Dynamic Labor Demand with Intangible Capital

Juan Castellanos

European University Institute

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Motivation

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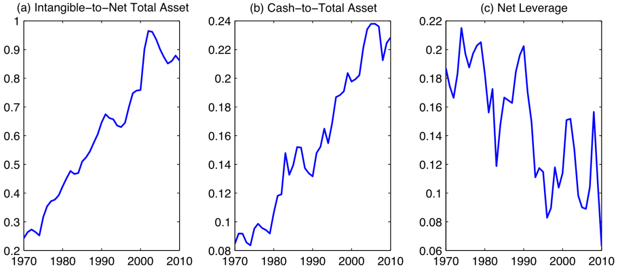
- *Technological advancements* since the 1980 have led to some interesting **trends**:
  * **Rise in intangible capital** relative to other forms of capital (Corrado and Hulten, 2010)
  * The increase in intangibles has also lead to an **increase in cash holdings** of US corporations (Falato et al. (2022)
  * **Growing demand for skilled labor**?
    - vast increase in the supply of skilled workers, but still increasing skill premium (Autor, 2014; Autor, 2019)
    - labor income share of high skilled workers constant, but total labor income share fall (Eisfeldt et al., 2022)
- These trends may have shaped **how corporations adjust their workforce in response to adverse shocks** (e.g. contractionary monetary policy)
  * Skilled workers help develop intangible capital (skill-intangible complementarity)
  * Skilled workers are harder to find and costlier to fire
  * Cash intensive firms don't need extra debt to pay for the wage bill, easier to keep workers
  * <u>Implication</u>: more skilled labor hoarding? is skilled employment less volatile?

Falato et al. (2022, JoF)

Figure 1: Intangible Capital, Cash Holdings and Leverage

The figure depicts the long-run trend in the intangible capital ratio (relative to total assets net of cash) in Panel (a), the cash ratio (relative to total assets) in Panel (b), and the net debt ratio (relative to total assets) in Panel (c). The ratios are plotted as equal-weighted averages across all firms in the sample in each year. Total assets refer to the balance sheet book value of total assets. The sample includes all Compustat firm-year observations from 1970 to 2010 with positive values for the book value of total assets and sales revenue for firms incorporated in the United States. Financial firms (SIC code 6000-6999) and utilities (SIC codes 4900-4999) are excluded from the sample, yielding a panel of 176,877 observations for 18,535 unique firms. Variable definition details are provided in Appendix B.



Autor (2022)

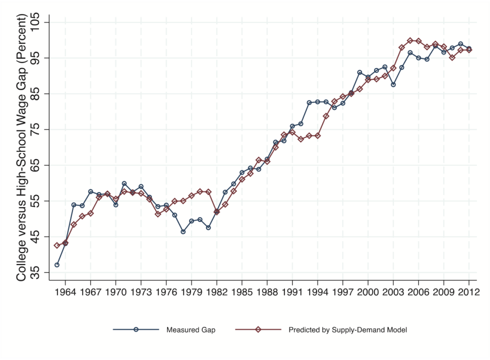


Figure 1: The supply of college graduates and the U.S. college/high school premium, 1963–2012

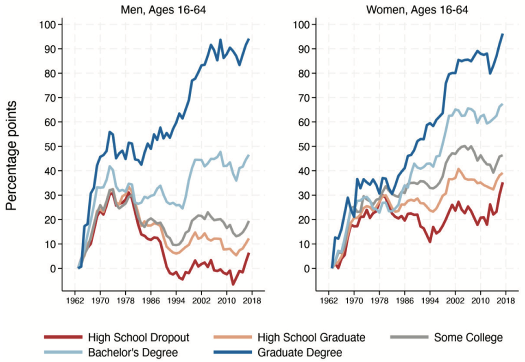


Figure 2: Cumulative percentage point changes in real mean weekly earnings of full-time, full-year workers ages 18–64, United States, 1963–2017

Model

Technology

- The firm combines **two types of capital**, tangible K^T and intangible K^N, and **two types of labor**, skilled N^S and unskilled N^U, to produce output.

- Firm's revenue function is given by

$$\Pi(Z, K^T, K^N, N^S, N^U) = Z^{1-\gamma}\Phi\left(K^T, K^N, N^S, N^U\right)^{\gamma} - Z\,F^o \tag{1}$$

  where Z is the idiosyncratic productivity shock of the firm, $Z\,F^o$ is the fixed operating costs and $\Phi\left(K^T, K^N, N^S, N^U\right)$ is an aggregator that combines all the four factors of production.

- Assume that it is Cobb-Douglas over tangible capital and CES over three remaining inputs. Similar to Krusell et al. (2000)

$$\Phi\left(K^T, K^N, N^S, N^U\right) = \left(K^T\right)^{\alpha}\left[\mu\left(N^u\right)^{\sigma} + (1-\mu)\left(\lambda\left(K^N\right)^{\rho} + (1-\lambda)\left(N^S\right)^{\rho}\right)^{\sigma/\rho}\right]^{(1-\alpha)/\rho} \tag{2}$$

  * $\frac{1}{1-\sigma}$: elasticity of substitution between intangibles (or skilled labor) and unskilled labor
  * $\frac{1}{1-\rho}$: elasticity of substitution between intangibles and skilled labor
  * $\sigma > \rho \implies$ skill-intangible complementarity

Real frictions: adjustment costs (only labor)

- **Labor adjustment** involves *fixed (non-convex) cost*, F_i^N, linear adjustment costs χ and quadratic adjustment costs ν. Thus, total labor adjustment costs are given by:

$$C(N^U, N^S, N^U_{-1}, N^S_{-1}) = \sum_{i=U,S} C_i(N^i, N^i_{-1}) \tag{3}$$

where

$$C_i(N^i, N^i_{-1}) = F_i^N + \chi(N^i - N^i_{-1}) + \nu \left(\frac{N^i - N^i_{-1}}{N^i_{-1}} \right)^2 N^i_{-1} \tag{4}$$

- **Capital adjustment** is *frictionless*. The low of motion for each type of capital is given by:

$$I^K = K^{j'} - (1 - \delta_j)K^j \tag{5}$$

where $j = \{T, N\}$ and δ_j is the depreciation rate ($\delta_N > \delta_T$).

Financial frictions: collateral constraint

- B is the firm net-debt position
  - $B > 0 \implies$ debt
  - $B < 0 \implies$ cash holdings

- Intangible capital cannot be used as collateral

- Only ***tangible* capital** constitute **eligible collateral**

$$B' \leq B^{limit}\left(K^{T'}\right) \equiv \frac{(1-\delta_T)K^{T'}}{1+r} \tag{6}$$

where r is the risk-free rate

Dynamic Programing Problem I

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- The value of the firm that decides to ***not*** **to adjust labor demand** is given by

$$
\begin{aligned}
W^{not}\left(N^U_{-1}, N^S_{-1}, K^T, K^N, B, Z\right) &= \max_{K^{T'}, K^{N'}, B'} D + \beta \mathbb{E}_{Z'|Z} W\left(N^U_{-1}, N^S_{-1}, K^{T'}, K^{N'}, B', Z'\right) \\
\text{s.t.} \quad D &= \Pi\left(Z, K^T, K^N, N^S, N^U\right) - \omega(N^U_{-1}, N^S_{-1}) - (1+r)B + B' \\
B' &\leq \frac{(1-\delta_T)K^{T'}}{1+r} \\
D &\geq 0
\end{aligned}
\tag{7}
$$

- The value of a firm that decides only to **adjust *one* type of labor** is given by

$$
\begin{aligned}
W^i\left(N^U_{-1}, N^S_{-1}, K^T, K^N, B, Z\right) &= \max_{N^i, K^{T'}, K^{N'}, B'} D + \beta \mathbb{E}_{Z'|Z} W\left(N^U, N^S, K^{T'}, K^{N'}, B', Z'\right) \\
\text{s.t.} \quad D &= \Pi\left(Z, K^T, K^N, N^S, N^U\right) - \omega\left(N^U_{-1}, N^S_{-1}\right) - C_i\left(N^U, N^S, N^U_{-1}, N^S_{-1}\right) - (1+r)B + B' \\
B' &\leq \frac{(1-\delta_T)K^{T'}}{1+r} \\
D &\geq 0
\end{aligned}
\tag{8}
$$

where $i = \{s, u\}$ denotes the type of labor being adjusted.

Dynamic Programing Problem II

- The value of the firm that decides to **adjust *both* types of labor** is given by

$$
\begin{aligned}
W^{s,u}\left(N^U_{-1}, N^S_{-1}, K^T, K^N, B, Z\right) &= \max_{N^U, N^S, K^{T\prime}, K^{N\prime}, B'} D + \beta \mathbb{E}_{Z'|Z} W\left(N^U, N^S, K^{T\prime}, K^{N\prime}, B', Z'\right) \\
\text{s.t.} \quad & D = \Pi\left(Z, K^T, K^N, N^S, N^U\right) - \omega\left(N^U_{-1}, N^S_{-1}\right) - C\left(N^U, N^S, N^U_{-1}, N^S_{-1}\right) - (1+r)B + B' \\
& B' \leq \frac{(1-\delta_T)K^{T\prime}}{1+r} \\
& D \geq 0
\end{aligned}
\tag{9}
$$

- The firm selects its most beneficial option:

$$
W\left(N^U_{-1}, N^S_{-1}, K^T, K^N, B, Z\right) = \max\{W^{not}, W^s, W^u, W^{s,u}\} \tag{10}
$$

Empirical Approach

What to do?

- Employer-employee data
  * Need access to **firm's balance sheets** to be able to get intangible capital to other asset, cash to other assets, net leverage etc.
  * Need access to **worker characteristics** to distinguish between skilled and unskilled labor
- These data should be useful to estimate the **parameters of the production function** ...
  * It is likely that it is not possible to log-linearize (2) and run regression to estimate $\{\alpha, \mu, \sigma, \lambda, \rho\}$. It would be interactions between them.
  * Solve and estimate the model for two different sub-samples (e.g. 1980s and 2010s).
    - What to expect? $\mu_{2010} > \mu_{1980}$, $\alpha_{2010} < \alpha_{1980}$?
    - If this this is true, the model should be able to predict a higher intangible to total assets, and larger demand of skilled labor. Interesting in itself?
- Look at the LP response of (un)skilled employment to an aggregate shock. Interested in the interaction between shock and intangible share