8200, 2023: basic Life Cycle Model with Intangible Capital

José Víctor Ríos Rull (joint with Vincenzo Quadrini)
Penn 2023

The issue

- Large Increase in Intangible Capital vs Tangible Capital

The issue

- Large Increase in Intangible Capital vs Tangible Capital
- Intangible Capital is more mobile across countries and can evade capital taxation more than tangible Capital

The issue

- Large Increase in Intangible Capital vs Tangible Capital
- Intangible Capital is more mobile across countries and can evade capital taxation more than tangible Capital
- What are the implications for the determination of capital income tax rates across countries?

The issue

- Large Increase in Intangible Capital vs Tangible Capital
- Intangible Capital is more mobile across countries and can evade capital taxation more than tangible Capital
- What are the implications for the determination of capital income tax rates across countries?
- Is it good to coordinate across countries?

The issue

- Large Increase in Intangible Capital vs Tangible Capital
- Intangible Capital is more mobile across countries and can evade capital taxation more than tangible Capital
- What are the implications for the determination of capital income tax rates across countries?
- Is it good to coordinate across countries?
- Answer these questions without assuming commitment on the part of governments.

Model 1

- Households stay in country j like $u(c, h)$ and discount β

Model 1

- Households stay in country j like $u(c,h)$ and discount β
- Country j multinationals (owned by its citizens). Observable output and inputs.

$$y^j = Q^j(m^{j,1}, m^{j,2}) \qquad\qquad q^{j,i} = \frac{\partial Q^j(m^{j,1}, m^{j,2})}{\partial m^{j,i}}.$$

$m^{j,i}$ intermediate input from country $i \in \{1,2\}$ for $Q^j(.,.)$ HD1. Only trade is via $m^{j,i}$

Model 1

- Households stay in country j like $u(c, h)$ and discount β
- Country j multinationals (owned by its citizens). Observable output and inputs.

$$y^j = Q^j(m^{j,1}, m^{j,2}) \qquad q^{j,i} = \frac{\partial Q^j(m^{j,1}, m^{j,2})}{\partial m^{j,i}}.$$

  $m^{j,i}$ intermediate input from country $i \in \{1, 2\}$ for $Q^j(.,.)$ HD1. Only trade is via $m^{j,i}$

- $$m^{j,i} = F(k_{j,i}, x_{j,i}, \ell_{j,i}) = z \left(k_{j,i}^{\alpha} \, x_{j,i}^{1-\alpha}\right)^{\theta} \ell_{j,i}^{1-\theta},$$

  k is tangible, x intangible capital, ℓ labor of multinational j in country n.

Model 1

- Households stay in country j like $u(c,h)$ and discount β
- Country j multinationals (owned by its citizens). Observable output and inputs.

$$y^j = Q^j(m^{j,1}, m^{j,2}) \qquad q^{j,i} = \frac{\partial Q^j(m^{j,1}, m^{j,2})}{\partial m^{j,i}}.$$

  $m^{j,i}$ intermediate input from country $i \in \{1,2\}$ for $Q^j(.,.)$ HD1. Only trade is via $m^{j,i}$

- $$m^{j,i} = F(k_{j,i}, x_{j,i}, \ell_{j,i}) = z \left(k_{j,i}^{\alpha} \; x_{j,i}^{1-\alpha}\right)^{\theta} \ell_{j,i}^{1-\theta},$$

  k is tangible, x intangible capital, ℓ labor of multinational j in country n.

- Profits are country specific

$$\pi^{j,i} \quad = \quad q^{j,i} \; F(k_{j,i}, x_{j,i}, \ell_{j,i}) - w^i \; \ell_{j,i} - \delta(k_{j,i} + x_{j,i}),$$

Model 1

- Households stay in country j like $u(c, h)$ and discount β
- Country j multinationals (owned by its citizens). Observable output and inputs.

$$y^j = Q^j(m^{j,1}, m^{j,2}) \qquad q^{j,i} = \frac{\partial Q^j(m^{j,1}, m^{j,2})}{\partial m^{j,i}}.$$

  $m^{j,i}$ intermediate input from country $i \in \{1, 2\}$ for $Q^j(.,.)$ HD1. Only trade is via $m^{j,i}$

-
$$m^{j,i} = F(k_{j,i}, x_{j,i}, \ell_{j,i}) = z \left(k_{j,i}^{\alpha} \; x_{j,i}^{1-\alpha}\right)^{\theta} \ell_{j,i}^{1-\theta},$$

  k is tangible, x intangible capital, ℓ labor of multinational j in country n.

- Profits are country specific

$$\pi^{j,i} = q^{j,i} \; F(k_{j,i}, x_{j,i}, \ell_{j,i}) - w^i \; \ell_{j,i} - \delta(k_{j,i} + x_{j,i}),$$

- Aggregate state is $\mathbf{s}$. A j firm's state is $\{k_{j,1}, k_{j,2}, x_j\}$. Both capitals are different

- $\tau^{A,j}$, Taxes on Corporation's Headquarters residual income $\pi^{A,j}$,

- $\tau^{A,j}$, Taxes on Corporation's Headquarters residual income $\pi^{A,j}$,
- $\tau^{K,j}$, Taxes on capital income $\pi^{K,i,j}$, (intermediate output net of labor income)

- $\tau^{A,j}$, Taxes on Corporation's Headquarters residual income $\pi^{A,j}$,
- $\tau^{K,j}$, Taxes on capital income $\pi^{K,i,j}$, (intermediate output net of labor income)
- $\tau^{\ell,j}$, Taxes on Labor income where it is used $\pi^{j,i}$, (Capital income where produced)

Firm's Problem: State $\{k_1, k_2, x\}$

- Dynamic Problem

$$
\begin{aligned}
V^j(\mathbf{s}, k_1, k_2, x; \Psi) &= \max_{i_1, i_2, n} \left\{ d + \left(R^j\right)^{-1} V^j(\mathbf{s}', k_1', k_2', x'; \Psi) \right\} \\
& \quad \text{s.t.} \\
d &= (1 - \tau_j^A) \left[(1 - \tau_1^K)\pi^{j,1} + (1 - \tau_2^K)\pi^{j,2} \right] - i_1 - i_2 - n, \\
k_i' &= k_i + i_i, \qquad i \in \{1, 2\} \\
x' &= (1 - \delta)x + n, \\
\tau &= \Psi(\mathbf{s}), \\
\mathbf{s}' &= \Phi(\mathbf{s}; \Psi).
\end{aligned}
$$

FOC

- Static part yields $q^{j,i}\ F_\ell(k_{j,i}, x_{j,i}, \ell_{j,i}) = w^i, \qquad i \in \{1, 2\}$ and

$$\left[q^{j,1}\ \ F_x(k_{j,1}, x_{j,1}, \ell_{j,1})\ -\ \delta\right]\ (1\ -\ \tau^{K,1})\ \ =\ \ \left[q^{j,2}\ \ F_x(k_{j,2}, x_{j,2}, \ell_{j,2})\ -\ \delta\right](1\ -\ \tau^{K,2}).$$

FOC

- Static part yields $q^{j,i}\ F_\ell(k_{j,i}, x_{j,i}, \ell_{j,i}) = w^i, \qquad i \in \{1,2\}$ and

$$\left[q^{j,1}\ \ F_x(k_{j,1}, x_{j,1}, \ell_{j,1})\ -\ \delta\right]\ \ (1\ -\ \tau^{K,1})\ \ =\ \ \left[q^{j,2}\ \ F_x(k_{j,2}, x_{j,2}, \ell_{j,2})\ -\ \delta\right](1\ -\ \tau^{K,2}).$$

- Dynamic FOCS

$$\left[1 + (1-\tau^A_{j,t})(1-\tau^K_{i,t})\frac{\partial \pi^{j,i\prime}}{\partial k_i'}\right] \quad = \quad R^j,$$

$$\left[1 + (1-\tau^A_{j,t})(1-\tau^K_{i,t})\frac{\partial \pi^{j,i\prime}}{\partial x'}\right] \quad = \quad R^j,$$

with $i \in \{1,2\}$.

Households and Equilibrium

$$\Omega^j(\mathbf{s}, a; \Psi) = \max_{c,h,a'} \left\{ u(c,h) + \beta\ \Omega^j\left(\mathbf{s}', a'; \Psi\right) \right\} \quad \text{s.t.}$$

$$\begin{aligned}
c &= (1-\tau^{Lj}) w^j h + (d^j + p^j) a + T^j - p^j a', \\
\tau &= \Psi(\mathbf{s}), \\
\mathbf{s}' &= \Phi(\mathbf{s}; \Psi),
\end{aligned}$$

with FOCs

$$\begin{aligned}
-u_h(c,h) &= w^j (1-\tau^{Lj})\, u_c(c,h) \\
u_c(c,h) p^j &= \beta u_c(c', h')(d^{j\prime} + p^{j\prime}).
\end{aligned}$$

- State $\mathbf{s}$ is capital in each country.
- **Equilibrium** is standard and generates $\mathbf{s}' = G(\mathbf{s}; \Psi)$, when $a^j = V^j(\mathbf{s};' \Psi)$

The determination of policies: Arbitrary taxes today

- Governments play Nash with each other. Take as given future policy **rules**

The determination of policies: Arbitrary taxes today

- Governments play Nash with each other. Take as given future policy **rules**
- Need to define notion of one–period-only deviation to τ

$$
\begin{aligned}
\widehat{V}_j(\mathbf{s}, k_1, k_2, x, \tau; \Psi) &= \max_{i_k, i_x} \left\{ d + \left(R^j(\mathbf{s}, \tau) \right)^{-1} V\left(\mathbf{s}', k_1', k_2', x'; \Psi\right) \right\} \qquad \text{s.t.} \\
d &= \widehat{\pi}_j(\mathbf{s}, k_1, k_2, x, \tau) - i_1 - i_2 - i_x, \\
k_i' &= (1-\delta) k_i + i_i, \\
x' &= (1-\delta) x + i_x, \\
\mathbf{s}' &= \widehat{\Phi}(\mathbf{s}, \tau; \Psi), \\
\tau^L &= \widehat{\varphi}(\mathbf{s}, \tau; \Psi).
\end{aligned}
$$

The determination of policies: Arbitrary taxes today

- Governments play Nash with each other. Take as given future policy **rules**
- Need to define notion of one–period-only deviation to τ

$$
\begin{aligned}
\widehat{V}_j(\mathbf{s}, k_1, k_2, x, \tau; \Psi) &= \max_{i_k, i_x} \left\{ d + \left(R^j(\mathbf{s}, \tau) \right)^{-1} \; V\left(\mathbf{s}', k_1', k_2', x'; \Psi\right) \right\} \qquad \text{s.t.} \\
d &= \widehat{\pi}_j(\mathbf{s}, k_1, k_2, x, \tau) - i_1 - i_2 - i_x, \\
k_i' &= (1-\delta) k_i + i_i, \\
x' &= (1-\delta) x + i_x, \\
\mathbf{s}' &= \widehat{\Phi}(\mathbf{s}, \tau; \Psi), \\
\tau^L &= \widehat{\varphi}(\mathbf{s}, \tau; \Psi).
\end{aligned}
$$

- Households

$$
\begin{aligned}
\widehat{\Omega}_j(\mathbf{s}, a, \tau; \Psi) &= \max_{c, h, a'} \left\{ u(c, h) + \beta \Omega_j\left(\mathbf{s}', a'; \Psi\right) \right\} \qquad \text{s.t.} \\
c &= (1 - \tau_j^L) w_j h + (d_j + p_j) a + T_j - p_j a', \\
\mathbf{s}' &= \widehat{\Phi}(\mathbf{s}, \tau; \Psi), \\
\tau^L &= \widehat{\varphi}(\mathbf{s}, \tau; \Psi),
\end{aligned}
$$

The determination of policies: Arbitrary taxes today

- Governments play Nash with each other. Take as given future policy **rules**
- Need to define notion of one–period-only deviation to τ

$$\begin{aligned}
\widehat{V}_j(\mathbf{s}, k_1, k_2, x, \tau; \Psi) &= \max_{i_k, i_x} \left\{ d + \left(R^j(\mathbf{s}, \tau) \right)^{-1} \ V\left(\mathbf{s}', k_1', k_2', x'; \Psi\right) \right\} \qquad \text{s.t.} \\
d &= \widehat{\pi}_j(\mathbf{s}, k_1, k_2, x, \tau) - i_1 - i_2 - i_x, \\
k_i' &= (1-\delta) k_i + i_i, \\
x' &= (1-\delta) x + i_x, \\
\mathbf{s}' &= \widehat{\Phi}(\mathbf{s}, \tau; \Psi), \\
\tau^L &= \widehat{\varphi}(\mathbf{s}, \tau; \Psi).
\end{aligned}$$

- Households

$$\begin{aligned}
\widehat{\Omega}_j(\mathbf{s}, a, \tau; \Psi) &= \max_{c,h,a'} \left\{ u(c,h) + \beta \Omega_j\left(\mathbf{s}', a'; \Psi\right) \right\} \qquad \text{s.t.} \\
c &= (1-\tau_j^L) w_j h + (d_j + p_j) a + T_j - p_j a', \\
\mathbf{s}' &= \widehat{\Phi}(\mathbf{s}, \tau; \Psi), \\
\tau^L &= \widehat{\varphi}(\mathbf{s}, \tau; \Psi),
\end{aligned}$$

- Yields equilibrium $\widehat{G}(\mathbf{s}, \tau; \Psi)$

- $$\max_{\tau^{K,j}} \ \widehat{\Omega}^j\left(\mathbf{s}, 1, \tau_1, \tau_2; \Psi\right) \qquad \text{s.t.}$$
$$\tau^{K,1}(\pi^{1,1} + \pi^{2,1}) + \tau^{A,1}\left[(1-\tau^{K,1})\pi^{1,1} + (1-\tau^{K,2})\pi^{1,2}\right] + \tau^{L,1} w^1 (L_{1,1} + L_{2,1}) = T^1,$$
$$\tau^{K,2}(\pi^{1,2} + \pi^{2,2}) + \tau^{A,2}\left[(1-\tau^{K,1})\pi^{2,1} + (1-\tau^{K,2})\pi^{2,2}\right] + \tau^{L,2} w_2 (L_{1,2} + L_{2,2}) = T^2.$$

Policy determination: Government Problem & Pol-Ec Equil

- $$\max_{\tau^{K,j}} \widehat{\Omega}^j\Big(\mathbf{s}, 1, \tau_1, \tau_2; \Psi\Big) \qquad \text{s.t.}$$
$$\tau^{K,1}(\pi^{1,1} + \pi^{2,1}) + \tau^{A,1}\Big[(1-\tau^{K,1})\pi^{1,1} + (1-\tau^{K,2})\pi^{1,2}\Big] + \tau^{L,1} w^1 (L_{1,1} + L_{2,1}) = T^1,$$
$$\tau^{K,2}(\pi^{1,2} + \pi^{2,2}) + \tau^{A,2}\Big[(1-\tau^{K,1})\pi^{2,1} + (1-\tau^{K,2})\pi^{2,2}\Big] + \tau^{L,2} w_2 (L_{1,2} + L_{2,2}) = T^2.$$
- First Step is to get a Nash Equil of both Countries Policies.

- $$\max_{\tau^{K,j}} \widehat{\Omega}^j\left(\mathbf{s}, 1, \tau_1, \tau_2; \Psi\right) \qquad \text{s.t.}$$
$$\tau^{K,1}(\pi^{1,1} + \pi^{2,1}) + \tau^{A,1}\left[(1-\tau^{K,1})\pi^{1,1} + (1-\tau^{K,2})\pi^{1,2}\right] + \tau^{L,1} w^1 (L_{1,1} + L_{2,1}) = T^1,$$
$$\tau^{K,2}(\pi^{1,2} + \pi^{2,2}) + \tau^{A,2}\left[(1-\tau^{K,1})\pi^{2,1} + (1-\tau^{K,2})\pi^{2,2}\right] + \tau^{L,2} w_2 (L_{1,2} + L_{2,2}) = T^2.$$
- First Step is to get a Nash Equil of both Countries Policies.
- Let them be $\tau = \psi(\mathbf{s}, \tau; \Psi)$

- $$\max_{\tau^{K,j}} \ \widehat{\Omega}^j\left(\mathbf{s}, 1, \tau_1, \tau_2; \Psi\right) \qquad \text{s.t.}$$
$$\tau^{K,1}(\pi^{1,1}+\pi^{2,1})+\tau^{A,1}\left[(1-\tau^{K,1})\pi^{1,1}+(1-\tau^{K,2})\pi^{1,2}\right]+\tau^{L,1}w^1(L_{1,1}+L_{2,1}) = T^1,$$
$$\tau^{K,2}(\pi^{1,2}+\pi^{2,2})+\tau^{A,2}\left[(1-\tau^{K,1})\pi^{2,1}+(1-\tau^{K,2})\pi^{2,2}\right]+\tau^{L,2}w_2(L_{1,2}+L_{2,2}) = T^2.$$

- First Step is to get a Nash Equil of both Countries Policies.

- Let them be $\tau = \psi(\mathbf{s}, \tau; \Psi)$

- The equilibrium time-consistent policy rule satisfies $\Psi(\mathbf{s}) = \psi(\mathbf{s}; \Psi)$.

Alternative Modelization

- Asset Holdings across Countries (same R

- Asset Holdings across Countries (same R
- Intangible Capital is not rival

Alternative Modelization

- Asset Holdings across Countries (same R
- Intangible Capital is not rival
- Sell Locally.

Alternative Modelization

- Asset Holdings across Countries (same R
- Intangible Capital is not rival
- Sell Locally.
- Transfer Pricing not Perfectly Observable

Alternative Modelization

- Asset Holdings across Countries (same R
- Intangible Capital is not rival
- Sell Locally.
- Transfer Pricing not Perfectly Observable
- Production of x Good has a positive Externality

- Asset Holdings across Countries (same R
- Intangible Capital is not rival
- Sell Locally.
- Transfer Pricing not Perfectly Observable
- Production of x Good has a positive Externality
- Legacy Investment makes it easier to post the factor in that country

- Asset Holdings across Countries (same R
- Intangible Capital is not rival
- Sell Locally.
- Transfer Pricing not Perfectly Observable
- Production of x Good has a positive Externality
- Legacy Investment makes it easier to post the factor in that country
- No Notion of $j-$country firms

Model 2

- Country j, generic firm, note $x^{j,m}$ is non-rival. Output is

$$y^{j,i} = F^j(k_{j,i}, x_j, \ell_{j,i}) = z \left(k_{j,i}^{\alpha}\ x_{j,i}^{1-\alpha}\right)^{\theta_k} \ell_{j,i}^{1-\theta_\ell},$$

Model 2

- Country j, generic firm, note $x^{j,m}$ is non-rival. Output is

$$y^{j,i} = F^j(k_{j,i}, x_j, \ell_{j,i}) = z \left(k_{j,i}^{\alpha} \; x_{j,i}^{1-\alpha} \right)^{\theta_k} \ell_{j,i}^{1-\theta_\ell},$$

- Intangible Capital is home produced

$$x^{j\prime} = (1-\delta)x^j + f^j\left(\ell_{j,x}\right)$$

Model 2

- Country j, generic firm, note $x^{j,m}$ is non-rival. Output is

$$y^{j,i} = F^j(k_{j,i}, x_j, \ell_{j,i}) = z \left(k_{j,i}^{\alpha}\ x_{j,i}^{1-\alpha}\right)^{\theta_k} \ell_{j,i}^{1-\theta_\ell},$$

- Intangible Capital is home produced

$$x^{j\prime} = (1-\delta)x^j + f^j\left(\ell_{j,x}\right)$$

- There is an Armington (CES) aggregator for final output in

$$Q^j = \left(Y^{j,1}, Y^{j,2}\right)$$

Model 2

- Country j, generic firm, note $x^{j,m}$ is non-rival. Output is

$$y^{j,i} = F^{j}(k_{j,i}, x_j, \ell_{j,i}) = z \left(k_{j,i}^{\alpha} \; x_{j,i}^{1-\alpha}\right)^{\theta_k} \ell_{j,i}^{1-\theta_\ell},$$

- Intangible Capital is home produced

$$x^{j\prime} = (1-\delta)x^{j} + f^{j}\left(\ell_{j,x}\right)$$

- There is an Armington (CES) aggregator for final output in

$$Q^{j} = \left(Y^{j,1}, Y^{j,2}\right)$$

- Profits in each country are allocated using transfer pricing. There are quadratic costs from deviating too much from standard accounting prices q^*

$$\begin{aligned}
\pi^{j,j} &= p^{j} \; F^{j,j}\left(k_{j,j}, x_j, \ell_{j,j}\right) - w^{j} \; \ell_{j,j} - \delta k_{j,j} + q^{j} \; x_j - C\left(q^{j} - q^{*}, x_j\right) \\
\pi^{j,i} &= p^{j} \; F^{j,i}\left(k_{j,i}, x_j, \ell_{j,i}\right) - w^{i} \; \ell_{j,i} - \delta k_{j,i} - q^{j} \; x_j
\end{aligned}$$

Model 2

- Country j, generic firm, note $x^{j,m}$ is non-rival. Output is

$$y^{j,i} = F^j(k_{j,i}, x_j, \ell_{j,i}) = z \left(k_{j,i}^{\alpha}\ x_{j,i}^{1-\alpha}\right)^{\theta_k} \ell_{j,i}^{1-\theta_\ell},$$

- Intangible Capital is home produced

$$x^{j\prime} = (1-\delta)x^j + f^j\left(\ell_{j,x}\right)$$

- There is an Armington (CES) aggregator for final output in

$$Q^j = \left(Y^{j,1}, Y^{j,2}\right)$$

- Profits in each country are allocated using transfer pricing. There are quadratic costs from deviating too much from standard accounting prices q^*

$$\begin{aligned}
\pi^{j,j} &= p^j\ F^{j,j}\left(k_{j,j}, x_j, \ell_{j,j}\right) - w^j\ \ell_{j,j} - \delta k_{j,j} + q^j\ x_j - C\left(q^j - q^*, x_j\right) \\
\pi^{j,i} &= p^j\ F^{j,i}\left(k_{j,i}, x_j, \ell_{j,i}\right) - w^i\ \ell_{j,i} - \delta k_{j,i} - q^j\ x_j
\end{aligned}$$

- Aggregate state is $\mathbf{s}$. A j firm's state is $\{k_{j,1}, k_{j,2}, x_j\}$.

Government

- $\tau^{A,j}$, Taxes on Corporation's Headquarters residual income $\pi^{A,j}$,

- $\tau^{A,j}$, Taxes on Corporation's Headquarters residual income $\pi^{A,j}$,
- $\tau^{K,j}$, Taxes on capital income $\pi^{K,i,j}$, (intermediate output net of labor income)

- $\tau^{A,j}$, Taxes on Corporation's Headquarters residual income $\pi^{A,j}$,
- $\tau^{K,j}$, Taxes on capital income $\pi^{K,i,j}$, (intermediate output net of labor income)
- $\tau^{\ell,j}$, Taxes on Labor income where it is used $\pi^{j,i}$, (Capital income where produced)

- $\tau^{A,j}$, Taxes on Corporation's Headquarters residual income $\pi^{A,j}$,
- $\tau^{K,j}$, Taxes on capital income $\pi^{K,i,j}$, (intermediate output net of labor income)
- $\tau^{\ell,j}$, Taxes on Labor income where it is used $\pi^{j,i}$, (Capital income where produced)
- Added issue of how difficult is to set $q^{j,i}$. We will get to this later.

Firm's Problem: State $\{k_1, k_2, x\}$

- Static Problem involves choosing q^j and it is interconnected across countries. Let $\pi^{j,i}(\mathbf{s}, \ell_{j,i}, q^j)$ yield the static profits conditional on choices

Firm's Problem: State $\{k_1, k_2, x\}$

- Static Problem involves choosing q^j and it is interconnected across countries. Let $\pi^{j,i}(\mathbf{s}, \ell_{j,i}, q^j)$ yield the static profits conditional on choices

- Dynamic Problem

$$
\begin{aligned}
V^j(\mathbf{s}, k_1, k_2, x; \Psi) &= \max_{\substack{\ell_1,\ell_2,q \\ i_1,i_2,\ell_x}} \left\{ d + \left(R^j\right)^{-1} V^j(\mathbf{s}', k_1', k_2', x'; \Psi) \right\} \qquad \text{s.t.} \\
d &= (1-\tau_j^A)\left[(1-\tau_1^K)\pi^{j,1}(\mathbf{s}, \ell_1, q^j) + (1-\tau_2^K)\pi^{j,2}(\mathbf{s}, \ell_2, q^j)\right] - i_1 - i_2 - w^j \ell_x, \\
k_i' &= k_i + i_i, \qquad i \in \{1,2\} \\
x' &= (1-\delta)x + f(\ell_x), \\
\tau &= \Psi(\mathbf{s}), \\
\mathbf{s}' &= \Phi(\mathbf{s}; \Psi).
\end{aligned}
$$

Firm's FOCs:

- Static

$$
\begin{aligned}
w^i &= (1-\tau_j^A)\ (1-\tau_i^K)\ p^j\ F_\ell^{j,i} \\
w^j &= (1-\tau_j^A)\ (1-\tau_j^K)\ p^j\ F_\ell^{j,j} \\
(1-\tau_j^A)\ (1-\tau_i^K)\ x_j &= (1-\tau_j^A)\ (1-\tau_j^K)\ \left[x_j - \mathcal{C}_q\right]
\end{aligned}
$$

Firm's FOCs:

- Static

$$w^i = (1-\tau_j^A)\ (1-\tau_i^K)\ p^j\ F_\ell^{j,i}$$
$$w^j = (1-\tau_j^A)\ (1-\tau_j^K)\ p^j\ F_\ell^{j,j}$$
$$(1-\tau_j^A)\ (1-\tau_i^K)\ x_j = (1-\tau_j^A)\ (1-\tau_j^K)\ \left[x_j - \mathcal{C}_q\right]$$

- Dynamic FOCS

$$R' = \left[1 + (1-\tau_j^{A\prime})(1-\tau_i^{K\prime})\ p^{j\prime}\, F_{k_i'}^{j,i}\right],$$
$$R' = \left[1 + (1-\tau_j^{A\prime})(1-\tau_j^{K\prime})\ p^{j\prime}\, F_{k_j'}^{j,j}\right],$$
$$R' = 1 + (1-\tau_j^{A\prime})p^{j\prime}\left[(1-\tau_i^{K\prime})\ \left(F_{x'}^{j,i} - q^{j\prime}\right) F_{x'}^{j,i} + (1-\tau_j^{K\prime})\ \left(F_{x'}^{j,j} + q^{j\prime}\right)\right],$$