labor market the number of hires depends only on the stock of vacancies.) We denote f the job finding rate, λ the separation rate, and $\theta = V/U$ market tightness (number of vacancies per unemployed).

   (i) Find the expression for job finding rate and the equilibrium unemployment rate as functions of market tightness.

   (ii) The cost to open a vacancy is κ. Worker's productivity is y and real wage is w. Firms open vacancies until their expected profits net of the cost of entering the labor market is zero.

   Write the free entry condition (or vacancy supply condition).

   (iii) The wage is negotiated between a worker and a firm. The outcome of the negotiation is:

   $$w = \frac{y + b + \theta\kappa}{2}$$

   where $b < y$ is the level of unemployment benefits. Use this wage equation and the free entry condition from (ii) to find the closed form expression for θ. (We assume that $y - b > \frac{2\lambda\kappa}{A}$ so that $\theta > 0$).

   (iv) How does an increase in unemployment benefits affect market tightness, the real wage, and unemployment? Illustrate graphically your answer.

3. Consider the search-matching model of unemployment. Assume that a dysfunctional credit market implies a higher cost to set up a job and open a vacancy. The cost to open a vacancy is denoted by κ. The matching function in the labor market is $H(U, V) = \sqrt{U}\sqrt{V}$, where U is the number of unemployed workers and V the number of vacancies. The letters λ, f and q have their usual meaning.

   (i) Find the expression for the equilibrium unemployment rate as a function of market tightness. (Recall that market tightness is defined as the number of vacancies per unemployed , $\theta = V/U$.)

   (ii) Represent graphically the determination of the equilibrium of the labor market.

   Explain how an increase in κ affects the equilibrium conditions and the unemployment rate.

4. **Skills Biased Technological Change:** This exercise uses the DMP framework to study the effects of "skills biased technological change", the idea that technological progress can be more beneficial for some groups of workers relative to others. To do so, we will assume that there are two different types of workers. One group are "low skilled", while the others are "high skilled". You can think of the low skill workers as those with routine jobs, such as working on an assembly line. High skill workers can be thought of as engineers, programmers, etc. Assume that there is an equal number of each type of worker, and that the size of each group is constant over time.

   Firms create vacancies that are intended for one type of worker. That is, firms must decide if they would like to hire a low or high skilled worker. There is a matching function for each type of worker. The number of matches between firms and low skilled workers is given by $m_l = m(u_l, v_l)$ where u_l is the number of unemployed, low skilled, workers and v_l is the number of vacancies created to hire low skilled workers. Likewise, the number of matches between firms and high skilled workers if given by $m_h = m(u_h, v_h)$. We will assume that the matching functions m_l and m_h satisfy the standard properties from the baseline DMP model.

   When a firm hires an low skilled worker, they produce output y in a match. When a firm hires a high skilled worker, they produce ηy in a match where $\eta > 1$. For example, if $\eta = 2$, then high skilled workers are two times more productive than low skilled workers.

All other elements of the baseline model model are unchanged: firms pay κ to fill a vacancy intended for either type of worker, each type of worker receives b in unemployment benefits while unemployed, both types of jobs are destroyed with probability λ, and both types of workers have bargaining power β.

(i) Define market tightness, and both the job finding and vacancy filling probabilities for each type of worker.

(ii) Write down the law of motion of unemployment for each type of worker and find the long run (steady-state) unemployment rate for each type of worker.

(iii) Describe in words the free entry condition, and write it for the two different types of jobs in the economy.

(iv) Suppose that each worker earns a wage w_l and w_h as described in the baseline DMP model. Write the wage for each type of worker.

(v) Draw a graph that determines the equilibrium wage, market tightness, and unemployment rate for each type of worker. Which type of worker has a lower unemployment rate?

(vi) Now suppose that there is a technological development which makes highly skilled workers even more productive relative to low skilled workers, i.e. η increases. Explain the effect of this change on the following:

   (a) Wages w_l and w_h.

   (b) The gap between wages, $w_h - w_l$.

   (c) The unemployment rate of low and high skilled workers.

   (d) The average unemployment duration of low and high skilled workers.

(vii) Assume that the output in a match with a low skilled worker is given by y/η. So, if η increases, the output in a match with low skilled workers will decrease. The output in a match with a high skilled worker is unchanged. Redo part (vi) under this assumption. Are there any new effects of an increase in η relative to what you found in part (vi)? Interpret your findings.