17. Search and Matching

Steady State

Yvan Becard
PUC-Rio

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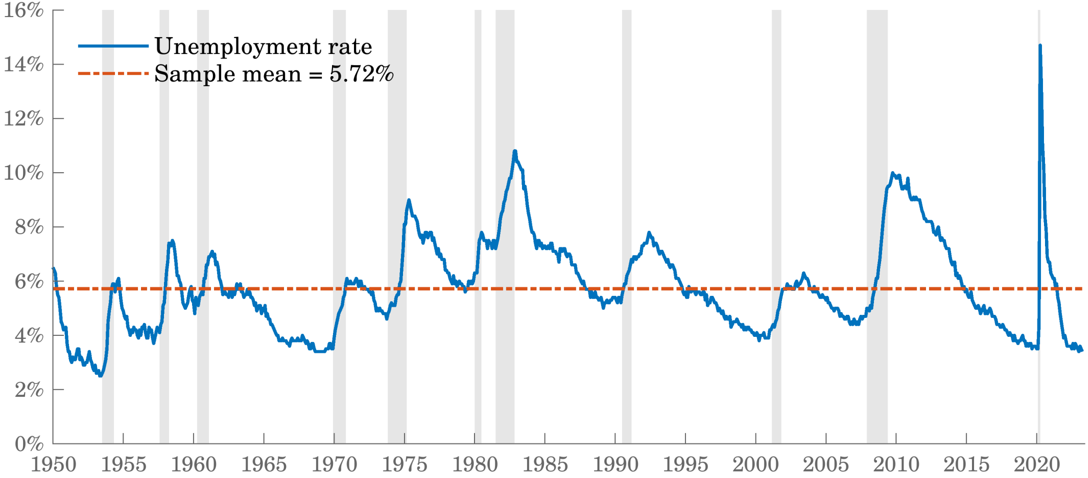
Something Is Missing

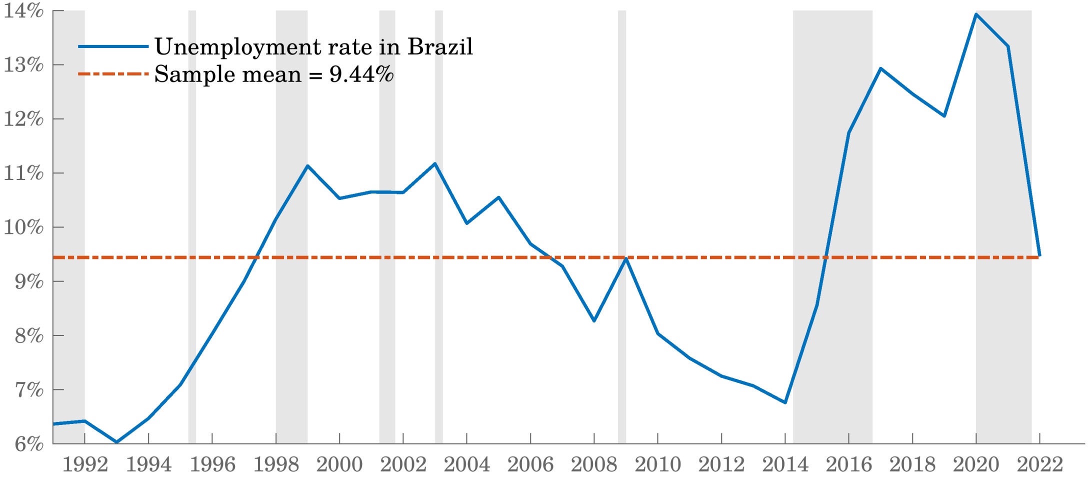
- We have studied two workhorses in macroeconomics
  - The neoclassical growth model, also known as the RBC model
  - The overlapping generations or OLG model
- In both environments, markets are competitive: in the labor market, the equilibrium wage ensures that labor supply always equal labor demand
- Thus unemployment is absent from these models

Unemployment in the United States



Source: US Bureau of Labor Statistics

Unemployment in Brazil



Source: World Bank

Unemployment

- Unemployment is a defining feature of modern economies: at all times a sizable fraction of the working-age population is involuntary unemployed
- Unemployment is countercyclical: it goes up in bad times, down in upturns
- Unemployment is bad for people: it can lead to loss of income, financial distress, poverty, anxiety, stress, depression, drugs, crime
- Unemployment is bad for society: lost of output, waste of resources, drain on government finances, migration, social tension

Working Is Good

"Work keeps at bay three great evils: boredom, vice, and need."

Voltaire, 1759, *Candide*

Causes

- What causes unemployment? How can we reduce it?
- These questions have occupied economists for decades
- Many theories have been proposed over the years
- As of today there is no consensus

Another Workhorse

- Today we study what has become the dominant theory of the labor market: the so-called Diamond-Mortensen-Pissarides search and matching model
- It is a theory of equilibrium unemployment
- The model is named after contributions by Diamond (1982), Mortensen (1982), Pissarides (1985), and Mortensen and Pissarides (1994)
- All three economists got the 2010 Nobel Prize precisely for this theory

Lecture Outline

1. Model Setup
2. Steady-State Equilibrium
3. Comparative Statics
4. Theory Versus Data

Main Reference: Ljungqvist and Sargent. 2018. *Recursive Macroeconomic Theory*, Fourth Edition, Chapter 29

1. Model Setup

Workers

- There is a continuum of identical workers; normalize their measure to one
- Workers are infinitely-lived
- Workers are risk neutral

Preferences

- The objective of each worker is to maximize the expected discounted value of labor income and leisure
- The utility of an employed worker is the wage rate w
- The utility of an unemployed worker is z which can be interpreted as leisure or unemployment benefits
- Workers' discount factor is $\beta = (1+r)^{-1}$, where r is the interest rate

Firms

- There is a continuum of firms
- Firms have the same discount factor as workers, $(1+r)^{-1}$
- Why? Think of the firms as being owned by the workers
- With no loss of generality, each firm employs at most one worker

Production

- The production technology has only one input, labor
- The production technology has constant returns to scale
- Each employed worker produces y units of output
- y is output per worker, ie productivity

Vacancy

- A firm entering the economy must post a job vacancy to find a suitable worker for the job and create a match
- To post a vacancy, the firm pays a vacancy cost c in each period
- Think of hiring costs: recruiters' salary, job board fees, referral program
- After a match the firm's per-period earnings are $y - w$

Average Cost Per Hire in the United States

	25th percentile	Median	75th percentile	Mean
Non-executive	\$354	\$1,244	\$4,375	\$4,683
Executive	\$1,500	\$8,750	\$35,000	\$28,329

Source: Society for Human Resource Management (2022)

Exogenous Separation

- At each period, every match is destroyed with probability s
- We call s the separation rate
- s is exogenous

Zero Profit

- We assume free entry of firms
- This implies that as long as expected profit is positive, there are firms entering the economy, driving expected profit until it reaches zero
- Thus free entry results in the expected discounted profit of a firm that posts a costly vacancy being zero

Matching Function

- Let $M(u, v)$ be a matching function
- $M(u, v)$ is a measure of successful matches in a period
- u is the aggregate measure of unemployed workers
- v is the aggregate measure of vacancies
- $M(u, v)$ is increasing in both u and v, concave, homogeneous of degree one

Filling a Vacancy

- Let $\theta \equiv v/u$ be labor market tightness
- The higher is θ, the more difficult it is for a firm to find a worker
- Let $q(\theta)$ be the probability that a vacancy is filled

$$q(\theta) \equiv \frac{M(u,v)}{v} = M\left(\frac{u}{v}, 1\right) = M(\theta^{-1}, 1)$$

- The probability of filling a vacancy is
  - Increasing in the number of unemployed workers u
  - Decreasing in the number of vacancies v

Finding a Job

- The probability that an unemployed worker is matched is

$$\theta q(\theta) = \frac{v}{u}\frac{M(u,v)}{v} = \frac{M(u,v)}{u} = M\left(1, \frac{v}{u}\right)$$

- The probability of finding a job is
  - Increasing in the number of vacancies v
  - Decreasing in the number of unemployed workers u

In the Real World – Heterogeneity

- Finding a job or filling a vacancy is no easy task: it is typically decentralized, uncoordinated, time-consuming, costly, and uncertain
- It is nontrivial because of heterogeneity and frictions among workers and firms, which come from several sources
  - Skills offered by workers versus those required by firms
  - Information about jobs and candidates (insiders versus outsiders)
  - Location of jobs and workers
  - Timing of jobs' and workers' availability

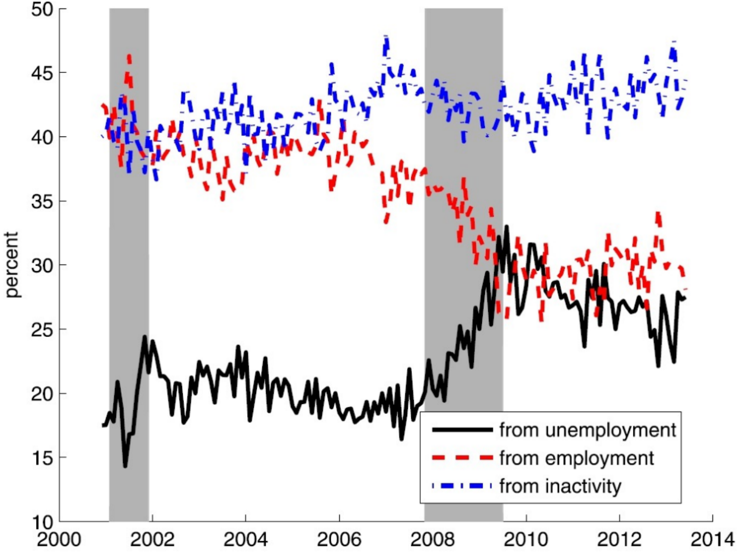
In the Real World – Uncertainty

- In the real world there is also uncertainty about the arrival of good jobs (workers) or goods workers (firms)
- Workers and firms have to decide whether to accept what is available or wait for a better alternative
- They can influence the arrival process itself by
  - Acquiring more information
  - Investing in education, retraining employees
  - Changing location

Matching

- The matching function is a modeling device that captures the implications of the costly and lengthy job hiring process
- But without the need to make frictions and heterogeneity explicit
- The matching function gives the outcome of the investment of resources by firms and workers as function of the inputs
- It is similar to an aggregate production function

Matching Function – Flows Into Employment



Source: Sedláček (2016)

Functional Form

- A common example of a matching function $M(u,v)$ is the Cobb-Douglas form

$$M(u,v) = Au^{\alpha}v^{1-\alpha}, \qquad A > 0,\ \alpha \in (0,1)$$

- This implies constant elasticities

$$\frac{\partial M(u,v)/M(u,v)}{\partial u/u} = -q'(\theta)\frac{\theta}{q(\theta)} = \alpha \quad \text{and} \quad \frac{\partial M(u,v)/M(u,v)}{\partial v/v} = 1-\alpha$$

- A rise in u increases matches by α; a rise in v increases matches by $1-\alpha$

2. Steady-State Equilibrium

Steady State

- Let us study first the stationary case
- In a steady state, the following two measures must be equal

$$\begin{aligned} \text{Employed workers being laid off} &= \text{Unemployed workers finding a job} \\ s(1-u) &= \theta q(\theta) u \end{aligned}$$

Unemployment

- The steady-state unemployment rate is thus

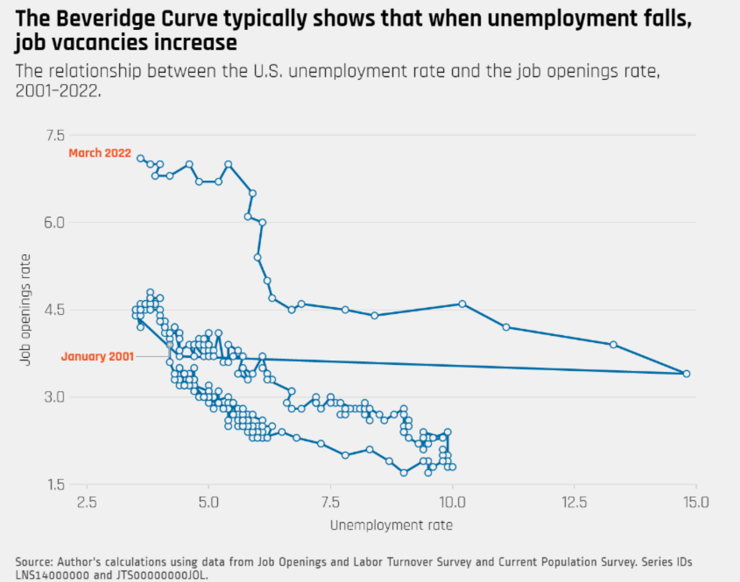
$$s(1-u) = \theta q(\theta) u \quad \Longrightarrow \quad u = \frac{s}{s + \theta q(\theta)} \tag{1}$$

- All other things being equal, the unemployment rate is
  - Increasing in the job separation rate s
  - Decreasing in labor market tightness $\theta = v/u$
  - Decreasing in the number of vacancies v

Beverage Curve

- The negative relationship between unemployment and job vacancies is called the Beveridge curve or UV curve
- The Beveridge curve was developed by Dow and Dicks-Mireau (1958) and named after British economist William Beveridge
- Beveridge never plotted the curve himself but was the first to discuss the link between u and v in 1944

Beveridge Curve in the US



Source: Equitable Growth (2022)

Model Beveridge Curve

- The search and matching model in steady state features a Beveridge curve

$$u = \frac{s}{s + \theta q(\theta)} = \frac{s}{s + M(1, \frac{v}{u})} \tag{1}$$

- All other things being equal, this equation predicts a negative relationship between u and v

Equilibrium Wage

- How do we determine the equilibrium value of the wage w?
- We turn to the situations faced by firms and workers
- We impose the no-profit condition for vacancies
- We impose Nash bargaining between a matched firm and worker

Nash Bargaining

- Nash bargaining refers to the solution of a simple two-player bargaining problem or game
- It is widely used in economics and game theory
- It was developed by US mathematician John Nash (1950, *Econometrica*)
- Nash won the economics Nobel prize in 1994 for his work on game theory (when he was a graduate student; see the movie *A Beautiful Mind* 2001)

Value Functions of Firms

- The firm's value of a filled job is

$$J = y - w + \beta[sV + (1-s)J]$$

- A filled job turns into a vacancy with probability s
- The firm's value of a vacancy is

$$V = -c + \beta\{q(\theta)J + [1-q(\theta)]V\}$$

- A vacancy turns into a filled job with probability $q(\theta)$

Job Creation

- Vacancies earn zero profits due to free entry, $V = 0$
- Therefore the previous equation becomes

$$J = \frac{c}{\beta q(\theta)}$$

- Plug this into the equation for J and solve for w

$$w = y - \frac{(r+s)c}{q(\theta)} \tag{2}$$

- This equation is referred to as the job creation condition

Cost Equals Benefit

- The wage rate w ensures that firms with vacancies break even in an expected present-value sense
- A firm's match surplus must be equal to $J = \frac{c}{\beta q(\theta)}$ in order for the firm to recoup its average cost of filling a vacancy
- We obtain the same condition if we equalize cost and expected benefit

$$c = \frac{q(\theta)}{1+r} \sum_{t=0}^{\infty} \left(\frac{1-s}{1+r} \right)^t (y-w) = q(\theta) \frac{y-w}{r+s}$$

Labor Demand

- Repeat the job creation condition

$$w = y - \frac{(r+s)c}{q(\theta)} \tag{2}$$

- The job creation condition in the search-and-matching model replaces the usual labor demand equation in competitive labor market models, $w = F_L$
- Firms can afford to pay a higher wage the
  - Higher the productivity of a worker y
  - Lower the vacancy cost c or interest rate r
  - Higher the probability of filling the vacancy $q(\theta)$
  - Lower labor market tightness θ

Value Function of Workers

- The value of an employed worker is

$$E = w + \beta[sU + (1-s)E]$$

- An employed worker loses her job with probability s
- The value of an unemployed worker is

$$U = z + \beta\{\theta q(\theta)E + [1-\theta q(\theta)]U\}$$

- An unemployed worker finds a job with probability $\theta q(\theta)$

Match Surplus

- The match between a firm and a worker generates a surplus
- The worker's share of the match surplus is $E - U$
- The firm's share of the match surplus is $J - V = J$ (free entry means $V = 0$)
- Let S be the total match surplus

$$S = (E - U) + J$$

- Let's see how S is shared between firm and worker

Nash Product

- The product of the two excess utilities is the Nash product
- The total surplus is shared according to the Nash product

$$\max_{(E-U),\, J} (E-U)^{\phi} J^{1-\phi}$$

$$\text{subject to} \quad S = E - U + J$$

- $\phi \in (0,1)$ is the worker's bargaining strength, ie her weight in the Nash product; if $\phi = 1$ all the bargaining power goes to the worker

Nash Solution

- Solving the Nash bargaining problem, ie deriving with respect to $E - U$ and J, gives us the Nash solution

$$E - U = \phi S \qquad \text{and} \qquad J = (1 - \phi) S$$

- Or equivalently

$$E - U = \frac{\phi}{1 - \phi} J$$

Wage

- Solve equation $E = w + \beta[sU + (1-s)E]$ for E

$$E = \frac{(1+r)w + sU}{r+s}$$

- Solve equation $J = y - w + \beta[sV + (1-s)J]$ for J

$$J = \frac{(1+r)(y-w)}{r+s}$$

- Plug these two into the Nash solution $E - U = \phi/(1-\phi)J$

$$w = \frac{r}{1+r}U + \phi\left(y - \frac{r}{1+r}U\right)$$

Annuity

- An annuity is a fixed sum of money paid to someone each year, typically for the rest of their life (life annuity)
- Suppose that X is an asset that pays annuity x each year

$$X = \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t x \quad \Longrightarrow \quad x = \frac{r}{1+r} X$$

- Therefore, $\frac{r}{1+r} U$ is the annuity value of being unemployed

Interpretation

- Repeat the equation for the equilibrium wage

$$w = \underbrace{\frac{r}{1+r}U}_{\text{Outside option}} + \underbrace{\phi\left(y - \frac{r}{1+r}U\right)}_{\text{Worker's share of match surplus}}$$

- The wage is equal to the outside option, ie the annuity $\frac{r}{1+r}U$, plus the worker's share ϕ of the one-period surplus

Annuity Value of Unemployment

- Solve $U = z + \beta\{\theta q(\theta)E + [1 - \theta q(\theta)]U\}$ for $E - U$

$$E - U = \frac{rU - (1+r)z}{\theta q(\theta)}$$

- Combine it with the solution $E - U = \frac{\phi}{1-\phi}J = \frac{\phi}{1-\phi}\frac{(1+r)c}{q(\theta)}$

$$\frac{r}{1+r}U = z + \frac{\phi\theta c}{1-\phi}$$

- This is the annuity value of being unemployed

Recap of the Model

- Firms' problem

(3) $$J = y - w + \beta[sV + (1-s)J] \implies J = \frac{1+r}{r+s}(y-w)$$

(4) $$V = -c + \beta\{q(\theta)J + [1-q(\theta)]V\} \implies J = \frac{(1+r)c}{q(\theta)}$$

- Workers' problem

(5) $$E = w + \beta[sU + (1-s)E] \implies E = \frac{(1+r)w + sU}{r+s}$$

(6) $$U = z + \beta\{\theta q(\theta)E + [1-\theta q(\theta)]U\} \implies E - U = \frac{rU - (1+r)z}{\theta q(\theta)}$$

- Nash bargaining

(7) $$E - U = \frac{\phi}{1-\phi}J$$

Equilibrium

- Combine (3) and (4) to retrieve the job creation condition

$$w = y - \frac{(r+s)c}{q(\theta)} \tag{8}$$

- Combine (3), (5), and (7)

$$w = \frac{r}{1+r}U + \phi\left(y - \frac{r}{1+r}U\right) \tag{9}$$

- Combine (4), (6), and (7)

$$\frac{r}{1+r}U = z + \frac{\phi\theta c}{1-\phi} \tag{10}$$

Wage Curve

- Combine the last two equations, (9) and (10), to obtain a wage curve

$$w = z + \phi(y - z + \theta c) \tag{11}$$

- Nash bargaining results in the worker being compensated for
  - Lost leisure z
  - A fraction ϕ of the firm's output in excess of z
  - A fraction ϕ of the vacancy cost c per unemployed worker that was saved due to the match

Labor Supply

- The wage curve is a positive relationship between w and θ

$$w = z + \phi(y - z + \theta c) \tag{11}$$

- Thus it can be seen as a labor supply equation: the more vacancies, the higher the wage demanded by workers

Demand and Supply

- Labor demand: from the firm's problem we derived a job creation condition, ie a negative relation between w and θ

$$w = y - \frac{(r+s)c}{q(\theta)} \tag{2}$$

- Labor supply: from the two problems and Nash bargaining we got a wage curve, ie a positive relation between w and θ

$$w = z + \phi(y - z + \theta c) \tag{11}$$

Labor Market Equilibrium

- Combine labor demand and supply

$$y - z = \frac{r + s + \phi\theta q(\theta)}{(1-\phi)q(\theta)}c$$

- This equation determines equilibrium tightness θ and ensures that firms' and workers' shares of the match surplus are the outcome of Nash bargain

Stationary Equilibrium

A stationary equilibrium is a set of value functions $\{J, V, E, U\}$, a wage w, vacancies v, unemployed workers u, and tightness $\theta \equiv v/u$ such that

1. $\{J, V, E, U\}$ satisfy

$$
\begin{aligned}
J &= y - w + \beta[sV + (1-s)J] \\
V &= -c + \beta\{q(\theta)J + [1 - q(\theta)]V\} \\
E &= w + \beta[sU + (1-s)E] \\
U &= z + \beta\{\theta q(\theta)E + [1 - \theta q(\theta)]U\}
\end{aligned}
$$

Stationary Equilibrium

2. The wage w is determined through Nash bargaining

$$\max_{(E-U),J} (E-U)^{\phi} J^{1-\phi} \quad \text{subject to} \quad S = E - U + J$$

3. There is free entry of firms, $V = 0$
4. Workers finding a job equal workers losing their job

$$\theta q(\theta) u = s(1-u)$$

Non-Clearing Wage

- The wage no longer serves as the adjustment variable that clears the market, ie that equalizes demand and supply
- In other words, labor demand is not equal to labor supply: there are workers who don't find a job (and firms who don't find workers)
- The labor market is not competitive or Walrasian
- This is a model of equilibrium unemployment

Summary of Key Equilibrium Conditions

- The stationary equilibrium is a triple $\{u, \theta, w\}$ that satisfies three equations

A. Job creation or labor demand

$$w = y - \frac{(r+s)c}{q(\theta)} \tag{2}$$

B. Wage curve or labor supply

$$w = z + \phi(y - z + \theta c) \tag{11}$$

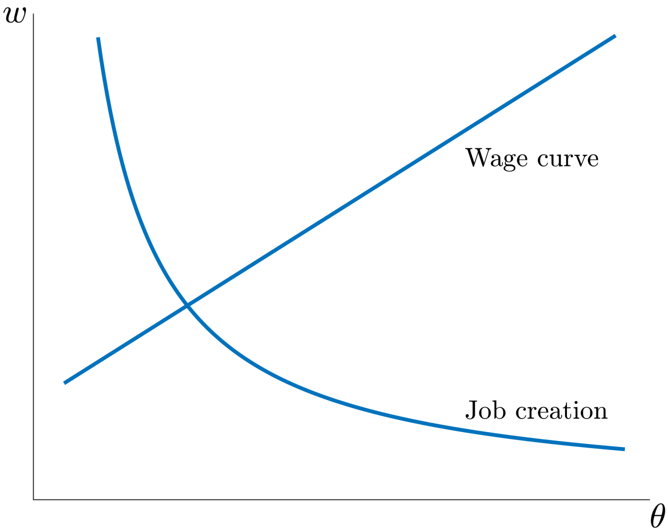
C. Beveridge curve

$$u = \frac{s}{s + \theta q(\theta)} = \frac{s}{s + M(1, \frac{v}{u})} \tag{1}$$

Labor Market Equilibrium

- We want to plot the previous these curves; for this we use two diagrams
- The first diagram is the tightness-wage chart (θ, w): job creation A and the wage curve B together determine the wage w and the ratio θ of v to u
- Job creation A slopes down (demand), it implies a negative θ-w relation
- The wage curve B slopes up (supply), it is a positive linear θ-w relation
- Equilibrium (θ, w) is at the intersection of the two curves and is unique
- The figure shows that the equilibrium θ is independent of unemployment

Labor Market Equilibrium

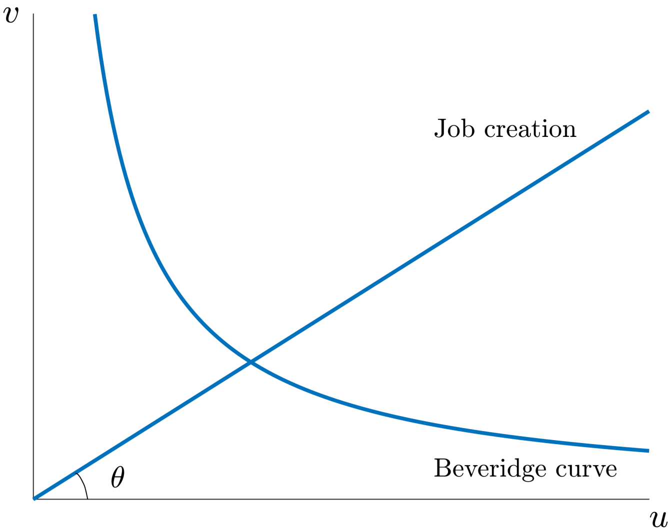


Beveridge Curve

- The second diagram is the Beveridge diagram (u, v)
- The Beveridge curve C implies a negative u-v relation and is convex to the origin by the properties of the matching technology
- Job creation is a line through the origin with positive slope θ
- To obtain θ, substitute the wage curve B into the job creation condition A

$$(1-\phi)(y-z) - \frac{r+s+\phi\theta q(\theta)}{q(\theta)}c = 0$$

Beveridge Curve



3. Comparative Statics

Experiments

- We are going to use the model to make some experiments
- We are in steady state, so a change in a parameter or variable brings us to another steady state, hence the term comparative statics
- As opposed to comparative dynamics where we shock the model and study its off-steady state properties

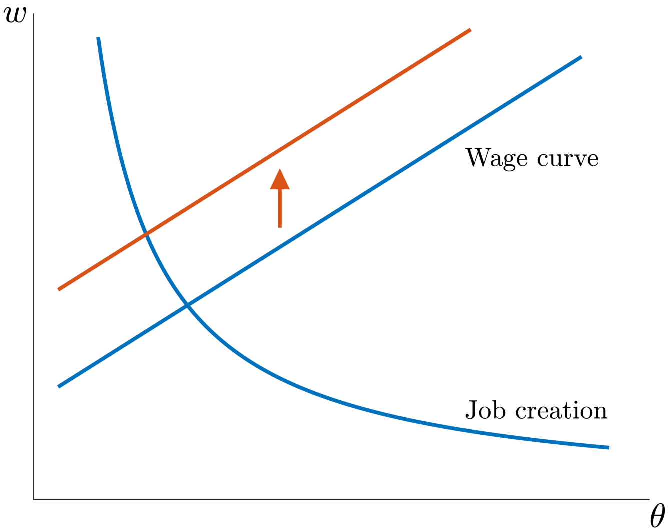
Increase in Unemployment Benefits

- Let's consider an increase in unemployment benefits z
- The increase in z directly affects the wage curve

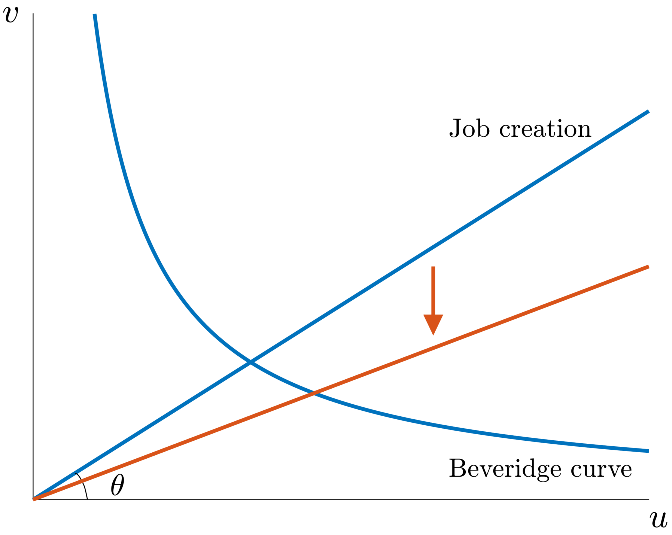
$$w = z + \phi(y - z + \theta c) \quad \Longrightarrow \quad \frac{\partial w}{\partial z} = 1 - \phi \geq 0$$

- The increase in z shifts the wage curve up as long as $\phi < 1$

Increase in Unemployment Benefits



Increase in Unemployment Benefits



Increase in Unemployment Benefits

- The outside option of workers z increases
- Workers ask for a higher wage, the wage curve shifts up
- Firms respond by reducing vacancies, creating fewer jobs
- Equilibrium tightness is lower, ie unemployment is higher

Increase in Separation

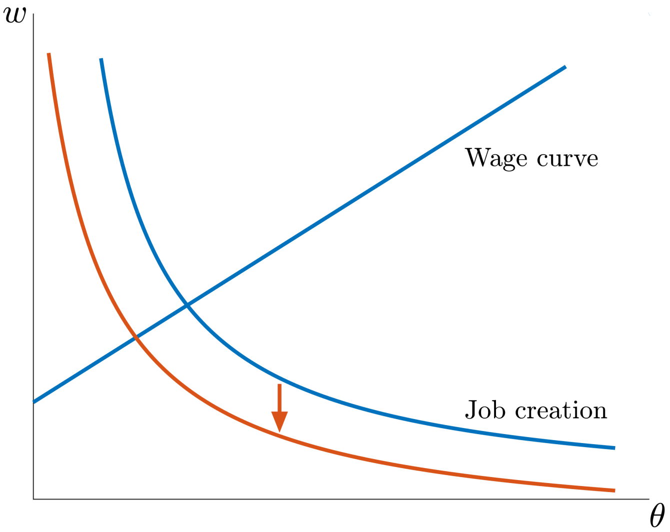
- Let's now consider an increase in the separation rate s
- The increase in s directly affects job creation by reducing w

$$w = y - \frac{(r+s)c}{q(\theta)} \quad \Longrightarrow \quad \frac{\partial w}{\partial s} = -\frac{c}{q(\theta)} < 0$$

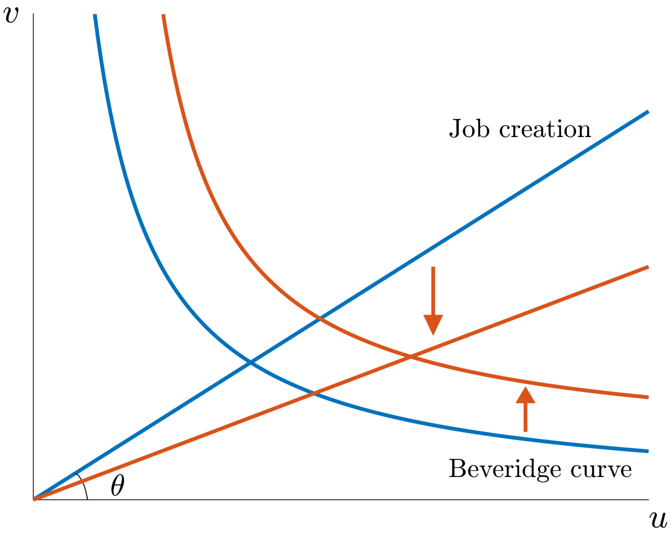
- The increase in s also shifts the Beveridge curve rightward

$$u = \frac{s}{s+\theta q(\theta)} \quad \Longrightarrow \quad \frac{\partial u}{\partial s} = \frac{\theta q(\theta)}{[s+\theta q(\theta)]^2} > 0$$

Increase in Separation



Increase in Separation



Increase in Separation

- More jobs are destroyed at each period
- Unemployment goes up, tightness goes down
- Firms have to post vacancies more often to refill jobs and thus must pay a higher cost upfront
- Thus they offer lower wages
- The effect on vacancies is ambiguous

Increase in Productivity

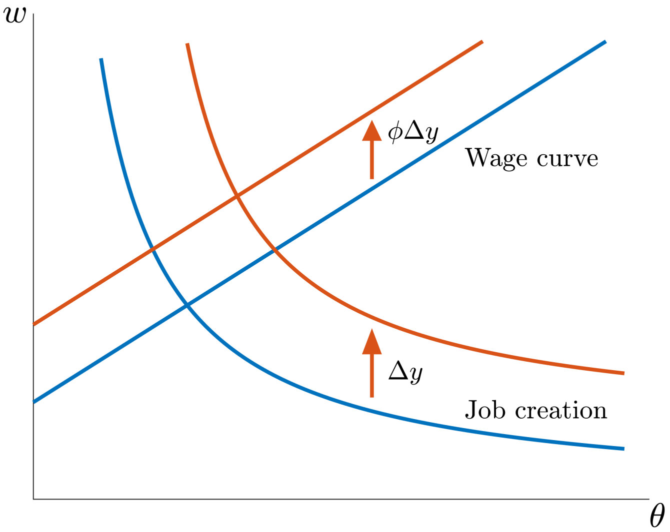
- We turn to an increase in productivity y
- This affects both job creation and the wage curve

$$w = y - \frac{(r+s)c}{q(\theta)}; \qquad w = z + \phi(y - z + \theta c)$$

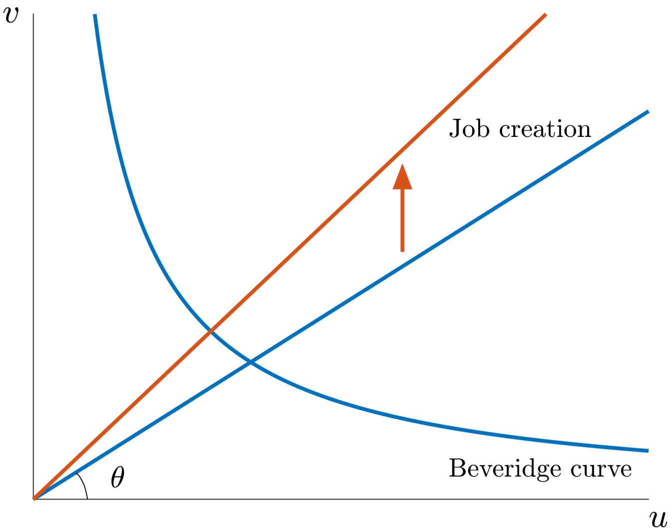
- The increase in y shifts both curves upward

$$\frac{\partial w}{\partial y} = 1; \qquad \frac{\partial w}{\partial y} = \phi$$

Increase in Productivity



Increase in Productivity



Increase in Productivity

- Workers are more productive
- Wages increase
- Firms open more vacancies
- Unemployment goes down
- Tightness goes up as a result

4. Theory Versus Data

Attractive Framework

- Search and matching theory is attractive for many reasons
  - It nicely describes how the labor market functions
  - It is analytically tractable
  - It has rich and intuitive comparative statics
  - It can easily be adapted to study labor market policy issues such as unemployment insurance
- But does the model fit the data?

The Shimer Puzzle

- Shimer (2005, *AER*) famously argues that the model cannot generate factual unemployment and vacancy fluctuations
- These are two central elements of the model
- This critique has been referred to as the Shimer puzzle

Model Versus Data

- Shimer collects data on US unemployment and vacancies
  - He detrends the data using a Hodrick-Prescott filter
  - He computes simple business-cycle statistics
- He extends the model to allow for aggregate fluctuations
  - He computes labor productivity shocks using US data
  - He feeds these shocks to the model out of steady state
  - He computes the same statistics implied by the model

Results

- Shimer reports results for US quarterly data, 1951–2003

		u	v	$\theta = v/u$
Data, standard deviation		0.190	0.202	0.382
Model, standard deviation		0.009	0.027	0.035
Data, autocorrelation		0.936	0.940	0.941
Model, autocorrelation		0.939	0.835	0.878
Data, correlation with	u	1.000	−0.894	−0.971
	v	–	1.000	0.975
	v/u	–	–	1.000
Model, correlation with	u	1.000	−0.927	−0.958
	v	–	1.000	0.996
	v/u	–	–	1.000

Comovements

- The model performs well along some dimensions
- The Beveridge curve holds, ie the negative u-v correlation is well captured
- Serial correlations are high as in the data

Volatility

- But the model fails dramatically on other aspects
- The volatility of u, v, and v/u is one order of magnitude too low
- The model provides little amplification: productivity shocks induce very small movements along the Beveridge curve
- Shimer also shows that shocks to the separation rate imply positive correlation between u and v, at odds with the data

Mechanism

- Why do u and v move so little after a productivity shock?
- Higher productivity increases the value of work versus leisure and thus makes unemployment less attractive
- It also decreases the relative cost of advertising a vacancy and thus increases the number of job postings by firms
- The result is higher v, lower u, as we observe in the data
- But that is not the end of the story

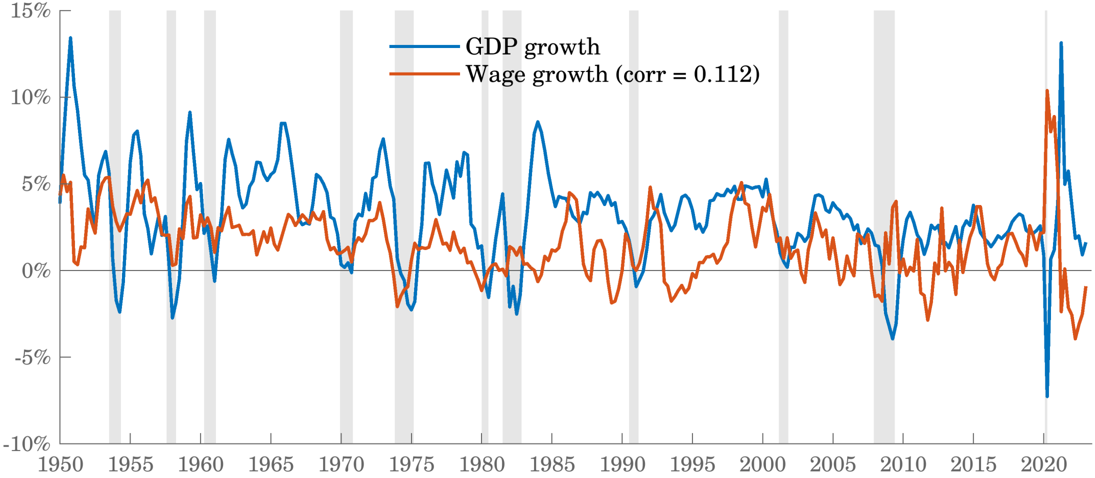
It's All in the Wage

- The increase in hiring shortens unemployment duration
- Worker's bargaining power rises, they negotiate a higher w
- Higher wages absorb most of the productivity increase
- This in turn eliminates the incentives for new vacancies
- The overall result is a large and positive effect on wages, but little impact on unemployment, vacancies, and job-finding rates

Lively Debate

- The Shimer puzzle sparked a lively debate in the literature
- Several papers have proposed "fixes" to the search and matching model so that it fits the data better
- The main issue is that the model wrongly generates
    - Volatile and procyclical wages
    - Nonvolatile unemployment and vacancies

US Wages Are Not Really Procyclical



Sources: US Bureau of Economic Analysis and US Bureau of Labor Statistics

Sticky Wages

- One solution proposed by the literature is to model rigid wages that respond less to shocks, sot that quantities (u, v) become more volatile
- Hall (2005) posits a wage norm $\hat{w}$ that must be paid to workers
- Menzio (2005) studies "firm-wage policy" where firms offer different wages to workers and strategically choose to be a low or high paying employers
- Hall and Milgrom (2008) replace Nash bargaining with alternating-offer bargaining in which firms and workers take turn making wage offers
- Gertler and Trigari (2009) propose staggered multiperiod wage contracting

Different Calibration

- Another solution is to change the calibration of the model
- Hagedorn and Manovskii (2008, *AER*) propose a new calibration strategy for the model's two central parameters
  - The value of leisure z
  - The worker's bargaining power ϕ

Shimer's Calibration

- Normalize productivity to unity, $y = 1$
- Shimer (2005) interprets z as an unemployment benefit and uses data on income replacement rates to set $z = 0.4y$
- To calibrate ϕ, Shimer estimates a matching function on monthly job finding and filling rates: he finds $\alpha = 0.72$ and sets $\phi = 0.72$

Non-Market Activity

- Hadegorn and Manovskii argue z should be much higher for three reasons

1. z represents the entire value of not working: leisure, home production, self-employment, unemployment benefits, welfare benefits
2. In a model with indivisible labor, a family chooses who works and who produces at home, so $y = z$ in equilibrium
3. Large and procyclical flows out-of-the-labor-force into employment suggest y is close to z for many people

- Based on all this they set $z = 0.95y$

Bargaining Power

- Hadegorn and Manovskii compute in the data
  - The capital and labor cost of posting vacancies
  - The elasticity of wages with respect to productivity
- They use these targets to calibrate the bargaining power of workers ϕ, which they set to $\phi = 0.052$

Results

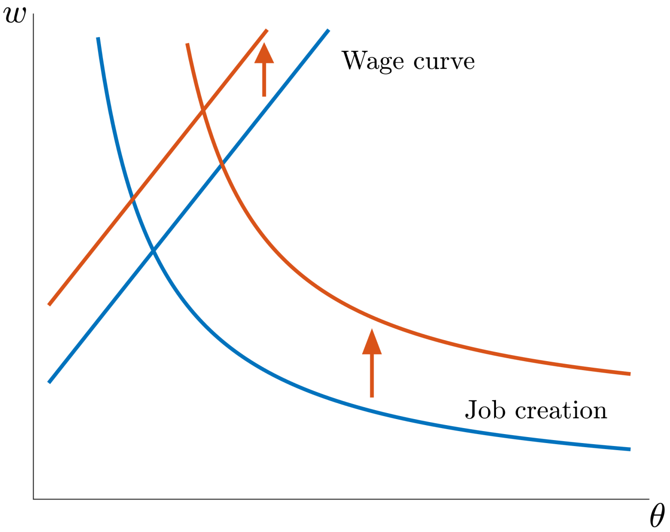
- Hagedorn and Manovskii (2008) find for 1951–2004 data

		u	v	$\theta = v/u$
Data, standard deviation		0.125	0.139	0.259
Model, standard deviation		0.145	0.169	0.292
Data, autocorrelation		0.870	0.904	0.896
Model, autocorrelation		0.830	0.575	0.751
Data, correlation with	u	1.000	-0.919	-0.977
	v	–	1.000	0.982
	v/u	–	–	1.000
Model, correlation with	u	1.000	-0.724	-0.916
	v	–	1.000	0.940
	v/u	–	–	1.000

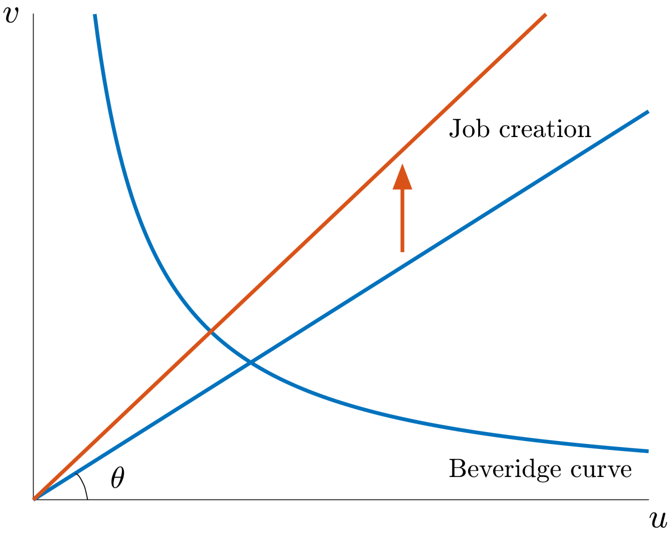
Puzzle Solved

- Data values differ because Hagedorn and Manovskii use a different smoothing parameter for the HP filter
- With this new calibration, the model generates factual volatility of unemployment, vacancy, and market tightness

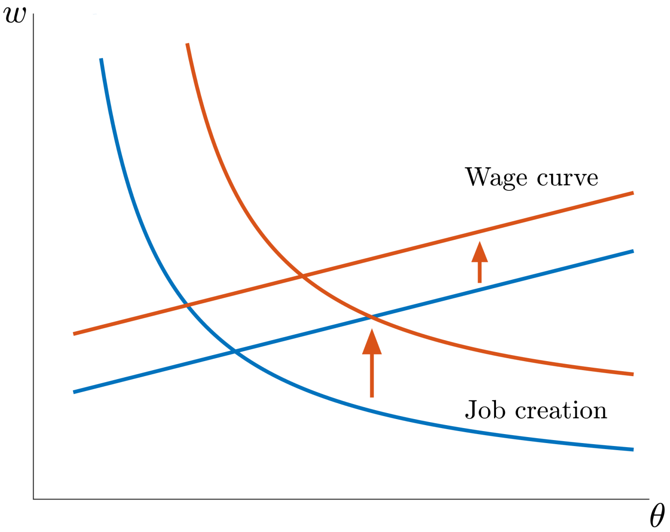
Shimer's Calibration



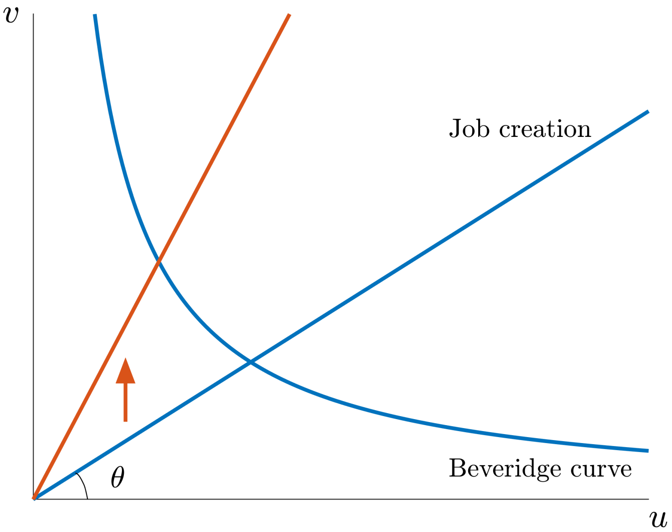
Shimer's Calibration



Hagedorn and Manovskii's Calibration



Hagedorn and Manovskii's Calibration



To Be Continued

- More about search and matching in lecture 18