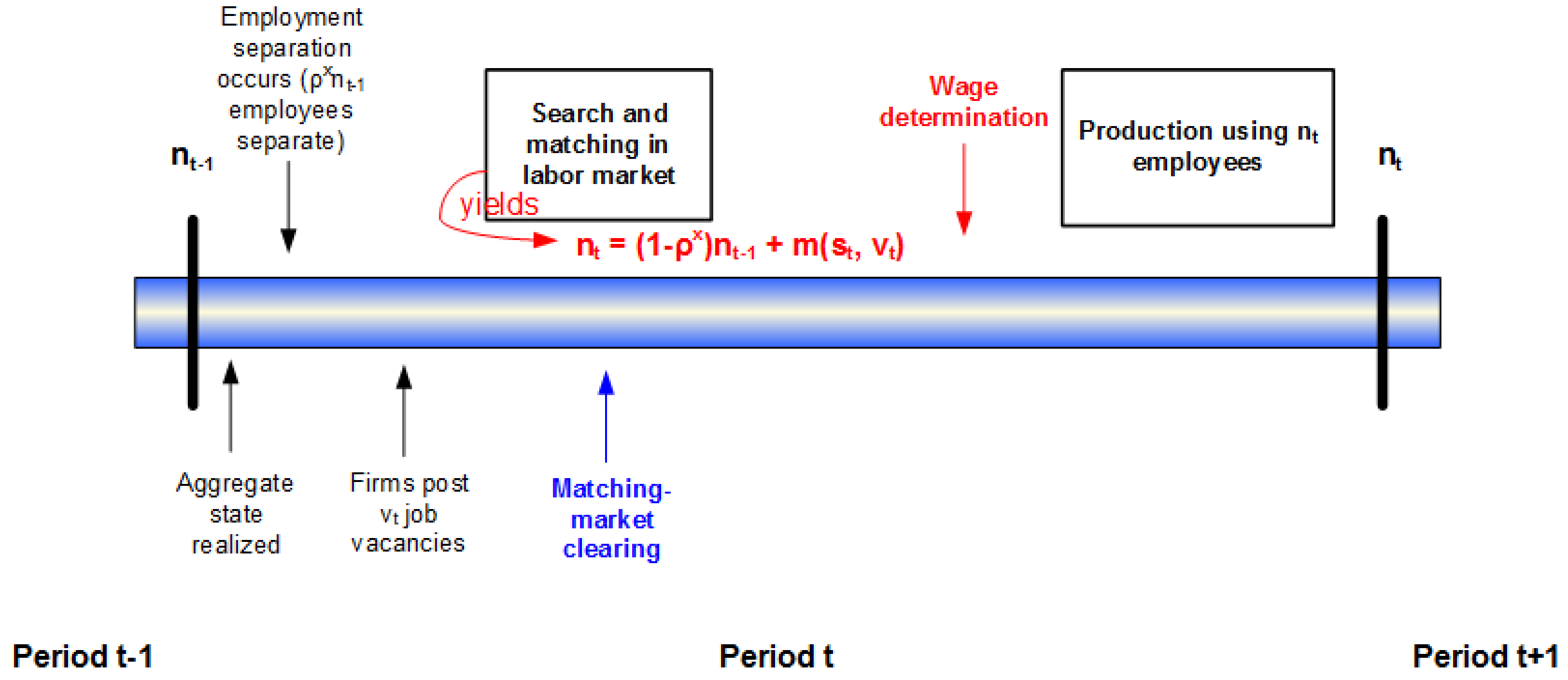
Matching Market Clearing

February 5, 2020

Timing of Events

- Matching market clearing …
- … then wage determination
- Focus just on extensive margin



LABOR SUPPLY (LFP)

- **Representative household**

$$\max_{c_t, n_t^s, s_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[u(c_t) - h\Big(\underbrace{\big(1-k_t^h\big)s_t + n_t^s}_{\equiv lfp_t} \Big) \right]$$

$$c_t = (1-\tau_t^n) w_t n_t^s + (1-k_t^h) s_t b$$

$$n_t^s = (1-\rho_x) n_{t-1}^s + s_t \cdot k_t^h$$

- $lfp_t = (1-k_t^h) s_t + n_t^s$

Labor Supply (LFP)

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- $lfp_t = (1-k_t^h)s_t + n_t^s$

- **Consumption-LFP optimality condition**

$$\frac{h'(lfp_t)}{u'(c_t)} = k_t^h (1-\tau_t^n) w_t + (1-k_t^h) \cdot b + k_t^h (1-\rho_x) E_t \left\{ \Xi_{t+1} \left(\frac{h'(lfp_{t+1}) - u'(c_{t+1}) b}{u'(c_{t+1})} \right) \cdot \left(\frac{1-k_{t+1}^h}{k_{t+1}^h} \right) \right\}$$

Value Equations

- Endogenous entry into matching market for workers?

- Endogenous LFP allows for richer analysis
  - How LFP responds to changes in ue benefits
  - How LFP responds to changes in taxes
  - Nests exogenous LFP model

NOTE: APART from their effects on wages

- Endogenize labor force participation (aka "labor supply")

- Value expressions for an atomistic individual's potential new job/potential new employee

$$\mathbf{W}_t = w_t + E_t\left\{\Xi_{t+1|t}\left[(1-\rho_x)\mathbf{W}_{t+1} + \rho_x\mathbf{U}_{t+1}\right]\right\}$$

$$\mathbf{U}_t = b$$

- Employment a state variable from household perspective
- Unemployment not a state variable from household perspective

LABOR SUPPLY (LFP)

- **Definition: Household optimality is a set of state-contingent functions for $\left\{c_t, s_t, n_t^s\right\}$ that satisfy**

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  - **Household budget constraint**

$$c_t = (1-\tau_t^n)w_t n_t^s + (1-k_t^h)s_t b$$

  - **Perceived law of motion of employment (aka job-finding constraint)**

$$n_t^s = (1-\rho_x)n_{t-1}^s + s_t \cdot k_t^h$$

taking as given exogenous processes $\left\{k_t^h, w_t, \tau_t^n\right\}$ and n_{-1}

Labor Demand (JC)

- **Representative firm**

$$\max_{v_t, n_t^D} E_0 \left[\sum_{t=0}^{\infty} \Xi_{t|0} \left(z_t f(n_t^D) - w_t n_t^f - \gamma v_t \right) \right]$$

$$\text{s.t. } n_t^D = (1-\rho_x) n_{t-1}^D + v_t k_t^f$$

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$$\text{s.t.} \quad n_t^D = (1-\rho_x) n_{t-1}^D + v_t k_t^f$$

- **Job-creation condition**

$$\frac{\gamma}{k_t^f} = z_t f'(n_t^D) - w_t n_t^D + (1-\rho_x) E_t \left\{ \Xi_{t+1|t} \frac{\gamma}{k_{t+1}^f} \right\}$$

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MATCHING MARKET CLEARING

- **Definition: Equilibrium optimality is a set of state-contingent functions $\{\theta_t, v_t, s_t, n_t, c_t\}$ that satisfies aggregate RC,**
  - **Consumption-LFP optimality condition**

$$\frac{h'\left((1-k^h(\theta_t))s_t + n_t^s\right)}{u'(c_t)} = k^h(\theta_t)(1-\tau_t^n)w_t + (1-k^h(\theta_t))\cdot b$$

$$+k^h(\theta_t)(1-\rho_x)E_t\left\{\Xi_{t+1}\left(\frac{h'(lfp_{t+1}) - u'(c_{t+1})b}{u'(c_{t+1})}\right)\cdot\left(\frac{1-k^h(\theta_{t+1})}{k^h(\theta_{t+1})}\right)\right\}$$

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  - **Aggregate LOM for employment**

$$n_t = (1-\rho_x)n_{t-1} + m(s_t, v_t)$$

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  - **AND…**

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$$n_t = (1-\rho_x)n_{t-1} + m(s_t, v_t)$$

  - **Matching-market clearing** $k^h(\theta_t)\cdot s_t = k^f(\theta_t)\cdot v_t = m(s_t, v_t)$

LABOR SUPPLY (LFP)

- **Consider $\rho_x = 1$, $b = 0$**
- **Definition: Household optimality is a set of state-contingent functions for $\{c_t, s_t, n_t^s\}$ that satisfy**

  - **Consumption-LFP optimality condition**

$$\frac{h'\left((1-k_t^h)s_t + n_t^s\right)}{u'(c_t)} = k_t^h(1-\tau_t^n)w_t$$

  - **Household budget constraint**

$$c_t = (1-\tau_t^n)w_t n_t^s$$

  - **Perceived "law of motion" of employment (aka job-finding constraint)**

$$n_t^s = s_t \cdot k_t^h$$

taking as given exogenous processes $\{k_t^h, w_t, \tau_t^n\}$ and n_{-1}

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$$n_t^s = s_t \cdot k_t^h \quad \Leftrightarrow \quad s_t = \frac{n_t^s}{k_t^h}$$

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$$\frac{h'\left(\frac{n_t^s}{k^h(\theta_t)}\right)}{u'(c_t)} = k(\theta_t)(1-\tau_t^n)w_t$$

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  - **Aggregate RC** $c_t + \gamma \cdot v_t = z_t f(n_t)$

  - **Consumption-LFP optimality condition**

$$\frac{h'\left(\frac{n_t}{k^h(\theta_t)}\right)}{u'(c_t)} = k^h(\theta_t)(1-\tau_t^n)w_t$$

  - **Job-creation condition**

$$\frac{\gamma}{k^f(\theta_t)} = z_t f'(n_t) - w_t$$

  - **Aggregate LOM for employment**

$$n_t = m(s_t, v_t)$$

  - **Matching-market clearing** $k^h(\theta_t) \cdot s_t = k^f(\theta_t) \cdot v_t = m(s_t, v_t)$

Matching Market Clearing

- **Definition: Equilibrium optimality is a set of state-contingent functions $\{\theta_t, v_t, s_t, n_t, c_t\}$ that satisfies**
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  - **Consumption-LFP optimality condition**

$$\frac{h'\left(\frac{n_t}{k^h(\theta_t)}\right)}{u'(c_t)} = k^h(\theta_t)(1-\tau_t^n)w_t$$

Solve for θ using hh job finding constraint

  - **Job-creation condition**

$$\frac{\gamma}{k^f(\theta_t)} = z_t f'(n_t) - w_t$$

Solve for θ using firm job hiring constraint

  - **Aggregate LOM for employment**

$$n_t = m(s_t, v_t)$$

  - **Matching-market clearing** $k^h(\theta_t)\cdot s_t = k^f(\theta_t)\cdot v_t = m(s_t, v_t)$

MATCHING MARKET CLEARING

- **Functional forms**

$$m(s_t, v_t) = s_t^{\alpha_n} v_t^{1-\alpha_n} \Rightarrow m_s(s_t, v_t) = \alpha_n s_t^{\alpha_n - 1} v_t^{1-\alpha_n} = \alpha_n \theta_t^{1-\alpha_n} \quad m_v(s_t, v_t) = (1-\alpha_n) s_t^{\alpha_n} v_t^{-\alpha_n} = (1-\alpha_n)\theta_t^{-\alpha_n}$$

$$k^h(\theta_t) = \theta_t^{1-\alpha_n} \qquad k^f(\theta_t) = \theta_t^{-\alpha_n}$$

$$f(n_t) = n_t^{\alpha} \Rightarrow f(n_t) = \alpha n_t^{\alpha-1}$$

$$h(lfp_t) = \frac{\psi_n}{1+1/\varphi_n} lfp_t^{1+1/\varphi_n} \Rightarrow h'(lfp_t) = \psi_n lfp_t^{1/\varphi_n} \qquad u(c_t) = c_t \Rightarrow u'(c_t) = 1$$

Matching Market Clearing

- Functional forms

$$m(s_t, v_t) = s_t^{\alpha_n} v_t^{1-\alpha_n} \Rightarrow m_s(s_t, v_t) = \alpha_n s_t^{\alpha_n - 1} v_t^{1-\alpha_n} = \alpha_n \theta_t^{1-\alpha_n} \quad m_v(s_t, v_t) = (1-\alpha_n) s_t^{\alpha_n} v_t^{-\alpha_n} = (1-\alpha_n)\theta_t^{-\alpha_n}$$

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$$\frac{h'\left(\frac{n_t}{k^h(\theta_t)}\right)}{u'(c_t)} = k^h(\theta_t) w_t \qquad \frac{\gamma}{k^f(\theta_t)} = z_t f'(n_t) - w_t$$

Substitute…(and set tax rate = 0)

MATCHING MARKET CLEARING

- **In (θ, n) space**

$$\psi_n \cdot \left(n_t \cdot \theta_t^{\alpha_n - 1}\right)^{1/\varphi_n} = \theta_t^{1-\alpha_n} w_t$$

$$\gamma = \theta_t^{-\alpha_n}\left(z_t \alpha n_t^{\alpha-1} - w_t\right)$$

...and solve for θ^{LFP} and θ^{JC}

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...and solve for θ^{LFP} and θ^{JC}

$$\theta_t^{LFP} = \left[\frac{w_t}{\psi_n \cdot n_t^{1/\varphi_n}}\right]^{-\frac{1}{(1-\alpha_n)(1+1/\varphi_n)}} \qquad \theta_t^{JC} = \left[\frac{z_t \alpha n_t^{\alpha-1} - w_t}{\gamma}\right]^{\frac{1}{\alpha_n}}$$

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- Arseneau and Chugh (2012 *JPE*, Proposition 1 (p. 950))
  - Efficient allocations characterized by

$$\left(MRS_{c_t, lfp_t} \equiv\right)\frac{h'(lfp_t)}{u'(c_t)} = \frac{\gamma \cdot m_s(s_t, v_t)}{m_v(s_t, v_t)}\left(\equiv MRT_{c_t, lfp_t}\right)$$

- Given functional forms, stated in (θ, n) space?...

MATCHING MARKET CLEARING

- **In (θ, n) space**

$$\psi_n \cdot \left(n_t \cdot \theta_t^{\alpha_n - 1}\right)^{1/\varphi_n} = \theta_t^{1-\alpha_n} w_t \qquad \gamma = \theta_t^{-\alpha_n}\left(z_t \alpha n_t^{\alpha-1} - w_t\right)$$

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- **Given functional forms, stated in (θ, n) space**

$$\theta_t^{LFP} = \theta_t^{JC}$$

Obvious in (decentralized equilibrium that supports...) efficient allocations....

Matching Market Clearing

- In (θ, n) space

$$\psi_n \cdot \left(n_t \cdot \theta_t^{\alpha_n - 1}\right)^{1/\varphi_n} = \theta_t^{1-\alpha_n} w_t \qquad \gamma = \theta_t^{-\alpha_n}\left(z_t \alpha n_t^{\alpha-1} - w_t\right)$$

...and solve for θ^{LFP} and θ^{JC}

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- Given functional forms, stated in (θ, n) space

$$\theta_t^{LFP,EFF} = \theta_t^{JC,EFF}$$

Obvious in (decentralized equilibrium that supports…) efficient allocations….

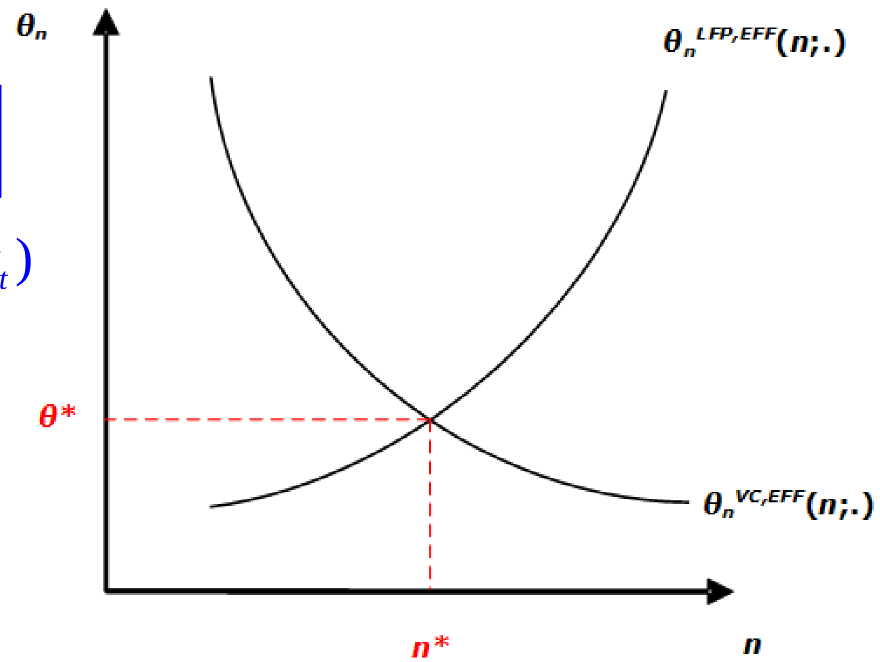
MATCHING MARKET CLEARING

- **Aggregate matching-market clearing**

Aggregate matching market clearing

$$k_t^h \cdot s_t = k_t^f \cdot v_t = m(s_t, v_t)$$

$$\equiv \text{new employees}_t$$



Matching Market Clearing

- ❒ **Aggregate matching-market clearing**
- ❒ **Experiment 1: labor income tax rate $\tau^n > 0$**

$$WEDGE_{n,\tau^n} \equiv \left| \int_{n^{LOW}}^{n^*} \left[\theta_n^{LFP,EFF}(n_i;\cdot) - \theta_n^{VC,EFF}(n_i;\cdot) \right] dn_i \right|$$

Aggregate matching market clearing

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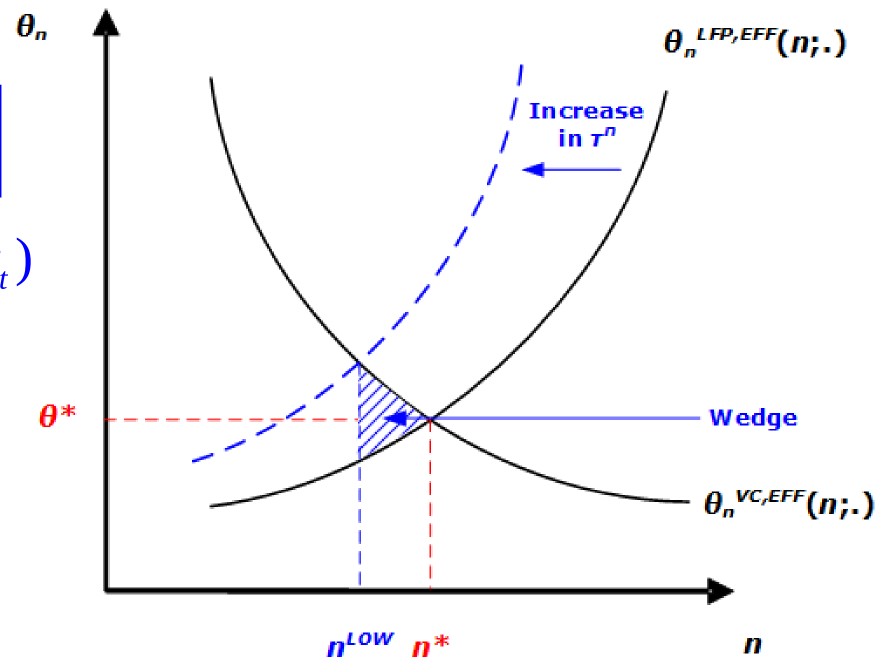


MATCHING MARKET CLEARING

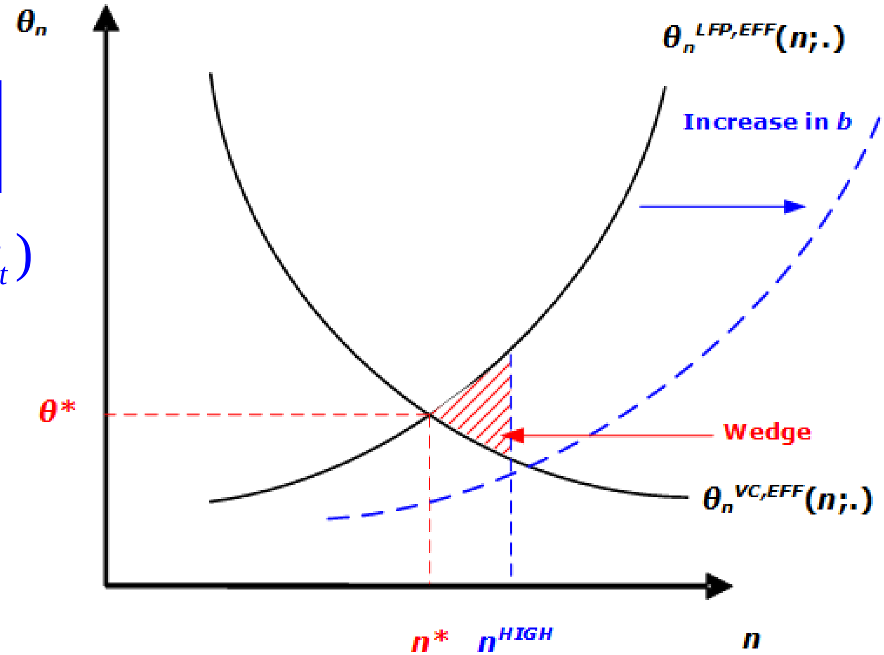
- Aggregate matching-market clearing
- Experiment 2: unemployment benefit *b* > 0

$$WEDGE_{n,b} \equiv \left| \int_{n^*}^{n^{HIGH}} \left[\theta_n^{LFP,EFF}(n_i;\cdot) - \theta_n^{VC,EFF}(n_i;\cdot) \right] dn_i \right|$$

Aggregate matching market clearing

$$k_t^h \cdot s_t = k_t^f \cdot v_t = m(s_t, v_t)$$

$$\equiv \text{new employees}_t$$



Matching Market vs. Walrasian Market

- Suppose efficient n^* (e.g., CSE or Nash-Hosios bargaining)
- Ceteris paribus: increase in labor tax rate
- Question: are "labor wedges" identical?