Lecture 11

Firm Entry

7/7

Perfect Competition

- The profit is

$$\Pi = AK^{\alpha}L^{1-\alpha} - rK - wL$$

- We substitute the FOCs into the above

$$MPK = \alpha AK^{\alpha-1}L^{1-\alpha} = r$$
$$MPL = (1-\alpha)AK^{\alpha}L^{-\alpha} = w$$

- We can show that

$$\Pi = 0$$

- Under perfect competition (with constant-returns-to-scale production function), firms always earn zero profit in equilibrium.

Implications for Firm Entry

- What does zero profit imply?
- For any potential entrant and any incumbent, it is **indifferent** between entry and exit.
- As a result, there is no mechanism determining the number of firms.
  - In other words, we cannot study how firm entry promotes job creation.

Goals

- Last week, we studied a version of the Dixit-Stiglitz model of monopolistic competition.
- Today, we extend the model to include the determination of the number of firms.

Monopolistic Competition with Firm Entry

Matsuyama, Kiminori. “Complementarities and cumulative processes in models of monopolistic competition.” Journal of Economic Literature (1995), Section 3A (The Basic Model)

Without Entry

- Consider the model in the previous lecture.
- Let $y(z)$ denote the input of variety z.
- Production function:

$$Y = \left(\int_0^1 y(z)^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}}$$

- $\sigma > 1$ is the elasticity of substitution between any two varieties.
- The number of monopolists is normalized by 1.

With Entry

- Let us now consider entry.
- Let n denote the **number of input variety**.
- Let $y(z)$ denote the input of variety z.
- Production function:

$$Y = \left(\int_0^n y(z)^{\frac{\sigma - 1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma - 1}}$$

- $\sigma > 1$ is the elasticity of substitution between any two varieties.

Intermediate Goods

- Let $p(z)$ denote the input price of variety z.
- The input demand minimizes total expenditure:

$$\min_{y(z)} \int_0^n p(z)y(z)dz$$

$$s.t.$$

$$Y = \left(\int_0^n y(z)^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}}$$

Intermediate Goods

- The Lagrangian is

$$\int_0^n p(z)y(z)dz + \lambda\left[Y - \left(\int_0^n y(i)^{\frac{\sigma-1}{\sigma}}di\right)^{\frac{\sigma}{\sigma-1}}\right]$$

- FOC for variety z is

$$p(z) = \lambda\frac{\sigma}{\sigma-1}\left(\int_0^n y(i)^{\frac{\sigma-1}{\sigma}}di\right)^{\frac{\sigma}{\sigma-1}-1}\frac{\sigma-1}{\sigma}y(z)^{\frac{\sigma-1}{\sigma}-1}$$

- FOC for variety j is

$$p(j) = \lambda\frac{\sigma}{\sigma-1}\left(\int_0^n y(i)^{\frac{\sigma-1}{\sigma}}di\right)^{\frac{\sigma}{\sigma-1}-1}\frac{\sigma-1}{\sigma}y(j)^{\frac{\sigma-1}{\sigma}-1}$$

Intermediate Goods

- Taking the ratio:

$$\frac{p(z)}{p(j)} = \frac{y(z)^{\frac{\sigma-1}{\sigma}-1}}{y(j)^{\frac{\sigma-1}{\sigma}-1}} = \left(\frac{y(z)}{y(j)}\right)^{\frac{-1}{\sigma}}$$

- Thus,

$$y(j) = \left(\frac{p(z)}{p(j)}\right)^{\sigma} y(z) = p(z)^{\sigma} p(j)^{-\sigma} y(z)$$

- Thus,

$$y(j)^{\frac{\sigma-1}{\sigma}} = p(z)^{\sigma-1} p(j)^{1-\sigma} y(z)^{\frac{\sigma-1}{\sigma}}$$

Intermediate Goods

- Substitute it into the production function:

$$Y = \left(\int_0^n y(j)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}$$

$$= \left(\int_0^n \left[p(z)^{\sigma-1} p(j)^{1-\sigma} y(z)^{\frac{\sigma-1}{\sigma}} \right] dj \right)^{\frac{\sigma}{\sigma-1}}$$

$$= p(z)^{\sigma} y(z) \left(\int_0^n [p(j)^{1-\sigma}] dj \right)^{\frac{\sigma}{\sigma-1}}$$

Intermediate Goods

- We obtain

$$y(z) = Yp(z)^{-\sigma}\left(\int_0^n [p(j)^{1-\sigma}]dj\right)^{\frac{\sigma}{1-\sigma}}$$

- This is the input demand function for variety z.
- We can simplify it further…

Intermediate Goods

- Now let us use $y(j) = p(z)^{\sigma} p(j)^{-\sigma} y(z)$ to rewrite the expenditures:

$$\int_0^n p(j)y(j)dj = y(z)p(z)^{\sigma} \int_0^n p(j)^{1-\sigma} dj$$

- Perfect competition in the final-goods market implies zero profit: $PY - \int_0^n p(j)y(j)dj = 0$
- Thus,

$$PY = y(z)p(z)^{\sigma} \int_0^n p(j)^{1-\sigma} dj$$

Intermediate Goods

- Solve it for $y(z)$ as

$$y(z) = PY\left[\int_0^n p(j)^{1-\sigma} dj\right]^{-1} p(z)^{-\sigma}$$

- Substitute it into the production function:

$$Y = PY\left[\int_0^n p(j)^{1-\sigma} dj\right]^{-1} \left(\int_0^n p(z)^{1-\sigma} dz\right)^{\frac{\sigma}{\sigma-1}}$$

- It simplifies to

$$1 = P\left[\int_0^n p(j)^{1-\sigma} dj\right]^{\frac{1}{\sigma-1}}$$

Intermediate Goods

- Finally,

$$P = \left[\int_0^n p(j)^{1-\sigma} dj \right]^{\frac{1}{1-\sigma}}$$

- RHS is the **price index** of the intermediate goods.

Intermediate Goods

- The input demand is therefore

$$y(z) = Yp(z)^{-\sigma}\left(\int_0^n [p(j)^{1-\sigma}]dj\right)^{\frac{\sigma}{1-\sigma}}$$
$$= Yp(z)^{-\sigma}P^{\sigma}$$

- Thus,

$$\frac{y(z)}{Y} = \left[\frac{p(z)}{P}\right]^{-\sigma}$$

- Relative demand for input z is decreasing in the relative price of the input.

Intermediate Goods

- Production requires labor input $\ell(z)$:
$$y(z) = \max\{0, \varphi[\ell(z) - f]\}$$
- φ is the marginal product of labor (MPL).
- f is the **overhead cost** of production.
  - e.g.) I spend so much time on course preparation!
- The labor units needed to produce $y(z)$ is
$$\ell(z) = f + \frac{y(z)}{\varphi}$$

Intermediate Goods

- Let w denote the wage rate. The profit is
$$\pi(z) = p(z)y(z) - w\ell(z)$$
- We assume perfectly competitive labor market.
- Input demand function:
$$\frac{y(z)}{Y} = \left[\frac{p(z)}{P}\right]^{-\sigma} \Leftrightarrow y(z) = YP^{\sigma}p(z)^{-\sigma}$$
- Production technology:
$$\ell(z) = f + \frac{y(z)}{\varphi}$$

Markup Pricing

- Profit:

$$\pi(z) = p(z)y(z) - w\ell(z)$$
$$= p(z)y(z) - w\left[f + \frac{y(z)}{\varphi}\right]$$
$$= YP^{\sigma}p(z)^{1-\sigma} - wf - \frac{w}{\varphi}YP^{\sigma}p(z)^{-\sigma}$$

- FOC with respect to $p(z)$:

$$p(z) = \frac{\sigma}{\sigma - 1}\frac{w}{\varphi}$$
$$= markup \times \frac{w}{MPL}$$

Price Index

- Thus,

$$P = \left[\int_0^n \left[\frac{\sigma}{\sigma - 1}\frac{w}{\varphi}\right]^{1-\sigma} dj\right]^{\frac{1}{1-\sigma}}$$

$$= \left[n\left[\frac{\sigma}{\sigma - 1}\frac{w}{\varphi}\right]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

$$= \frac{\sigma}{\sigma - 1}\frac{w}{\varphi}n^{\frac{1}{1-\sigma}}$$

- P is decreasing in n (because $\sigma > 1$).

Aggregate Output

- Because $p(z)$ is the same for all intermediate-good firms, the input $y(z)$ is the same for all z.
- Thus, the aggregate production satisfies

$$Y = \left(\int_0^n y^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}} = yn^{\frac{\sigma}{\sigma-1}}$$

- Because ny units of intermediate goods are used, the aggregate productivity is

$$\frac{Y}{ny} = n^{\frac{1}{\sigma-1}}$$

Revenue

- Input demand:

$$y(z) = YP^{\sigma}p(z)^{-\sigma}$$
$$= Y\left[\frac{\sigma}{\sigma-1}\frac{w}{\varphi}n^{\frac{1}{1-\sigma}}\right]^{\sigma}\left[\frac{\sigma}{\sigma-1}\frac{w}{\varphi}\right]^{-\sigma}$$
$$= Yn^{\frac{\sigma}{1-\sigma}}$$

- The firm's revenue is

$$r(z) = p(z)y(z) = \frac{\sigma}{\sigma-1}\frac{w}{\varphi}y(z)$$

Profit

- The profit is

$$\pi(z) = p(z)y(z) - w\left[f + \frac{y(z)}{\varphi}\right]$$
$$= \frac{\sigma}{\sigma - 1}\frac{w}{\varphi}y(z) - \frac{w}{\varphi}y(z) - wf$$
$$= \frac{1}{\sigma - 1}\frac{w}{\varphi}y(z) - wf$$
$$= \frac{r(z)}{\sigma} - wf$$

Closing the Model

- Households supply L units of labor.
- There are n firms, and each employs ℓ workers.
- Thus,

$$L = n\ell = n\left[f + \frac{y}{\varphi}\right]$$

- Thus,

$$\frac{y}{\varphi} = \frac{L}{n} - f$$

Firm Entry

- The profit is

$$\pi(z) = \frac{1}{\sigma - 1}\frac{w}{\varphi}y(z) - wf$$
$$= \frac{1}{\sigma - 1}w\left[\frac{L}{n} - f\right] - wf$$

- Thus, $\pi(z) \geq 0$ if and only if

$$\frac{1}{\sigma - 1}\left[\frac{L}{n} - f\right] \geq f \Leftrightarrow \frac{\mu}{1+\mu}\frac{L}{n} \geq f$$

- This is the condition for firm entry.

Equilibrium Number of Firms

- The free entry condition:

$$\pi(z) = 0 \Leftrightarrow \frac{\mu}{1+\mu}\frac{L}{n} = f$$
$$\Leftrightarrow n = \frac{\mu}{1+\mu}\frac{L}{f}$$

- Thus, the equilibrium number of firms is
  - Increasing in the markup rate μ.
  - Decreasing in the overhead fixed cost f.
- $L = n\ell$ implies that an increasing in n decreases ℓ, which decreases y and increases p.

Externality

- The aggregate production:

$$Y = \left(\int_0^n y^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}} = yn^{\frac{\sigma}{\sigma-1}}$$

- Because ny units of intermediate goods are used, the aggregate productivity is

$$\frac{Y}{ny} = n^{\frac{1}{\sigma-1}}$$

- Firm entry causes **externality**, or **scale effects**.
- Models of international trade tend to have it.

Eliminating the Scale Effects

- In many labor market applications, we work with models without the scale effects.
- To do so, we usually **discount** the production function by the scale component:

$$Y = n^{\frac{-1}{\sigma-1}}\left(\int_0^n y^{\frac{\sigma-1}{\sigma}}dz\right)^{\frac{\sigma}{\sigma-1}} = \left(n^{-\frac{1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}\left(\int_0^n y^{\frac{\sigma-1}{\sigma}}dz\right)^{\frac{\sigma}{\sigma-1}}$$

$$= \left(n^{-\frac{1}{\sigma}}\int_0^n y^{\frac{\sigma-1}{\sigma}}dz\right)^{\frac{\sigma}{\sigma-1}}$$

Eliminating the Scale Effects

The specific assumptions are as follows.

I.A. Workers

There are L workers/consumers, indexed by j. In each period, worker j has a utility function given by

$$(1) \qquad V_j = \left[m^{-1/\sigma} \sum_{i=1}^{m} C_{ij}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)},$$

2.1.1. Monopolistic competition in the goods market

Households are both consumers and workers. As consumers they are risk neutral in the aggregate consumption good. Agents have Dixit–Stiglitz preferences over a continuum of differentiated goods. We use Blanchard and Giavazzi (2003)'s formulation, which allows us to connect demand elasticity σ to the number of firms n, while also allowing us to focus on the direct effects of increased competition on the demand elasticity facing firms.[4] Goods demand each period is derived from the household's optimization problem:

$$\max\left(n^{-\frac{1}{\sigma}} \int c_{i,j}^{\frac{\sigma-1}{\sigma}}\, di\right)^{\frac{\sigma}{\sigma-1}} \qquad (1)$$

Eliminating the Scale Effects

- Let $p(z)$ denote the input price of variety z.
- The input demand minimizes total expenditure:

$$\min_{y(z)} \int_0^n p(z)y(z)dz$$

$$s.t.$$

$$Y = \frac{1}{N}\left(\int_0^n y(z)^{\frac{\sigma-1}{\sigma}} dz\right)^{\frac{\sigma}{\sigma-1}}$$

- For now, Let us define the scale component as

$$n^{\frac{1}{\sigma-1}} = N$$

Eliminating the Scale Effects

- The Lagrangian is

$$\int_0^n p(z)y(z)dz + \lambda\left[Y - \frac{1}{N}\left(\int_0^n y(i)^{\frac{\sigma-1}{\sigma}}di\right)^{\frac{\sigma}{\sigma-1}}\right]$$

- FOC for variety z is

$$p(z) = \lambda\frac{1}{N}\frac{\sigma}{\sigma-1}\left(\int_0^n y(i)^{\frac{\sigma-1}{\sigma}}di\right)^{\frac{\sigma}{\sigma-1}-1}\frac{\sigma-1}{\sigma}y(z)^{\frac{\sigma-1}{\sigma}-1}$$

- FOC for variety j is

$$p(j) = \lambda\frac{1}{N}\frac{\sigma}{\sigma-1}\left(\int_0^n y(i)^{\frac{\sigma-1}{\sigma}}di\right)^{\frac{\sigma}{\sigma-1}-1}\frac{\sigma-1}{\sigma}y(j)^{\frac{\sigma-1}{\sigma}-1}$$

Eliminating the Scale Effects

- Taking the ratio:

$$\frac{p(z)}{p(j)} = \frac{y(z)^{\frac{\sigma-1}{\sigma}-1}}{y(j)^{\frac{\sigma-1}{\sigma}-1}} = \left(\frac{y(z)}{y(j)}\right)^{\frac{-1}{\sigma}}$$

- Thus,

$$y(j) = \left(\frac{p(z)}{p(j)}\right)^{\sigma} y(z) = p(z)^{\sigma} p(j)^{-\sigma} y(z)$$

- Thus,

$$y(j)^{\frac{\sigma-1}{\sigma}} = p(z)^{\sigma-1} p(j)^{1-\sigma} y(z)^{\frac{\sigma-1}{\sigma}}$$

Eliminating the Scale Effects

- Substitute it into the production function:

$$Y = \frac{1}{N}\left(\int_0^n y(j)^{\frac{\sigma-1}{\sigma}}dj\right)^{\frac{\sigma}{\sigma-1}}$$

$$= \frac{1}{N}\left(\int_0^n \left[p(z)^{\sigma-1}p(j)^{1-\sigma}y(z)^{\frac{\sigma-1}{\sigma}}\right]dj\right)^{\frac{\sigma}{\sigma-1}}$$

$$= \frac{1}{N}p(z)^{\sigma}y(z)\left(\int_0^n [p(j)^{1-\sigma}]dj\right)^{\frac{\sigma}{\sigma-1}}$$

Eliminating the Scale Effects

- We obtain

$$y(z) = YNp(z)^{-\sigma}\left(\int_0^n [p(j)^{1-\sigma}]dj\right)^{\frac{\sigma}{1-\sigma}}$$

- This is the input demand function for variety z.
- We can simplify it further…

Eliminating the Scale Effects

- Now let us use $y(j) = p(z)^{\sigma} p(j)^{-\sigma} y(z)$ to rewrite the expenditures:

$$\int_0^n p(j)y(j)dj = y(z)p(z)^{\sigma} \int_0^n p(j)^{1-\sigma} dj$$

- Perfect competition in the final-goods market implies zero profit: $PY - \int_0^n p(j)y(j)dj = 0$
- Thus,

$$PY = y(z)p(z)^{\sigma} \int_0^n p(j)^{1-\sigma} dj$$

Eliminating the Scale Effects

- Solve it for $y(z)$ as

$$y(z) = PY\left[\int_0^n p(j)^{1-\sigma}dj\right]^{-1} p(z)^{-\sigma}$$

- Substitute it into the production function:

$$Y = \frac{1}{N}PY\left[\int_0^n p(j)^{1-\sigma}dj\right]^{-1} \left(\int_0^n p(z)^{1-\sigma}dz\right)^{\frac{\sigma}{\sigma-1}}$$

- It simplifies to

$$N = P\left[\int_0^n p(j)^{1-\sigma}dj\right]^{\frac{1}{\sigma-1}}$$

Eliminating the Scale Effects

- Thus,

$$P = N\left[\int_0^n p(j)^{1-\sigma}dj\right]^{\frac{1}{1-\sigma}}$$

- Remember that $N = n^{\frac{1}{\sigma-1}}$. Thus,

$$P = n^{\frac{1}{\sigma-1}}\left[\int_0^n p(j)^{1-\sigma}dj\right]^{\frac{1}{1-\sigma}}$$

$$= \left[\frac{1}{n}\int_0^n p(j)^{1-\sigma}dj\right]^{\frac{1}{1-\sigma}}$$

Eliminating the Scale Effects

- The input demand is therefore

$$y(z) = Yn^{\frac{1}{\sigma-1}} p(z)^{-\sigma} \left(\int_0^n [p(j)^{1-\sigma}] dj \right)^{\frac{\sigma}{1-\sigma}}$$
$$= Yn^{-1} p(z)^{-\sigma} P^{\sigma}$$

- Thus,

$$\frac{y(z)}{Y} = n^{-1} \left[\frac{p(z)}{P} \right]^{-\sigma}$$

- Firm entry reduces the input demand for all incumbent firms (= increased competition).

Eliminating the Scale Effects

- Production requires labor input $\ell(z)$:
$$y(z) = \max\{0, \varphi[\ell(z) - f]\}$$
- φ is the marginal product of labor (MPL).
- f is the **overhead cost** of production.
  - e.g.) I spend so much time on course preparation!
- The labor units needed to produce $y(z)$ is
$$\ell(z) = f + \frac{y(z)}{\varphi}$$

Eliminating the Scale Effects

- Let w denote the wage rate. The profit is
$$\pi(z) = p(z)y(z) - w\ell(z)$$
- We assume perfectly competitive labor market.
- Input demand function:
$$\frac{y(z)}{Y} = n^{-1}\left[\frac{p(z)}{P}\right]^{-\sigma} \Leftrightarrow y(z) = n^{-1}YP^{\sigma}p(z)^{-\sigma}$$
- Production technology:
$$\ell(z) = f + \frac{y(z)}{\varphi}$$

Eliminating the Scale Effects

- Profit:

$$\pi(z) = p(z)y(z) - w\ell(z)$$
$$= p(z)y(z) - w\left[f + \frac{y(z)}{\varphi}\right]$$
$$= n^{-1}YP^{\sigma}p(z)^{1-\sigma} - wf - \frac{w}{\varphi}n^{-1}YP^{\sigma}p(z)^{-\sigma}$$

- FOC with respect to $p(z)$:

$$p(z) = \frac{\sigma}{\sigma - 1}\frac{w}{\varphi}$$
$$= markup \times \frac{w}{MPL}$$

Eliminating the Scale Effects

- Thus,

$$P = \left[\frac{1}{n}\int_0^n \left[\frac{\sigma}{\sigma - 1}\frac{w}{\varphi}\right]^{1-\sigma} dj\right]^{\frac{1}{1-\sigma}}$$
$$= \left[\frac{1}{n} n \left[\frac{\sigma}{\sigma - 1}\frac{w}{\varphi}\right]^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$
$$= \frac{\sigma}{\sigma - 1}\frac{w}{\varphi} = p$$

- P is now **independent** of n in equilibrium.

Eliminating the Scale Effects

- Input demand:

$$y(z) = n^{-1} Y P^{\sigma} p(z)^{-\sigma}$$
$$= n^{-1} Y \left[\frac{\sigma}{\sigma - 1}\frac{w}{\varphi}\right]^{\sigma} \left[\frac{\sigma}{\sigma - 1}\frac{w}{\varphi}\right]^{-\sigma}$$
$$= n^{-1} Y$$

- The firm's revenue is

$$r(z) = p(z)y(z) = \frac{\sigma}{\sigma - 1}\frac{w}{\varphi} y(z)$$

Eliminating the Scale Effects

- The profit is

$$\pi(z) = p(z)y(z) - w\left[f + \frac{y(z)}{\varphi}\right]$$
$$= \frac{\sigma}{\sigma - 1}\frac{w}{\varphi}y(z) - \frac{w}{\varphi}y(z) - wf$$
$$= \frac{1}{\sigma - 1}\frac{w}{\varphi}y(z) - wf$$
$$= \frac{r(z)}{\sigma} - wf$$

Eliminating the Scale Effects

- Households supply L units of labor.
- There are n firms, and each employs ℓ workers.
- Thus,

$$L = n\ell = n\left[f + \frac{y}{\varphi}\right]$$

- Thus,

$$\frac{y}{\varphi} = \frac{L}{n} - f$$

Eliminating the Scale Effects

- The profit is

$$\pi(z) = \frac{1}{\sigma - 1}\frac{w}{\varphi}y(z) - wf$$
$$= \frac{1}{\sigma - 1}w\left[\frac{L}{n} - f\right] - wf$$

- Thus, $\pi(z) \geq 0$ if and only if

$$\frac{1}{\sigma - 1}\left[\frac{L}{n} - f\right] \geq f \Leftrightarrow \frac{\mu}{1 + \mu}\frac{L}{n} \geq f$$

- This is the condition for firm entry.

Eliminating the Scale Effects

- The free entry condition:

$$\pi(z) = 0 \Leftrightarrow \frac{\mu}{1+\mu}\frac{L}{n} = f$$
$$\Leftrightarrow n = \frac{\mu}{1+\mu}\frac{L}{f}$$

- Thus, the equilibrium number of firms is
  - Increasing in the markup rate μ.
  - Decreasing in the overhead fixed cost f.
- $L = n\ell$ implies that an increasing in n decreases ℓ, which decreases c and increases p.

Optimal Entry

- **With scale effects**, the aggregate output is

$$Y = yn^{\frac{\sigma}{\sigma-1}}$$

- From the labor supply,

$$L = n\ell = n\left[f + \frac{y}{\varphi}\right] \Leftrightarrow y = \left(\frac{L}{n} - f\right)\varphi$$

- Thus,

$$Y = \left(\frac{L}{n} - f\right)\varphi n^{\frac{\sigma}{\sigma-1}}$$

Optimal Entry

- Consider

$$\max_{n} \left(\frac{L}{n} - f \right) \varphi n^{\frac{\sigma}{\sigma - 1}}$$

- The optimal number of firms **under scale effects** is

$$n = \frac{L}{\sigma f}$$

- The equilibrium number of firms is

$$n = \frac{\mu}{1 + \mu} \frac{L}{f} = \frac{L}{\sigma f}$$

Optimal Entry

- **Without scale effects**, the aggregate output is

$$Y = ny$$

- From the labor supply,

$$L = n\ell = n\left[f + \frac{y}{\varphi}\right] \Leftrightarrow y = \left(\frac{L}{n} - f\right)\varphi$$

- Thus,

$$Y = \left(\frac{L}{n} - f\right)\varphi n = (L - fn)\varphi$$

- Thus, n should be as small as possible.

Optimal Entry

- With scale effects, entry **happens to be efficient** as two opposing effects causing inefficiency cancel out each other:
  - Entry increases overhead costs nf.
  - Entry increases the aggregate productivity.
- Without scale effects, the planner finds it inefficient to pay entry costs nf.
- See Section 3.E of Matsuyama (1995).

Firm Entry and Job Creation

Ebell and Haefke, "Product Market Deregulation and the US Employment Miracle," *Review of Economic Dynamics*, 2009.

The Basic Idea

- We now introduce the DMP component into the model of firm entry.
- Unlike the DMP model, we need monopolistic **firms**.
- We shall continue to use the model without scale effects in the aggregate production function.

Competitive Labor Market

- Each monopolist's profit is
$$\pi(z) = p(z)y(z) - w\ell(z)$$
- Input demand function:
$$\frac{y(z)}{Y} = n^{-1}\left[\frac{p(z)}{P}\right]^{-\sigma}$$
- Production technology:
$$\ell(z) = f + \frac{y(z)}{\varphi}$$
- The model is **static**.

Search-Matching Frictions

- The (discrete-time) **Bellman equation**:

$$J(\ell) = \max_{v}\left\{py - w(\ell)\ell - cv + \frac{1}{1+r}J(\ell_{+1})\right\}$$

$$s.t.$$

$$\frac{y(z)}{Y} = n^{-1}\left[\frac{p(z)}{P}\right]^{-\sigma}$$

$$y = \varphi\ell$$

$$\ell_{+1} = (1-\lambda)\ell + q(\theta)v$$

- The firm **cannot change output immediately** because of labor market frictions.

Search-Matching Frictions

- The inverse demand is

$$p = P\left(\frac{ny}{Y}\right)^{-\frac{1}{\sigma}} = Pn^{-\frac{1}{\sigma}}Y^{\frac{1}{\sigma}}y^{-\frac{1}{\sigma}}$$

- The revenue is

$$py = Pn^{-\frac{1}{\sigma}}Y^{\frac{1}{\sigma}}y^{1-\frac{1}{\sigma}} = Pn^{-\frac{1}{\sigma}}Y^{\frac{1}{\sigma}}(\varphi\ell)^{1-\frac{1}{\sigma}} = \Phi\ell^{\frac{\sigma-1}{\sigma}}$$

- Thus,

$$J(\ell) = \max_{v}\left\{\Phi\ell^{\frac{\sigma-1}{\sigma}} - w(\ell)\ell - cv + \frac{1}{1+r}J(\ell_{+1})\right\}$$
$$s.t.\ \ \ell_{+1} = (1-\lambda)\ell + q(\theta)v$$

Job Creation

- Consider

$$J(\ell) = \max_{v} \left\{ \Phi \ell^{\frac{\sigma-1}{\sigma}} - w(\ell)\ell - cv + \frac{1}{1+r} J(\ell_{+1}) \right\}$$

$$s.t.\ \ \ell_{+1} = (1-\lambda)\ell + q(\theta)v$$

- FOC with respect to v:

$$c = q(\theta)\frac{1}{1+r} J'(\ell_{+1})$$

- The Envelope condition:

$$J'(\ell) = \frac{\sigma-1}{\sigma}\Phi \ell^{\frac{\sigma-1}{\sigma}-1} - w(\ell) - w'(\ell)\ell + \frac{1-\lambda}{1+r} J'(\ell_{+1})$$

Job Creation

- Use FOC to eliminate $J'(\ell_{+1})$ from the Envelope condition to obtain
$$J'(\ell) = \frac{\sigma - 1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}}$$
$$-w(\ell) - w'(\ell)\ell + \frac{(1-\lambda)c}{q(\theta)}$$
- This the marginal firm value of employment.

Job Creation

- FOC implies that in any steady state,

$$\frac{(1+r)c}{q(\theta)} = J'(\ell)$$

- Thus, we obtain the job-creation condition

$$\frac{(1+r)c}{q(\theta)} = \frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}} - w(\ell) - w'(\ell)\ell + \frac{(1-\lambda)c}{q(\theta)}$$

Job Creation

- The job-creation condition:

$$\frac{(r+\lambda)c}{q(\theta)} = \frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}} - w(\ell) - w'(\ell)\ell$$

- Notice that we need to figure out $w'(\ell)$.

Workers

- Consider the (discrete-time) Pissarides model.
- W : Value of employment.
- U : Value of job search.
- b : unemployment benefit.
- $\delta = \frac{1}{1+r}$: the discount factor.
- Value of being employed:
$$W = w(\ell) + \lambda\delta U + (1-\lambda)\delta W$$
- Value of job search:
$$U = b + \theta q(\theta)\delta W + [1-\theta q(\theta)]\delta U$$

Intra-Firm Bargaining

- Nash bargaining outcome in the DMP model:
$$\beta[J - V] = (1 - \beta)[W - U].$$
- One firm versus **many workers**:
$$\beta[J(\ell) - J(\ell - \Delta)] = (1 - \beta)\Delta[W - U]$$
- One firm versus randomly selected Δ workers.
- The value of disagreement is $J(\ell - \Delta)$ because Δ workers walk away, forcing the firm to produce with $\ell - \Delta$ employees.

Intra-Firm Bargaining

- Consider:

$$\beta[J(\ell) - J(\ell - \Delta)] = (1 - \beta)\Delta[W - U].$$

- $\Delta \to 0$,

$$\beta J'(\ell) = (1 - \beta)[W - U].$$

- This means that the firm is bargaining with **one** worker. But, who is this worker?
- Each worker is treated as the **marginal** worker.
    - Whenever you negotiate with the firm, you will be treated as the ℓth worker.

Intra-Firm Bargaining

- Consider

$$\beta J'(\ell) = (1-\beta)[W-U]$$

- We need to know $J'(\ell)$ and $W-U$.
- The good news is, we know $J'(\ell)$:

$$J'(\ell) = \frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}} - w(\ell) - w'(\ell)\ell + \frac{(1-\lambda)c}{q(\theta)}$$

- See page 58.

Deriving $W - U$

- Consider
$$W = w(\ell) + \lambda\delta U + (1-\lambda)\delta W$$
$$U = b + \theta q(\theta)\delta W + [1-\theta q(\theta)]\delta U$$
- Subtract the terms of the second equation from the other to obtain
$$W - U = w(\ell) - b + \lambda\delta U + (1-\lambda)\delta W$$
$$-\theta q(\theta)\delta W - [1-\theta q(\theta)]\delta U$$
- Thus,
$$W - U = w(\ell) - b$$
$$+[1-\lambda-\theta q(\theta)]\delta[W-U]$$

Deriving $W - U$

- From $\beta J'(\ell) = (1-\beta)[W-U]$, we obtain
$$(W-U) = \frac{\beta}{1-\beta} J'(\ell)$$
- FOC of the firm implies that in any steady state,
$$\frac{(1+r)c}{q(\theta)} = J'(\ell)$$
- Thus,
$$(W-U) = \frac{\beta}{1-\beta}\frac{(1+r)c}{q(\theta)}$$

Deriving $W - U$

- Therefore,

$$\begin{aligned} W - U &= w(\ell) - b + [1 - \lambda - \theta q(\theta)]\delta[W - U] \\ &= w(\ell) - b \\ &\quad +[1 - \lambda - \theta q(\theta)]\delta \frac{\beta}{1-\beta}\frac{(1+r)c}{q(\theta)} \\ &= w(\ell) - b \\ &\quad +[1 - \lambda - \theta q(\theta)] \frac{\beta}{1-\beta}\frac{c}{q(\theta)} \end{aligned}$$

Intra-Firm Bargaining

- Consider

$$\beta J'(\ell) = (1-\beta)[W-U]$$

- We know:

$$J'(\ell) = \frac{\sigma - 1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}}$$
$$-w(\ell) - w'(\ell)\ell + \frac{(1-\lambda)c}{q(\theta)}$$
$$W - U = w(\ell) - b$$
$$+[1-\lambda-\theta q(\theta)]\frac{\beta}{1-\beta}\frac{c}{q(\theta)}$$

Intra-Firm Bargaining

- Thus, the wage rate must satisfy

$$\beta\left[\frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}}-w(\ell)-w'(\ell)\ell+\frac{(1-\lambda)c}{q(\theta)}\right]$$
$$=(1-\beta)\left\{w(\ell)-b+\frac{\beta}{1-\beta}\frac{[1-\lambda-\theta q(\theta)]c}{q(\theta)}\right\}$$

- Arrange terms to obtain:

$$w'(\ell)\ell+\frac{1}{\beta}w(\ell)=\frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}}+\frac{1-\beta}{\beta}b+c\theta$$

- This is an <u>ordinary differential equation</u> in ℓ.

Solving ODE

- Observe that

$$\frac{d\left[w(\ell)\ell^{\frac{1}{\beta}}\right]}{d\ell} = w'(\ell)\ell^{\frac{1}{\beta}} + \frac{1}{\beta}w(\ell)\ell^{\frac{1}{\beta}-1}$$

$$= \left[w'(\ell)\ell + \frac{1}{\beta}w(\ell)\right]\ell^{\frac{1}{\beta}-1}$$

$$= \left[\frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}} + \frac{1-\beta}{\beta}b + c\theta\right]\ell^{\frac{1}{\beta}-1}$$

$$= \frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}+\frac{1}{\beta}-1} + \left[\frac{1-\beta}{\beta}b + c\theta\right]\ell^{\frac{1}{\beta}-1}$$

Solving ODE

- Consider

$$\frac{d\left[w(\ell)\ell^{\frac{1}{\beta}}\right]}{d\ell} = \frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}+\frac{1}{\beta}-1} + \left[\frac{1-\beta}{\beta}b + c\theta\right]\ell^{\frac{1}{\beta}-1}$$

- Integrate LHS:

$$\int_0^\ell \frac{d\left[w(i)i^{\frac{1}{\beta}}\right]}{di}di = w(\ell)\ell^{\frac{1}{\beta}} - \lim_{\ell\to 0} w(\ell)\ell^{\frac{1}{\beta}}$$

$$= w(\ell)\ell^{\frac{1}{\beta}}$$

Solving ODE

- Integrate RHS:

$$\int_0^{\ell}\left\{\frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}+\frac{1}{\beta}-1}+\left[\frac{1-\beta}{\beta}b+c\theta\right]\ell^{\frac{1}{\beta}-1}\right\}di$$

$$=\frac{\frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}+\frac{1}{\beta}}}{\frac{-1}{\sigma}+\frac{1}{\beta}}+\left[\frac{1-\beta}{\beta}b+c\theta\right]\beta\ell^{\frac{1}{\beta}}$$

$$=\frac{\frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}+\frac{1}{\beta}}}{\frac{-1}{\sigma}+\frac{1}{\beta}}+[(1-\beta)b+\beta c\theta]\ell^{\frac{1}{\beta}}$$

Solving ODE

- Finally, we obtain

$$w(\ell)\ell^{\frac{1}{\beta}} = \frac{\frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}+\frac{1}{\beta}}}{\frac{-1}{\sigma}+\frac{1}{\beta}} + [(1-\beta)b + \beta c\theta]\ell^{\frac{1}{\beta}}$$

- Thus,

$$w(\ell) = \beta\frac{\sigma-1}{\sigma-\beta}\Phi\ell^{\frac{-1}{\sigma}} + (1-\beta)b + \beta c\theta$$

- DMP: $w = \beta y + (1-\beta)b + \beta c\theta$
- As $\sigma \to \infty$, the two wage equations are the same.

Aggregation

- If there are n firms, then the aggregate number of vacancies is
$$nv$$
- Labor market tightness:
$$\theta = \frac{nv}{u}$$
- Labor force is 1.
- Aggregate number of employees satisfies
$$1 - u = n\ell$$

Aggregation

- Worker flows:

$$u_{t+1} = u_t + \lambda(1 - u_t) - \theta_t q(\theta_t) u_t$$

- In any steady state, (as usual) we obtain

$$u = \frac{\lambda}{\lambda + \theta q(\theta)}$$

- Aggregate number of employees:

$$1 - u = n\ell \Leftrightarrow u = 1 - n\ell$$

- Thus,

$$n\ell = 1 - \frac{\lambda}{\lambda + \theta q(\theta)}$$

Steady-State Equilibrium

- The job-creation condition:

$$\frac{(r+\lambda)c}{q(\theta)} = \frac{\sigma-1}{\sigma}\Phi\ell^{\frac{-1}{\sigma}} - w(\ell) - w'(\ell)\ell$$

- The wage equation:

$$w(\ell) = \beta\frac{\sigma-1}{\sigma-\beta}\Phi\ell^{\frac{-1}{\sigma}} + (1-\beta)b + \beta c\theta$$

- Take the derivative to obtain

$$w'(\ell) = \frac{-1}{\sigma}\beta\frac{\sigma-1}{\sigma-\beta}\Phi\ell^{\frac{-1}{\sigma}-1}$$

Steady-State Equilibrium

- The job-creation condition:

$$w(\ell) = \frac{\sigma - 1}{\sigma - \beta}\Phi\ell^{\frac{-1}{\sigma}} - \frac{(r + \lambda)c}{q(\theta)}$$

- The wage equation:

$$w(\ell) = \beta\frac{\sigma - 1}{\sigma - \beta}\Phi\ell^{\frac{-1}{\sigma}} + (1 - \beta)b + \beta c\theta$$

- Worker flows:

$$u = \frac{\lambda}{\lambda + \theta q(\theta)}$$

$$u = 1 - n\ell$$

Closing the Model

- Remember

$$\Phi = Pn^{-\frac{1}{\sigma}}Y^{\frac{1}{\sigma}}\varphi^{\frac{\sigma-1}{\sigma}}$$

- Output (see p.28)

$$Y = n^{\frac{-1}{\sigma-1}}\left(\int_0^n y^{\frac{\sigma-1}{\sigma}}dz\right)^{\frac{\sigma}{\sigma-1}} = ny$$

- Price index (see p.37)

$$P = n^{\frac{1}{\sigma-1}}\left[\int_0^n p^{1-\sigma}dj\right]^{\frac{1}{1-\sigma}} = p$$

Closing the Model

- Let the final consumption good be the numeraire (= units of measurement). Thus, we normalize
$$P = 1$$
- Then, $p = P = 1$. With $Y = ny$, we obtain
$$\begin{aligned}\Phi &= n^{-\frac{1}{\sigma}}(ny)^{\frac{1}{\sigma}}\varphi^{1-\frac{1}{\sigma}} \\ &= n^{-\frac{1}{\sigma}}(n\varphi\ell)^{\frac{1}{\sigma}}\varphi^{1-\frac{1}{\sigma}} \\ &= \varphi\ell^{\frac{1}{\sigma}}\end{aligned}$$

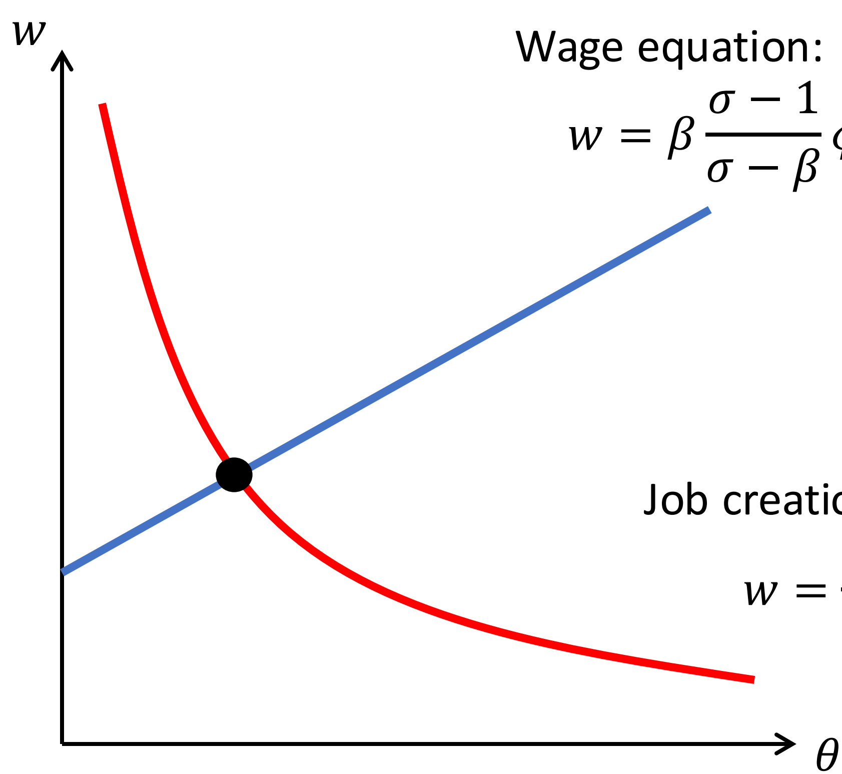
Short-Run (?) Steady State

- The job-creation condition:
$$w = \frac{\sigma - 1}{\sigma - \beta}\varphi - \frac{(r+\lambda)c}{q(\theta)}$$
- The wage equation:
$$w = \beta\frac{\sigma - 1}{\sigma - \beta}\varphi + (1-\beta)b + \beta c\theta$$
- Worker flows:
$$u = \frac{\lambda}{\lambda + \theta q(\theta)}$$
$$u = 1 - n\ell$$

Relationship with the DMP Model

- Let $\sigma \to \infty$. Then, the job-creation condition is
$$w = \varphi - \frac{(r + \lambda)c}{q(\theta)}$$
- The wage equation becomes
$$w = \beta\varphi + (1 - \beta)b + \beta c\theta$$
- These equations are identical to those of the textbook Pissarides model.

Short-Run (?) Steady State



Wage equation:

$$w = \beta \frac{\sigma - 1}{\sigma - \beta} \varphi + (1 - \beta) b + \beta c \theta$$

Job creation condition:

$$w = \frac{\sigma - 1}{\sigma - \beta} \varphi - \frac{(r + \lambda) c}{q(\theta)}$$

Short-Run (?) Steady State

- Ebell and Haefke assumes that the number of firms n is a parameter.
- They further assume

$$\sigma = \bar{\sigma} g(n), g'(n) > 0$$

- Thus, the elasticity of substitution increases with n.
- As the number of firms increases, the markup decreases to get closer to the competitive economy.

Short-Run (?) Steady State

- Clearly, the solution pair (w, θ) depends on the number of firms n.
- Thus, JC and wage jointly imply
$$\frac{(r+\lambda)c}{q(\theta)} + \beta c\theta = (1-\beta)\frac{\bar{\sigma}g(n) - 1}{\bar{\sigma}g(n) - \beta}\varphi - (1-\beta)b$$
- LHS is increasing in θ.
- An increase in n increases the RHS. Thus,
$$\frac{d\theta}{dn} > 0, \frac{du}{dn} < 0$$

Firm Entry

- The value of operation with ℓ employees:

$$J(\ell) = \max_{v} \left\{ \Phi \ell^{\frac{\sigma-1}{\sigma}} - w(\ell)\ell - cv + \delta J(\ell_{+1}) \right\}$$
$$s.t. \;\; \ell_{+1} = (1-\lambda)\ell + q(\theta)v$$

- Thus, the value of the firm **with 0 employee** is

$$J(0) = \max_{v} \{0 - cv + \delta J(\ell_{+1})\}$$
$$s.t. \;\; \ell_{+1} = 0 + q(\theta)v$$

- FOC is

$$c = q(\theta)\delta J'(\ell_{+1})$$

Firm Entry

- Existing firms and entrants face the same condition:

$$J'(\ell_{+1}) = \frac{(1+r)c}{q(\theta)}$$

- This means that ℓ_{+1} is the same for **all** firms, incumbents and entrants.
  - In other words, the entrant creates a **huge** number of vacancies to make sure that the employees in the next period will be the same as incumbent firms.
  - There will be **no size distribution** of firms.

Firm Entry

- Given the vacancy-filling rate, each entrant creates
$$\frac{\ell_{+1}}{q(\theta)}$$
units of vacancies so that the employee will be
$$q(\theta) \times \frac{\ell_{+1}}{q(\theta)} = \ell_{+1}$$
- Thus, the value of entry is
$$J(0) = -c\,\frac{\ell_{+1}}{q(\theta)} + \frac{1}{1+r} J(\ell_{+1})$$

Firm Entry

- We assume each entrant must pay
$$F > 0$$
units of fixed entry cost.
- Thus, n increases if and only if
$$J(0) > F$$
- Thus, n is determined so that
$$J(0) = -c\frac{\ell_{+1}}{q(\theta)} + \frac{1}{1+r}J(\ell_{+1}) = F$$

Steady State with Firm Entry

- In any steady state,

$$-c\frac{\ell}{q(\theta)}+\frac{1}{1+r}J(\ell)=F$$

- From the Bellman equation,

$$J(\ell)=\varphi\ell-w(\ell)\ell-cv+\frac{1}{1+r}J(\ell)$$
$$\ell=(1-\lambda)\ell+q(\theta)v$$

- Eliminate v to obtain

$$\frac{r}{1+r}J(\ell)=\varphi\ell-w(\ell)\ell-\frac{c\lambda}{q(\theta)}\ell$$

Steady State with Firm Entry

- Thus, the free entry condition for firms is

$$\varphi - w - \frac{(r+\lambda)c}{q(\theta)} = \frac{rF}{\ell}$$

- Other equations are

$$w = \frac{\sigma - 1}{\sigma - \beta}\varphi - \frac{(r+\lambda)c}{q(\theta)}$$

$$w = \beta\frac{\sigma - 1}{\sigma - \beta}\varphi + (1-\beta)b + \beta c\theta$$

$$n\ell = 1 - \frac{\lambda}{\lambda + \theta q(\theta)}$$

Steady State with Firm Entry

- Eliminate w from the equations to obtain

$$\frac{1-\beta}{\sigma-\beta}\varphi = \frac{rF}{\ell}$$

$$(1-\beta)\frac{\sigma-1}{\sigma-\beta}\varphi = \frac{(r+\lambda)c}{q(\theta)} + \beta c\theta + (1-\beta)b$$

- Notice that under a constant σ, the first condition determines ℓ while the second condition pins down θ <u>without any interaction between firm entry and the labor market</u>.

Steady State with Firm Entry

- Let us now assume (as in Ebell and Haefke)

$$\sigma = \bar{\sigma} g(n), g'(n) > 0$$

- Then,

$$\frac{1-\beta}{\bar{\sigma} g(n) - \beta} \varphi = \frac{rF}{\ell}$$

$$(1-\beta) \frac{\bar{\sigma} g(n) - 1}{\bar{\sigma} g(n) - \beta} \varphi = \frac{(r+\lambda)c}{q(\theta)} + \beta c \theta + (1-\beta) b$$

$$n\ell = 1 - \frac{\lambda}{\lambda + \theta q(\theta)}$$

Solving the Model

- The vacancy-filling rate: $q(\theta) = A\theta^{-\alpha}$
- Product market competitiveness: $\sigma = \bar{\sigma} g(n) = n$
- Then,

$$\frac{1-\beta}{n-\beta}\varphi = \frac{rF}{\ell}$$

$$(1-\beta)\frac{n-1}{n-\beta}\varphi = \frac{(r+\lambda)c}{A\theta^{-\alpha}} + \beta c\theta + (1-\beta)b$$

$$n\ell = 1 - \frac{\lambda}{\lambda + A\theta^{1-\alpha}}$$

Solving the Model

- Let us eliminate ℓ. Then,

$$\frac{1-\beta}{n-\beta}\varphi = rnF\,\frac{\lambda + A\theta^{1-\alpha}}{A\theta^{1-\alpha}}$$

$$(1-\beta)\frac{n-1}{n-\beta}\varphi = \frac{(r+\lambda)c}{A\theta^{-\alpha}} + \beta c\theta + (1-\beta)b$$

- Parameter values

$$A = 0.327, \lambda = 0.024, b = 0.626, c = 0.173,$$

$$\beta = 0.5, \alpha = 0.5, r = \frac{0.04}{12}, \varphi = 1, F = 0.6$$

Solving the Model

```
# Solving the Ebell-Haefke model

%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
from scipy.optimize import root
plt.rcParams['figure.figsize'] = (6,6)

# Parameter values

r = 0.04/12
A = 0.327
α = 0.5
λ = 0.024
c = 0.173
β = 0.5
b = 0.626
φ = 1
F = 0.6

# Free Entry Condition
def FE(θ, n):
    return (1-β)*φ/(n-β) - r*n*F*(λ+A*(θ**(1-α)))/(A*(θ**(1-α)))
# Job Creation Condition
def JC(θ, n):
    return (r+λ)*c*(θ**α)/A + (1 - β)*b + β*c*θ - (1-β)*φ*(n-1)/(n-β)
# Unemployment rate
def Unemp(θ):
    return λ/(λ + A*(θ**(1 - α)))
```

```
# Solving the model

def func(x):
    f = [FE(x[0], x[1]),
         JC(x[0], x[1])]
    return f
sol = root(func, [1, 1.5])
sol.x

eq_theta = sol.x[0]
eq_n = sol.x[1]
eq_u = Unemp(eq_theta)

print(f'Equilibrium tightness is {eq_theta:.4f}')
print(f'Equilibrium number of firms is {eq_n:.4f}')
print(f'Equilibrium unemployment rate is {eq_u:.4f}')
```

```
Equilibrium tightness is 1.7498
Equilibrium number of firms is 15.6422
Equilibrium unemployment rate is 0.0526
```

Further Readings

- Ebell and Haefke, "Product Market Deregulation and the US Employment Miracle," *Review of Economic Dynamics*, 2009.
  - Available from NUCT.
- Blanchard and Giavazzi, "Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets," *Quarterly Journal of Economics*, 2003.

Reading Assignment

- Melitz, "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica*, 2003.
  - Section 2 (Setup of the model), Section 3 (Firm Entry and Exit) and Section 4 (Equilibrium in a Closed Economy).
  - Available from NUCT.