Role of Networks in Structural Transformation

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ECO 2302 Research Proposal

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Motivation

- Structural Transformation
  - Process of moving labor across an economic sectors during the development process
  - Forces driving ST
    - Supply side: Sectoral TFP/labor productivity
    - Demand side: Income effect on sectoral consumption

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- Questions:
  - How is sectoral productivity determined through input-output (IO) network?
  - What is the role of income effect in a model with production network?
  - Does network change over stages of development and be a channel behind structural change?
  - How does sectoral productivity in 1 country affect other's productivity and structural transformation patterns?

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- Conclusions and next steps

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$$X_i = T_i \left(\frac{L_i}{\gamma_i}\right)^{1-\gamma_i} \left(\frac{M_i}{\gamma_i}\right)^{\gamma_i}$$

$$\text{s.t.} \quad M_i = \prod_{j=1}^{N} \left(\frac{X_{ij}}{\beta_{ij}}\right)^{\beta_{ij}}, \quad \text{with} \quad \sum_{j=1}^{N} \beta_{ij} = 1$$

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- Firms in each sectors are perfectly competitive

Households

- Households have nonhomothetic preferences implicitly defined as

$$\left[\sum_{i=1}^{N} \varphi_i^{\frac{1}{\sigma}} \left(\frac{C_i}{U^{\epsilon_i}}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} = 1$$

- Homethetic CES preference is the special case when $\epsilon_i = 1 \quad \forall i$

Competitive Equilibrium

Competitive Equilibrium is defined as a set of allocations $\{C_i\}_{i=1}^N$, $\{X_i\}_{i=1}^N$, $\{X_{ij}\}_{i,j=1}^N$ and set of prices $\{P_i\}_{i=1}^N$ (wages normalized to 1) such that

- Given prices $\{P_i\}_{i=1}^N$, $\{X_i\}_{i=1}^N$ and $\{X_{ij}\}_{i,j=1}^N$ solves firm's problem
- Given prices $\{P_i\}_{i=1}^N$, $\{C_i\}_{i=1}^N$ maximizes household's utility under budget constraint
- Goods markets clear

$$X_i = C_i + \sum_{j=1}^{N} X_{ji} \quad \forall i = 1, ..., N$$

- Labor market clears

$$\sum_{i=1}^{N} L_i = 1$$

Firm's Prime Problem

- FOCs imply

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$$X_i = T_iP_iX_i\prod_{j=1}^{N}P_j^{-\gamma_i\beta_{ij}} \quad \Rightarrow \quad P_i = \frac{1}{T_i}\prod_{j=1}^{N}P_j^{\gamma_i\beta_{ij}}$$

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- Solve for P_i

$$P_i = \prod_{j=1}^{N} T_j^{\boldsymbol{\Omega}_{ij}}, \quad \text{where} \quad \boldsymbol{\Omega} \equiv (\gamma' \boldsymbol{\beta} - I)^{-1}$$

Household's Problem

- FOCs yield

$$\frac{P_i C_i}{P_j C_j} = \frac{\varphi_i}{\varphi_j} \left(\frac{P_i}{P_j} \right)^{1-\sigma} U^{\epsilon_i - \epsilon_j}$$

- Combining with budget constraint $\sum_{i=1}^{N} P_i C_i = 1$ and definition of U, we can solve for C_i
- The relative prices and income level determine sectoral expenditure share

Market Clearing

- Combine with market clearing condition

$$P_i X_i = P_i C_i + \sum_{j=1}^{N} P_i X_{ji} = P_i C_i + \sum_{j=1}^{N} \gamma_j \beta_{ji} P_j X_j$$

- We can solve for $P_i X_i$ as function of $\{P_i C_i\}_{i=1}^{N}$

$$\mathbf{PX} = \mathbf{PC} + diag(\gamma)\beta\mathbf{PX} \quad \Rightarrow \quad \mathbf{PX} = [I - diag(\gamma)\beta]^{-1}\mathbf{PC}$$

- With the prices P_i and the firm's problem, we can solve for X_i and X_{ij}

Supply Side: Sectoral Labor Productivity

- Define Y_i as real value-added in sector i by

$$P_i Y_i \equiv P_i X_i - \sum_{j=1}^{N} P_j X_{ij} = (1 - \gamma_i) P_i X_i = L_i$$

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$$A_i \equiv \frac{Y_i}{L_i} = \frac{1}{P_i}$$

- As a result, we can decompose sectoral labor productivity

$$A_i = \prod_{j=1}^{N} T_j^{-\mathbf{\Omega}_{ij}}$$

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  - weighted by the intensity of input linkages
- Cross-country differences in sectoral labor productivity could be explained by
  - Difference in sectoral TFPs
  - Difference in network structures $->$ Network structures differ across stages of development?

Demand Side: Income Effect

- In this model, consumption (C_i) and value-added (Y_i) are different

$$\text{Consumption:} \quad C_i = X_i - \sum_{j=1}^{N} X_{ji}$$

$$\text{Value-Added:} \quad Y_i = X_i - \sum_{j=1}^{N} \frac{P_j X_{ij}}{P_i}$$

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- Labor share L_i is determined by value-added share $P_i Y_i$ not by $P_i C_i$
  - $L_i = P_i Y_i = (1-\gamma_i) P_i X_i$
  - $\mathbf{PX} = [I - diag(\gamma)\beta]^{-1}\mathbf{PC}$

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- High sectoral share is the result of
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  - Intensive supply to other sectors with high expenditure demand
- Different implications for income effects from models without network
  - Income elasticity for some sectors may be smaller
  - Downstream linkages potentially capture some effects $\rightarrow$ Income effect on network structure?

Conclusions

- Role of production networks in structural change
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- Role of production networks in structural change
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- Next steps:
  - Use World Input-Output Table (WIOD) data
  - Document patterns in cross-country production networks over time
  - Quantify the role of network structure in accounting for cross-country heterogeneous structural change patterns