Human Capital Investments and Expectations About Career and Family

Matthew Wiswall & Basit Zafar

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Motivation

- Much of the literature on wage inequality trends looks at issue through competitive lens i.e. W=MPL.
- Changes to wage inequality can only ever be driven by changes to supply or demand/technology.
- When considering rise in graduate wage premium, in a competitive environment it is almost tautological that technology is responsible given increase in supply of graduates.
- Introducing search frictions allows for other explanations:
  1. ***Transition Rates****: Transition out of unemployment, between jobs, and into unemployment impact average wages.*
  2. **Wage Bargain**: Institutions affecting the wage bargain matter e.g. welfare, minimum wages, unions etc.

Motivation

- Will embed frictions, as per **?**, within a classic model of tech change and wage inequality by **?**- henceforth KORV
- In KORV rising graduate wage premium is driven by capital skill complementarity and falling capital prices.
- Adding search frictions to this model serves two aims:
  1. ***Robustness****: See whether estimates of capital skill complementarity robust to alternative wage setting environments.*
  2. **Decomposition**: Decompose growth of wage inequality into changes to supply, technological, frictional and institutional components.

Key Results

- **Theory Contribution**. Develop a framework where wage inequality is driven by changes to labour supply, technology, frictional (and institutional) components.
- **Quantitative Contribution**. I find that allowing for the evolution of search frictions does not significantly change the findings of **?**, in the sense that:
  1. Parameter estimates determining the elasticity of subs. between capital and skilled/unskilled labour are very similar in competitive and frictional version of model.
  2. Without capital skill complementarity (CSC), both the competitive and frictional versions of the model fail to explain growth of wage inequality.

Outline

Related Literature

1. **Literature explaining wage inequality dynamics.**
    - Skills biased tech change - e.g. Katz and Murphy (1992) - then task biased tech change - Autor and Acemoglu (2011)
    - Labour Supply: Card & Lemieux (2001)
    - Institutional explanations: DiNardo et al (1996)
    - *Contribution: Develop model that nests tech, supply and institution explanations, adds transition rates as candidate explanation, and allows counterfactuals.*
2. **Literature explaining cross-sectional inequality.**
    - Postel-Vinay and Robin (2002) decompose residual inequality into worker and firm heterogeneity and frictions. Find frictions account for 45-60% of residual inequality.
    - Abowd, Kramarz, and Margolis (1999) find much larger worker and firm effects (c.80% of residual wage variance).
    - *Contribution: Applying search literature to explain change in cross-sectional inequality rather than just level.*

The Model: Workers

- Two skill levels - unskilled/skilled- indexed by $i \in u, s$.
- Efficiency in production of skill types denoted by $\Psi_{i,t}$ (assumed stationary).
- Exogenous job destruction $\delta_{i,t}$
- Flow income in unemployment is $b_{i,t} * MPL_{i,t}$
- Choose to work or not - hours per worker ($h_{i,t}$) exogenous (from data)
- Job offer arrival in unemployment and in employment denoted by $\lambda_{0,i,t}$ and $\lambda_{1,i,t}$ respectively.
- Exogenous job offer rates: i.e. vacancy creation not modelled.
- Risk neutral

The Model: Firms

- I wish to allow for both capital to labour substitution in production, and substitution between skill types.
- Not easy in pure search/match framework e.g. potential for complex intra-firm bargaining problems as per **?**.
- Proposed solution is to have two sectors of production:
  1. An intermediate goods sector with search frictions
  2. Competitive final good sector that combines intermediate goods and capital, with no frictions but with imperfect substitutability of all factors.

The Model: Final Goods Firm

- Final good produced using capital structures, $k_{s,t}$, capital equipment, $k_{e,t}$, and skilled and unskilled labour s_t & u_t:

$$Y_t = A_t k_{s,t}^{\alpha}[\mu u_t^{\sigma} + (1-\mu)(\lambda k_{e,t}^{\rho} + (1-\lambda)s_t^{\rho})^{\frac{\sigma}{\rho}}]^{\frac{1-\alpha}{\sigma}} \tag{1}$$

Without frictions (as per KORV)

- Labour input is hours worked in efficiency units e.g $u_t \equiv \Psi_{u,t} h_{u,t}$, $s_t \equiv \Psi_{s,t} h_{s,t}$
- Elas. of subs. between unskilled labour and capital equipment (and skilled labour) is $\frac{1}{1-\sigma}$. Elas. of subs. between skilled labour and capital equipment is $\frac{1}{1-\rho}$
- Defining $\pi_t \equiv w_{s,t}/w_{u,t}$, profit max implies:

$$g_{\pi_t} \simeq (1-\sigma)(g_{h_{u,t}} - g_{h_{s,t}}) + \sigma(g_{\Psi_{s,t}} - g_{\Psi_{u,t}}) + (\sigma-\rho)\lambda\Big(\frac{k_{e,t}}{s_t}\Big)(g_{k_{e,t}} - g_{\Psi_{s,t}} - g_{h_{s,t}}) \tag{2}$$

The Model: Intermediate Goods Sectors

With Frictions: Intermediate Good Firms

- I now interpret u_t and s_t as intermediate goods produced using unskilled and skilled labour.
- Labour is hired by heterogeneous intermediate firms with match quality ν, and population cdf $F_{i,t}(\nu)$.
- $\ell_{t,u}(\nu)$ is fraction of employees in a match of quality ν.
- A worker in a match of quality ν produces exactly ν units of intermediate good for every hour they work.
- $y_{i,t}$ is the total amount of intermediate goods produced by skill type i for $i \in u, s$.

$$u_t \equiv \Psi_{u,t} y_{u,t} = \Psi_{u,t} h_{u,t} \int_{\nu_{inf}}^{\nu_{max}} \nu \ell_{t,u}(\nu) d\nu \tag{3}$$

$$s_t \equiv \Psi_{s,t} y_{s,t} = \Psi_{s,t} h_{s,t} \int_{\nu_{inf}}^{\nu_{max}} \nu \ell_{t,s}(\nu) d\nu \tag{4}$$

Wage Determination

- Final good producers pay a price, p_i, for a unit of type i intermediate good given by $p_i = \frac{\partial Y}{\partial y_i}\Psi_i$ (for $i \in \{u, s\}$).

Unemployed Workers

- When an unemployed worker of skill type i meets a potential employer of type ν, a Nash type bargaining game ensues and worker is hired at wage contract $\phi(p_i, \nu)$ that solves:

$$V(p_i, \phi(p_i, \nu), \nu) = U(b_i p_i) + \beta[V(p_i, p_i\nu, \nu) - U(b_i p_i)] \quad (5)$$

- $\beta \in [0, 1]$ is the bargaining parameter

Wage Determination

Employed Workers

- When an employed worker of skill type i meets a potential alternate employer, a bargaining game involving the worker and both employers of types $[\nu^+ \geqslant \nu^-]$ is played, the outcome is that the worker:
  - ends up accepting the more productive type firm's offer
  - receives a wage $\phi(p_i, \nu^-, \nu^+)$ that solves

$$V(p_i, \phi(p_i, \nu^-, \nu^+), \nu^+) = V(p_i, p_i\nu^-, \nu^-) + \beta[V(p_i, p_i\nu^+, \nu^+) - V(p_i, p_i\nu^-, \nu^-)] \tag{6}$$

Wage and Employment Distributions

- Jumping ahead..the distribution of workers of type i across intermediate firms is (with $\kappa_{1,i} \equiv \lambda_{1,i}/\delta_i$):

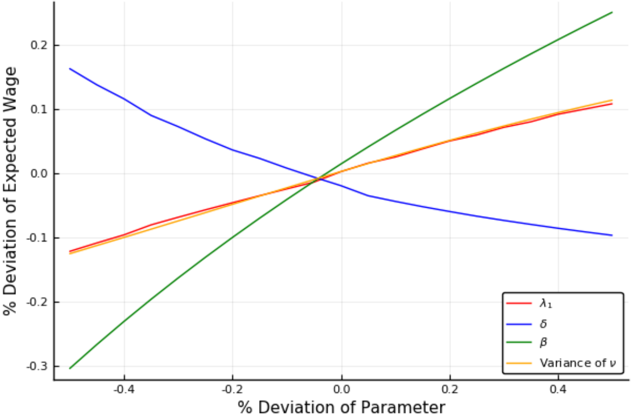
$$\ell_i(\nu) = \frac{1+\kappa_{1,i}}{[1+\kappa_{1,i}\bar{F}_i(\nu)]^2} f_i(\nu) \tag{7}$$

- And crucially the expected wage for a worker of type i is:

$$\begin{aligned} E(w_i) &= E(E(w_i|\nu)) \\ &= p_i \int_{\underline{\nu}}^{\nu_{max}} \Big[\nu - \big([1+\kappa_{1,i}\bar{F}_i(\nu)]^2 \times \\ &\int_{\nu_{inf}}^{\nu} \frac{(1-\beta)[1+\frac{\delta_i}{\delta_i+\rho}\kappa_{1,i}\bar{F}_i(x)]}{[1+\frac{\delta_i}{\delta_i+\rho}\kappa_{1,i}\beta\bar{F}_i(x)][1+\kappa_{1,i}\bar{F}_i(x)]^2} dx\big)\Big]\ell_i(\nu)d\nu \end{aligned} \tag{8}$$

Wage Impact of Search Frictions

Figure: Wage Impact of Parameters



Wage and Employment Distributions

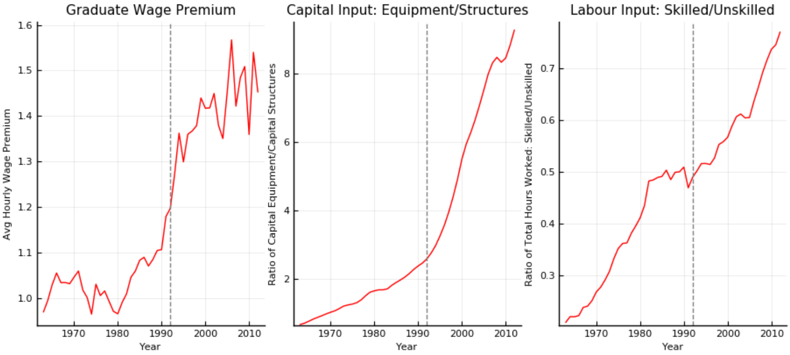
- Summing up:
  - Under KORV, with no frictions:

$$g_{\pi_t} \propto (g_{h_{u,t}}/g_{h_{s,t}}), (g_{\Psi_{s,t}}/g_{\Psi_{u,t}}), (g_{k_{e,t}}/g_{h_{s,t}}) \tag{9}$$

  - Under KORV with frictions:

$$\begin{aligned} g_{\pi_t} \propto\ & (g_{h_{u,t}}/g_{h_{s,t}}), (g_{\Psi_{s,t}}/g_{\Psi_{u,t}}), (g_{k_{e,t}}/g_{h_{s,t}}), \\ & (\mathbf{g}_{\beta_{\mathbf{s,t}}}/\mathbf{g}_{\beta_{\mathbf{u,t}}}), (\mathbf{g}_{\mathbf{b_{s,t}}}/\mathbf{g}_{\mathbf{b_{u,t}}}), (\mathbf{g}_{\kappa_{\mathbf{1,s,t}}}/\mathbf{g}_{\kappa_{\mathbf{1,u,t}}}) \end{aligned} \tag{10}$$

Data: The KORV story



Data: The KORV story with frictions

- Under KORV, with no frictions:

$$g_{\pi_t} \propto (g_{h_{u,t}}/g_{h_{s,t}}),\ (g_{\Psi_{s,t}}/g_{\Psi_{u,t}}),\ (g_{k_{e,t}}/g_{h_{s,t}}) \tag{11}$$

- Under KORV with frictions:

$$g_{\pi_t} \propto (g_{h_{u,t}}/g_{h_{s,t}}),\ (g_{\Psi_{s,t}}/g_{\Psi_{u,t}}),\ (g_{k_{e,t}}/g_{h_{s,t}}), \tag{12}$$

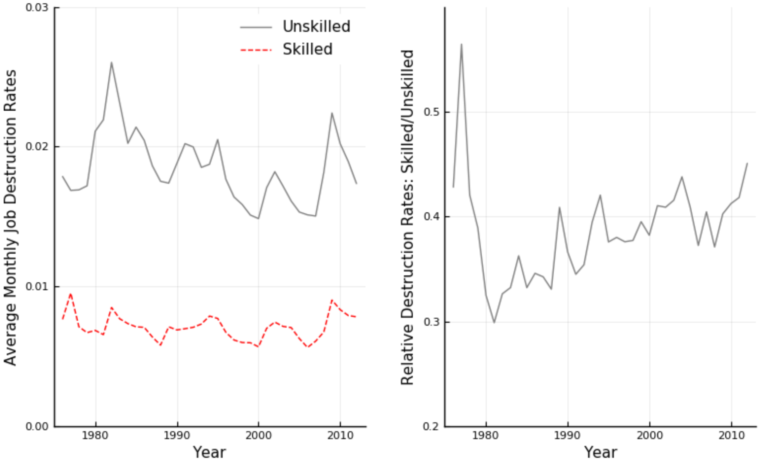
$$(\mathbf{g}_{\beta_{\mathbf{s,t}}}/\mathbf{g}_{\beta_{\mathbf{u,t}}}),\ (\mathbf{g}_{\mathbf{b_{s,t}}}/\mathbf{g}_{\mathbf{b_{u,t}}}),\ (\mathbf{g}_{\kappa_{\mathbf{1,s,t}}}/\mathbf{g}_{\kappa_{\mathbf{1,u,t}}}) \tag{13}$$

- So question is do trends for **transition rates**, and for institutional parameters differ much for graduates relative to non-graduates?

Data: The KORV story with frictions

Transition Data: Job Destruction Rates

Source: Current Population Survey, Monthly Files

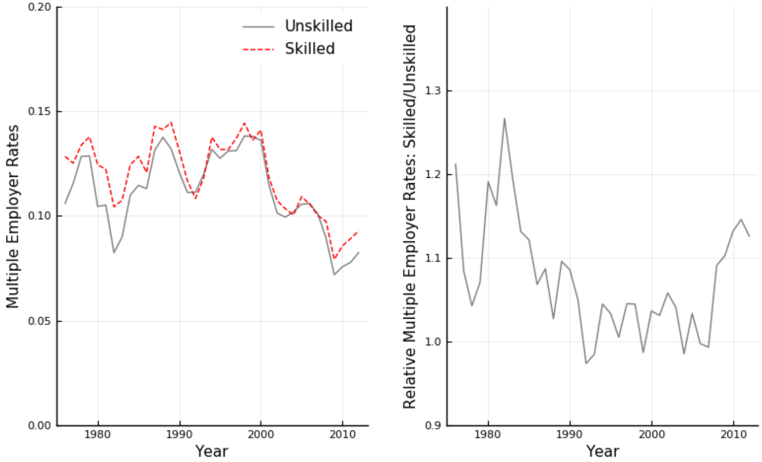


Data: The KORV story with frictions

Transition Data: Job transition Rates

Source: Current Population Survey, Monthly Files

- Used as empirical target for estimating job contact rate, $\lambda_{1,i,t}$



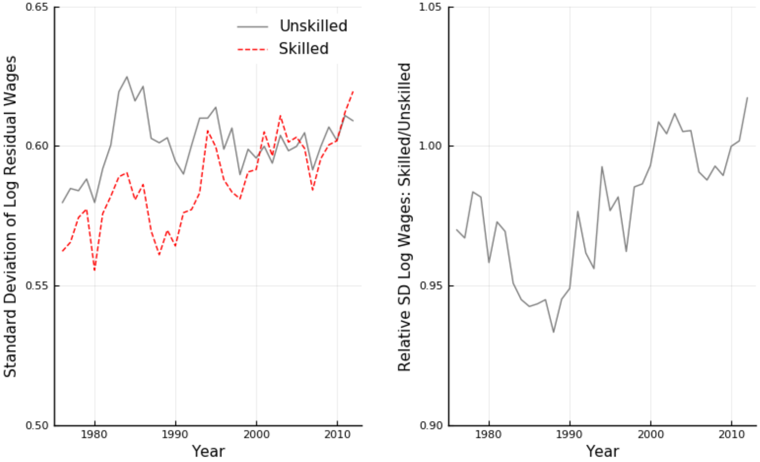
Mobility Rate Comparison

Data: The KORV story with frictions

Distribution data: Standard Dev of Resid. Log Wages

Source: Current Population Survey

- Used as empirical target for estimating $F_{i,t}$

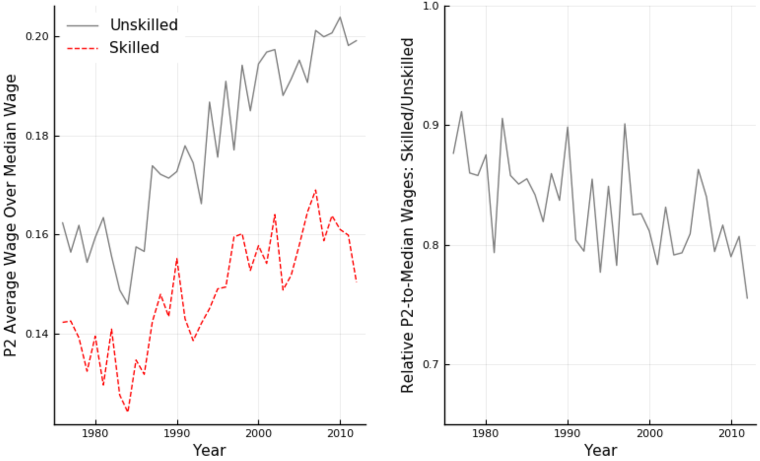


Data: The KORV story with frictions

Distribution data: Lower Bound of Wage Distribution

Source: Current Population Survey

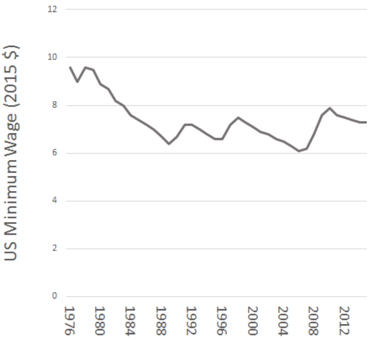
- Used as target for estimating reservation match quality $\nu_{inf,i,t}$

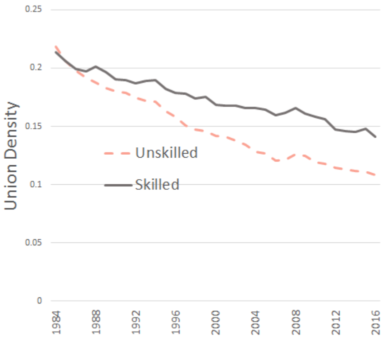


Data: The KORV story with frictions

Institutions

- Not used in estimation (yet)





Estimation Overview

- Recall wage equation in model:

$$E(w_{i,t}) = p_{i,t} \int_{\underline{\nu}}^{\nu_{max}} \Bigg[\nu - \Big([1+\kappa_{1,i,t}\bar{F}_{i,t}(\nu)]^2 \times \int_{\nu_{inf}}^{\nu} \frac{(1-\beta)[1+\frac{\delta_{i,t}}{\delta_{i,t}+\rho}\kappa_{1,i,t}\bar{F}_{i,t}(x)]}{[1+\frac{\delta_{i,t}}{\delta_{i,t}+\rho}\kappa_{1,i,t}\beta\bar{F}_{i,t}(x)][1+\kappa_{1,i,t}\bar{F}_{i,t}(x)]^2} dx \Big) \Bigg] \ell_{i,t}(\nu) d\nu$$

$$= \underbrace{E_\nu(w_{i,t}, p_{i,t} = 1)}_{\textbf{Stage 1 of Estimation}} \times \underbrace{p_{i,t}}_{\textbf{Stage 2 of Estimation}}$$

$$p_{i,t} = \frac{\partial Y_{i,t}}{\partial y_{i,t}} \Psi_{i,t}$$

- Estimation proceeds in two stages:
  1. $E_\nu(w_{i,t}, p_{i,t} = 1)$. Estimate parameters determining job market frictions and shape of within skill wage distribution.
     - Determines shape but not location of wage distribution.
  2. $p_{i,t}$. Estimate parameters of KORV production function
     - Determines location but not shape of wage distribution.

Estimation Approach

- Use SMM in two stages:
  1. $E_\nu(w_{i,t}, p_{i,t} = 1)$. Estimate parameters determining job market frictions and shape of within skill wage distribution:
     - Job contact rates for employed, $\lambda_{1,i,t}$ for $i \in u, s$.
       Empirical Target: Proportion of continuously employed workers with more than one employer (non concurrent) over year
     - Sampling distribution of offers, $F_{i,t(\nu)}$ for $i \in u, s$. Assume log normal with lower bound $\nu_{inf,i,t}$, mean $\zeta_{i,t}$ (will normalise this) and variance $\eta_{i,t}$.
       Empirical Targets:Variance of Log Wages, p2/50 wage percentile ratio

     Estimation Detail: Search parameters
  2. $p_{i,t}$. Estimate parameters for KORV production function:
     - *Empirical Targets: Time series of Graduate Wage Premium, Labour Share, Output and No arbitrage condition for Capital Structures and Equipment.*

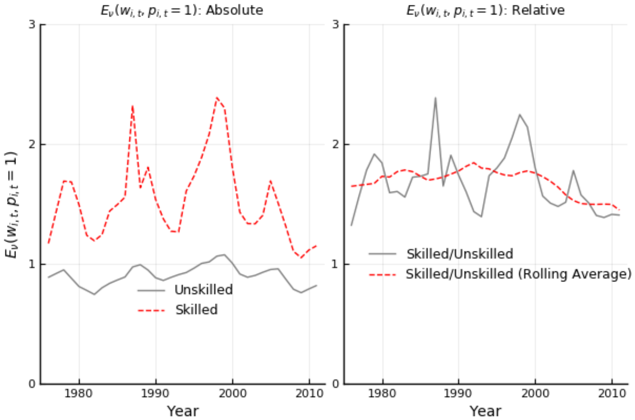
     Estimation Detail: KORV parameters

Results: Stage 1 (Search Frictions)

$$E(w_{i,t}) = \underbrace{E_\nu(w_{i,t}, p_{i,t} = 1)}_{\textbf{Stage 1 of Estimation}} \times \underbrace{p_{i,t}}_{\textbf{Stage 2 of Estimation}}$$

$$p_{i,t} = \frac{\partial Y_{i,t}}{\partial y_{i,t}} \Psi_{i,t}$$

Figure: $E_\nu(w_{i,t}, p_{i,t} = 1)$



Results: Stage 2 (KORV Production Function)

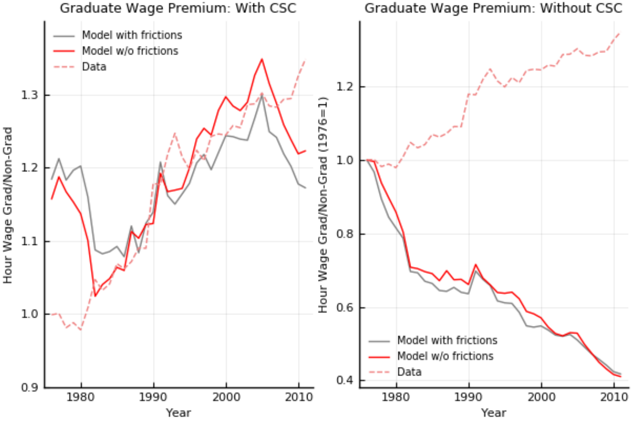
Table: KORV parameter values: the importance of frictions

Parameter	With Frictions	Without Frictions
λ	0.505	0.568
μ	0.833	0.806
α	0.083	0.091
γ	-0.186	-0.209
σ	0.329	0.352
Elas. of Subs. btw S and K_{eq}, $\varepsilon_{S,K_{eq}}$ $(= 1/1 - \gamma))$	0.843	0.827
Elas. of Subs. btw U and K_{eq}, $\varepsilon_{U,K_{eq}}(= 1/1 - \sigma))$	1.489	1.544
CSC Strength: $\boldsymbol{\varepsilon_{U,K_{eq}} - \varepsilon_{S,K_{eq}}}$	**0.646**	**0.716**

Results: Stage 2 (KORV Production Function)

Without some degree of capital skill complementarity (i.e. $\sigma = \gamma$) then both competitive and frictional version of models unable to explain increase in wage premium:

Figure: Model Fit: No Capital Skill Complementarity (CSC)



Conclusions and Next Steps

- I have developed a model where relative average wages of skill groups determined by:
  1. relative labour supply and capital use (**?**)
  2. transition probabilities, replacement rates, and bargaining strength (**?**)
- This approach allows analysis of impact of search frictions on wage inequality, and implications for estimates of CSC.
- Find that accounting for changes to transition rates and outside options does not change estimates of CSC.
- Next steps:
  1. incorporate institutions i.e. minimum wage, estimate bargaining strength (probably requires MEE data).
  2. Move away from skilled vs non-skilled split of data.

Thank you! Comments/Questions?

Appendix A: Data

Transition Data: Job transition vs Multiple Employer Rates

Source: Current Population Survey, Monthly Files

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Appendix B: KORV Estimation With Frictions

1.Estimate Contact Rates

- In all cases, note that I target a rolling six year average of the data rather than the actual annual series.
- I assume that $\nu_{min} \geqslant b$ so $\lambda_{0,i}$ simply equals the empirical unemployment exit rate
- $\lambda_{1,i}$ is chosen to target the proportion of individuals continuously employed in a year who have more than one employer (call this τ).
  - This is given in model by the following expression (which turns out to be independent of distribution, F):

$$\tau_i = 1 - \int_{\nu_{min}}^{\nu_{max}} (1 - \lambda_{1,i}\bar{F}(\nu))^{12}\ell_i(\nu) \tag{14}$$

Appendix B: KORV Estimation With Frictions

2. Estimate Distribution of Firm Heterogeneity

- Per period revenue generated at a match of quality ν, is $p_i \nu$ (recall $p_i = \frac{\partial Y}{\partial y_i} \Psi_i$)
- The distribution of wages for skill type i employees across the quality distribution will be, up to a scale, independent of p_i.
- I can therefore estimate distribution of wages, independently of KORV production parameters (which influenc p_i).
- Assume distribution is log-normal, and normalize mean, leaving variance and lower bound ($\eta_{i,t}$ and $\nu_{inf_{i,t}}$) to be estimated.
- Empirical Targets:Variance of Log Wages, p2/50 wage percentile ratio

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Appendix C: KORV Estimation Detail

- Estimation is based on three equations coming from firms FOC's and no-arbitrage condition

$$\frac{w_{u,t}h_{u,t} + w_{s,t}h_{s,t}}{Y_t} = lsh_t(X_t, \Psi_t; \phi) \tag{15}$$

$$\frac{w_{s,t}h_{s,t}}{w_{u,t}h_{u,t}} = wbr_t(X_t, \Psi_t; \phi) \tag{16}$$

$$(1-\delta_s) + A_{t+1}G_{k_s}((X_t, \Psi_t; \phi) = E_t(\frac{q_t}{q_{t+1}})(1-\delta_e) +$$

$$q_t A_{t+1} G_{k_e}((X_t, \Psi_t; \phi) \tag{17}$$

- Here X_t is the set of factor inputs $(k_{s,t}, k_{e,t}, u_t, s_t)$, and ϕ is the vector of all parameters.
- The system of equations above can be summarized in vector form as $Z_t = f(X_t, \Psi_t, \epsilon_t; \phi)$

Appendix C: KORV Estimation Detail

1. Instrument hours worked, so exogenous data is $\hat{X}_t = (k_{s,t}, k_{e,t}, \hat{h}_{u,t}, \hat{h}_{s,t})$
2. Draw S values of the shocks to labour efficiency,ψ_t^i for each period t to get S realizations of $Z_t^i = f(\hat{X}_t, \Psi_t^i, \epsilon_t^i; \phi)$
3. Use these S realizations to obtain the following moments:

$$m_s(\hat{X}_t, \phi) = \frac{1}{S} \sum_{i=1}^{S} f(\hat{X}_t, \Psi_t^i, \epsilon_t^i; \phi) \tag{18}$$

$$V_s(\hat{X}_t, \phi) = \frac{1}{S-1} \sum_{i=1}^{S} (Z_t^i - m_s(\hat{X}_t, \phi))(Z_t^i - m_s(\hat{X}_t, \phi))' \tag{19}$$

4. Maximize the following objective function:

$$l_s(\hat{X}_t, \phi) = \frac{1}{2T} \sum_{t=1}^{T} \Big\{ (Z_t - m_s(\hat{X}_t, \phi))' V_s(\hat{X}_t, \phi) \tag{20}$$

$$\times (Z_t - m_s(\hat{X}_t, \phi)) + ln(det(V_s(\hat{X}_t, \phi))) \Big\} \tag{21}$$

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