Dynamic Demand for Capital and Labor: Evidence from Chinese Industrial Firms

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Abstract
This paper employs a structural econometric approach to study the joint dynamic demand for capital and labor in Chinese firms. We recover key structural parameters in a dynamic model of interrelated factor demands subject to joint convex and non-convex costs. The model is able to replicate the stylized facts directly observed from Chinese manufacturing firm-level data over the period 1998-2007. Our estimates reveal that frictions exhibit significant convex and fixed costs when adjusting capital or employment stock. Moreover, the adjustments in two factor inputs are inter-related, and adjusting capital and labor simultaneously is more costly than adjusting two inputs sequentially. Our counterfactual analysis suggests that removing the frictions in both capital and labor adjustments will lead to a 1% increase in aggregate total factor productivity (TFP) and a 7% increase in aggregate output.

Motivation
- Existing literature studies dynamics of capital or labor separately
- Labor dynamics: Hembree et al. (1996), Cooper et al. (2009), Cooper et al. (2018)
- Investment dynamics: Cooper et al. (2008), Aker et al. (2015), Wu et al. (2018), Tang et al. (2021)
- Chinese firms experienced dramatic changes in capital and labor markets
- Labor market: reform in household registration system, break “iron-rice bowl” in state sector, labor law revision
- Capital market: huge inflow of FDI, state firms reform, investment tax
- This paper studies the joint dynamics of capital and labor and their impact on aggregate TFP

Main Takeaways
- Recover structural parameters in a dynamic model, so it can replicate the stylized facts directly observable from Chinese firm-level data from 1998 to 2007
- Joint convex and fixed costs are significant; adjustments in capital and labor are inter-related
- Simultaneous adjustment is more costly than sequential adjustment
- Counterfactual: aggregate TFP 1% by 1% and aggregate output increases by 7% if all adj. costs are removed

Data and Variables
- Annual Surveys of Industrial Production 1998-2007: all state firms and non-state firms with annual revenue more than $600,000
- Investment rate: \( i - \frac{K_{t+1} - K_t}{K_t} \approx \ln K_{t+1} - \ln K_t + \delta \)
- Employment growth rate: \( \frac{L_{t+1} - L_t}{L_t} \approx \ln L_{t+1} - \ln L_t \)

Stylized Facts
- Table 1: Moments on investment rate and employment growth rate
- Table 2: Estimation of structural parameters in the model
- Table 3: Compare model with data
- Table 4: Estimation of structural parameters in various sub-samples

A Dynamic Model
- In a stationary equilibrium, the firm’s problem is described by the following Bellman equation:
  \[
  V(A, K, L) = \max [AK^{\alpha}L^{1-\alpha} - LW_0 - J - C(A, K, L, L) + \beta EV(A, K', L')]
  \]
  Where \( K' = (1-\delta)K + \delta L \)
  \( \ln A = -\mu \gamma \ln A + c - N(0, 1) \)

A general functional form for the adjustment costs when firms adjust capital, labor, or both is:

\[
C(I) = \begin{cases} 
C(I) &= \frac{C^0 - \delta C}(A, K, L, 1) - \frac{C^0 - \delta C}(A, K, L, 0) \\
&\text{if} I = 0 \\
C(I) &= \frac{C^0 - \delta C}(A, K, L, 1) - \frac{C^0 - \delta C}(A, K, L, 0) \\
&\text{if} I = 0 \\
C(I) &= C(I) - \frac{\delta C}{C}(A, K, L, 1) - \frac{\delta C}{C}(A, K, L, 0) \\
&\text{if} I = 0
\end{cases}
\]

- \( C(I) \) represents fixed-convex cost, \( \delta C(I) \) represents convex cost, when adjusting K (alone)
- \( C(I) \) is joint fixed cost, \( \delta C(I) \) is joint convex cost, extra cost with simultaneous adjustment in K and L
- \( \delta C(I) < 0 \) and \( \delta C(I) < 0 \) ⇒ simultaneous adjustment is cost-saving
- \( \delta C(I) > 0 \) and \( \delta C(I) < 0 \) ⇒ simultaneous adjustment is cost-saving
- The firm’s problem is at intensive margin: \( V(A, K, L) = \max [V^0(A, K, L), V^0(A, K, L)] \)
- The firm’s problem is at extensive margin: \( \{\text{find } (K, L) \} \in V^0(A, K, L), \text{find } K \in v^0(A, K, L), \text{and find } L \in v^0(A, K, L) \)

Robustness Check
- Table 4: Estimation of structural parameters in various sub-samples

Counterfactual
- At stationary equilibrium, joint fixed cost⇒ joint quasiparadigm cost
- Sequential adjustment is preferred over simultaneous adjustment

Table 1: Moments on investment rate and employment growth rate

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Median</th>
<th>Std Dev</th>
<th>90% CI Upper</th>
<th>90% CI Lower</th>
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</thead>
<tbody>
<tr>
<td>Revenue less than $600,000</td>
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<tr>
<td>Investment rate</td>
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<tr>
<td>Employment growth rate</td>
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Table 2: Estimation of structural parameters in the model

Table 3: Compare model with data

Table 4: Estimation of structural parameters in various sub-samples