A Labor Capital Asset Pricing Model

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CSEF-EIEF-SITE Conference on Finance and Labor
September 8th, 2016, Capri

Labor Market Dynamics

- The labor markets are very dynamic.
  - More than 10% of U.S. workers separate from their firms each quarter.
  - They move to a new firm, or become unemployed, or leave labor force.
  - Searching for new employees can be costly for firms.

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☞ This paper: Diamond-Mortensen-Pissarides labor search frictions

- Search costs: heterogeneity or information frictions.
- Key variable: labor market tightness

$$\theta = \frac{\text{Vacancies}}{\text{Unemployed workers}}$$

Contributions

1. Empirical evidence
   - Loadings on the labor market tightness predict returns
   - Annual spread 6%

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1. Empirical evidence
   - Loadings on the labor market tightness predict returns
   - Annual spread 6%
2. Labor market augmented capital asset pricing model
   - Firms post vacancies facing search frictions
   - Equilibrium in the labor market
   - Aggregate matching efficiency shocks
   - Labor market tightness factor priced in the cross section

Mechanism

- Cash-flow effect
  - A positive shock to matching efficiency reduces hiring costs.
  - Equilibrium market tightness relates positively to matching efficiency.
- Discount rate effect
  - Matching efficiency carries a negative price of risk.
  - A positive shock to matching efficiency reduces the value of job creation.

Mechanism

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  - Matching efficiency carries a negative price of risk.
  - A positive shock to matching efficiency reduces the value of job creation.
- Proportional hiring/firing cost: labor policy has regions of inactivity.
- Firms with positive loadings on labor market tightness are hedged:
  - hire workers when matching efficiency is high
  - have procyclical cash flow with matching efficiency
- The *cyclicality* of firms' labor decisions determine their risk loadings.

Related Literature

- Production-based asset pricing Cochrane 1991; Jermann 1998; Berk, Green, and Naik 1999; Carlson, Fisher, and Giammarino 2004; Zhang 2005; Kogan and Papanikolaou 2013

- Labor frictions and stock market Chen, Kacperczyk, Ortiz-Molina 2011; Eisfeldt and Papanikolaou 2013; Donangelo 2014; Favilukis and Lin 2015; Donangelo, Gourio, and Palacios 2015; Belo, Lin, and Bazdresch 2015; Belo, Lin, Li, Zhao 2015

- Labor search and matching Mortensen and Pissarides 1994; Andolfatto 1996; Davis, Faberman, and Haltiwanger (2006, 2013), Elsby and Michaels 2013; Sahin, Song, Topa, and Violante 2014

Empirical Results

Empirical Specification

1. Labor Market
   - Conference Board: Help Wanted Index
   - BLS: monthly unemployment and labor force participation rates
   - Labor market tightness

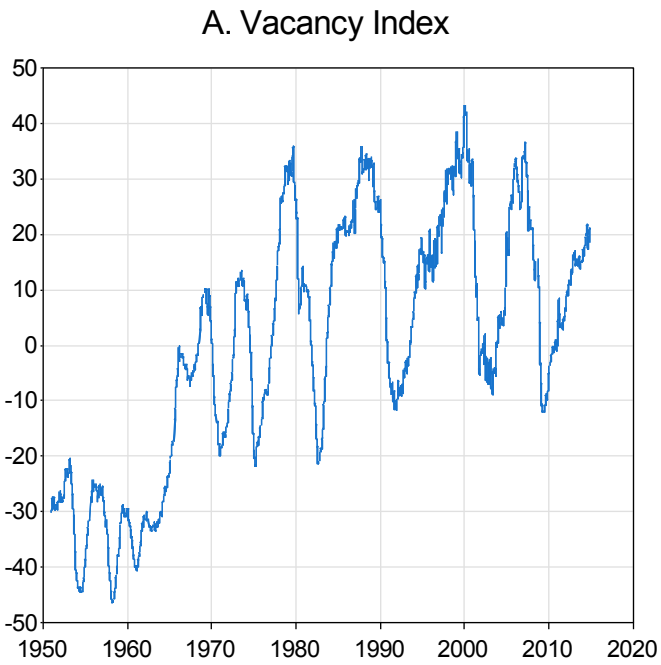
$$\theta_t = \frac{\text{Vacancy Index}_t}{\text{Unemployment Rate}_t \times \text{LFPR}_t}$$

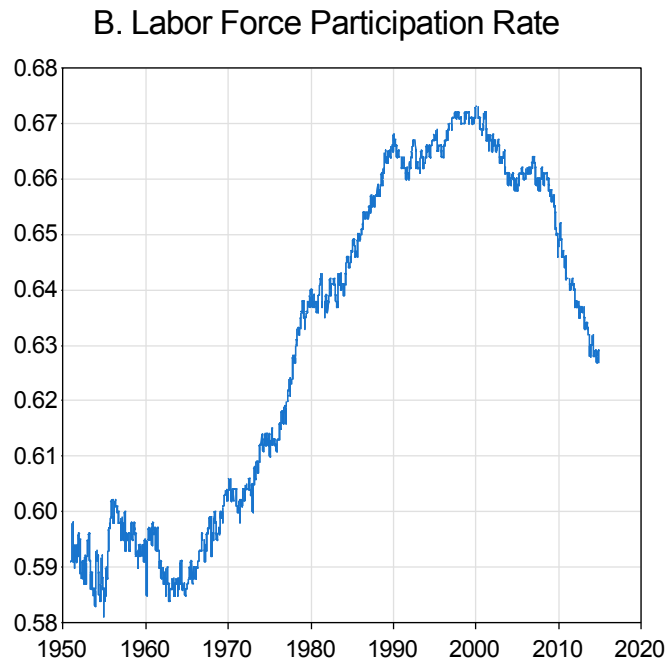
   - Labor market tightness factor

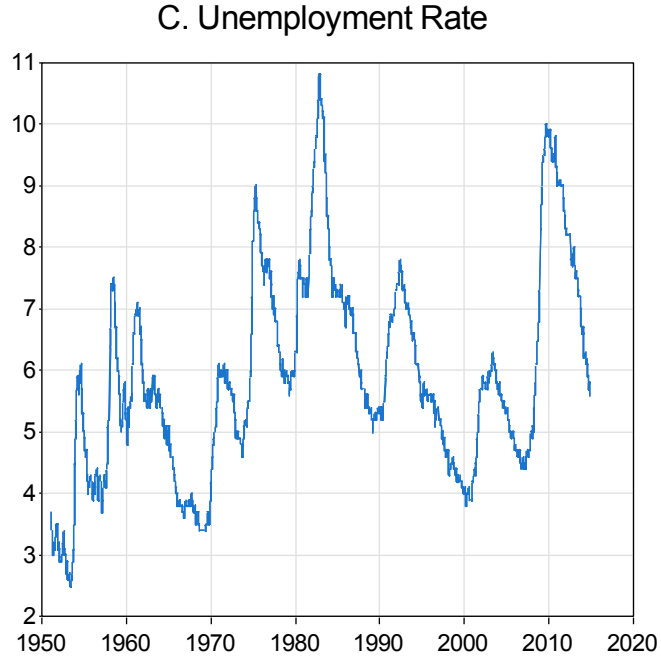
$$\vartheta_t \equiv \log(\theta_t) - \log(\theta_{t-1})$$

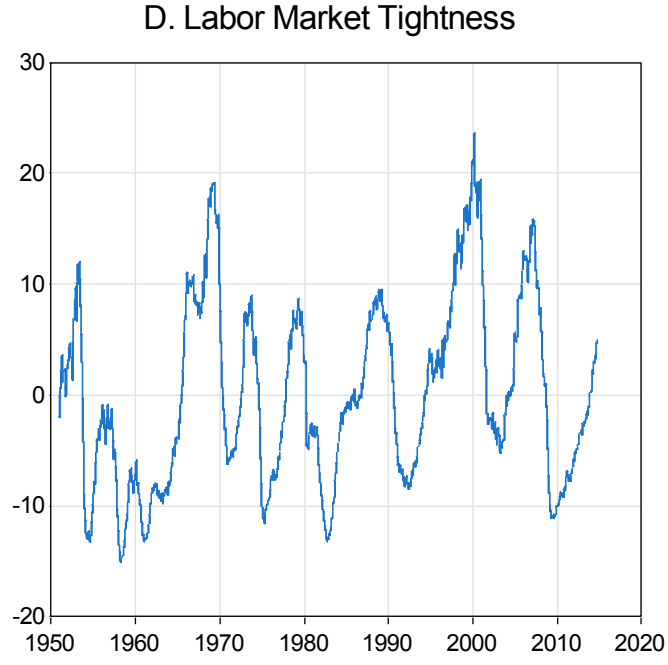
2. Financial Market
   - CRSP monthly stock returns
   - Loadings from rolling two-factor regressions

$$R_{i,t} - R_{f,t} = \alpha_{i,\tau} + \beta^M_{i,\tau}(R_{M,t} - R_{f,t}) + \beta^\theta_{i,\tau}\vartheta_t + \varepsilon_{i,t}$$


A. Vacancy Index
50
40
30
20
10
0
-10
-20
-30
-40
-50
1950
1960
1970
1980
1990
2000
2010
2020


B. Labor Force Participation Rate
0.68
0.67
0.66
0.65
0.64
0.63
0.62
0.61
0.60
0.59
0.58
1950
1960
1970
1980
1990
2000
2010
2020


C. Unemployment Rate
11
10
9
8
7
6
5
4
3
2
1950
1960
1970
1980
1990
2000
2010
2020


D. Labor Market Tightness
30
20
10
0
-10
-20
1950
1960
1970
1980
1990
2000
2010
2020

Summary Statistics

	Mean	Standard Deviation	Correlation with ϑ
LMT ϑ	0.11	5.43	
Vacancy index	0.20	3.27	0.82
Unemployment rate	0.08	3.30	-0.83
Labor force participation rate	0.01	0.29	-0.13
Industrial production	0.24	0.88	0.54
CPI	0.30	0.32	-0.08
Dividend yield	3.15	1.13	-0.15
T-Bill rate	0.37	0.25	-0.13
Term spread	1.49	1.20	0.11
Default spread	0.98	0.45	-0.26

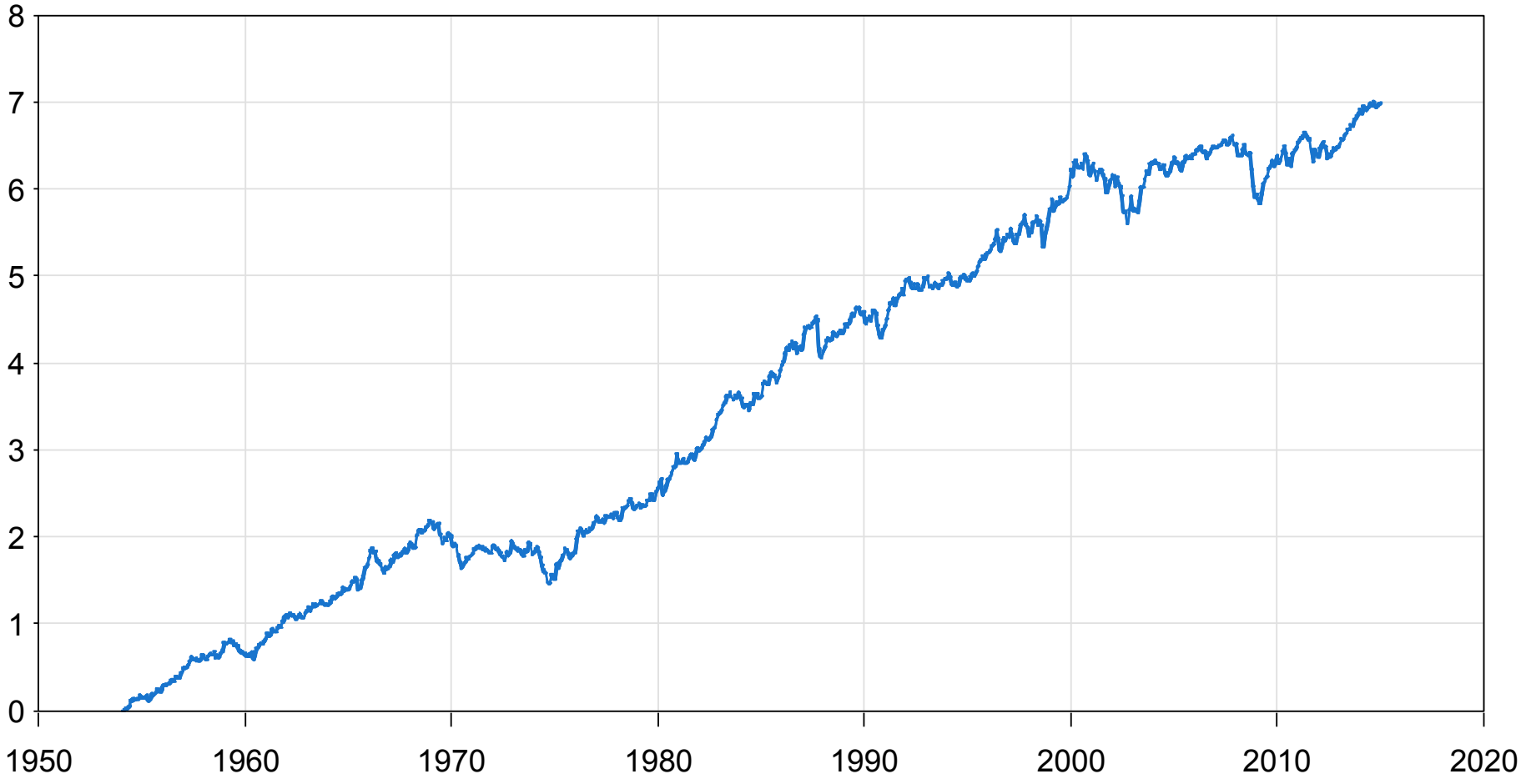
Portfolio Sorts Based on β_θ

		Raw	Alphas			4-Factor Loadings			
Decile	β_θ	Ret	CAPM	3-Factor	4-Factor	MKT	HML	SMB	UMD
Low	-0.80	1.14	0.02	0.04	0.03	1.16	-0.1	0.42	0.01
2	-0.38	1.10	0.11	0.11	0.11	1.04	0.02	-0.01	-0.01
3	-0.23	1.07	0.12	0.09	0.12	0.99	0.07	-0.08	-0.03
4	-0.12	1.02	0.10	0.07	0.07	0.96	0.09	-0.09	-0.01
5	-0.02	1.01	0.09	0.03	0.02	0.97	0.14	-0.10	0.01
6	0.06	0.98	0.06	0.02	0.00	0.97	0.10	-0.11	0.03
7	0.16	0.99	0.05	0.03	0.05	0.97	0.04	-0.07	-0.01
8	0.28	0.97	-0.02	-0.02	0.01	1.02	-0.01	0.05	-0.04
9	0.46	0.89	-0.18	-0.16	-0.11	1.11	-0.09	0.21	-0.05
High	0.92	0.66	-0.52	-0.51	-0.41	1.19	-0.16	0.64	-0.11
L-H		0.48	0.54	0.55	0.44	-0.03	0.06	-0.22	0.12
t-stat		[3.66]	[4.12]	[4.20]	[3.31]	[-1.23]	[1.09]	[-4.95]	[3.54]

Portfolio Characteristics

Decile	β^{θ}	β^{M}	BM	ME	RU	AG	IK	HN	Lev
Low β^{θ}	-0.80	1.36	0.89	4.84	15.44	12.92	32.59	6.36	0.75
2	-0.38	1.16	0.92	5.73	13.68	13.02	29.39	7.16	0.81
3	-0.23	1.06	0.91	6.09	12.67	11.01	27.34	5.70	0.75
4	-0.12	1.02	0.92	6.27	12.92	11.36	27.05	6.72	0.78
5	-0.02	1.00	0.92	6.22	13.37	11.17	26.08	5.00	0.79
6	0.06	1.01	0.94	5.99	13.08	11.51	26.44	5.12	0.77
7	0.16	1.04	0.94	5.84	13.35	11.30	27.35	5.94	0.77
8	0.28	1.09	0.95	5.52	13.55	11.41	28.17	5.50	0.73
9	0.46	1.17	0.94	4.98	13.71	12.23	29.54	6.95	0.77
High β^{θ}	0.92	1.32	0.92	3.99	16.13	12.63	32.87	6.86	0.78

Log Cumulative Return of the Low-High Portfolio



Risk Factors

	Mean	Standard Deviation	Sharpe Ratio	Correlation with LMT
LMT	0.48	3.56	0.14	
MKT	0.60	4.35	0.14	-0.13
HML	0.37	2.73	0.13	0.07
SMB	0.19	2.94	0.07	-0.21
UMD	0.72	4.00	0.18	0.13

Robustness

	Raw	Alphas		
	Return	CAPM	FF	CARHART
A. Excluding micro caps				
Low-High	0.43	0.47	0.48	0.33
t-statistic	[3.75]	[4.05]	[4.05]	[2.80]
B. Alternative ϑ: residual from projecting on macro				
Low-High	0.48	0.54	0.55	0.50
t-statistic	[3.55]	[3.99]	[4.05]	[3.60]
C. Alternative ϑ: ARMA (1,1) specification				
Low-High	0.46	0.53	0.53	0.42
t-statistic	[3.50]	[3.87]	[3.86]	[3.05]
D. Controlling for Pastor-Stambaugh liquidity factor				
Low-High	0.50	0.47	0.49	0.38
t-statistic	[2.99]	[2.84]	[2.93]	[2.25]
E. Controlling for Novy-Marx profitability factor				
Low-High	0.47	0.49	0.47	0.36
t-statistic	[3.15]	[3.23]	[3.06]	[2.29]

Fama-MacBeth Regressions

Const	β^{θ}	β^{M}	ME	BM	RU	HN	IK	AG
(1)	-0.37	-0.02	-0.09	0.20	0.36			
	[-3.37]	[-0.21]	[-2.54]	[3.70]	[2.61]			
(2)	-0.36	-0.05	-0.08	0.20	0.37	-0.33		
	[-3.66]	[-0.44]	[-2.24]	[3.33]	[2.73]	[-2.83]		
(3)	-0.36	-0.02	-0.09	0.20	0.36		-0.03	
	[-3.61]	[-0.25]	[-2.63]	[3.52]	[2.74]		[-1.18]	
(4)	-0.37	-0.02	-0.09	0.17	0.36			-0.52
	[-3.66]	[-0.22]	[-2.50]	[2.93]	[2.64]			[-3.08]
(5)	-0.35	-0.06	-0.09	0.18	0.39	-0.13	0.16	-0.52
	[-3.50]	[-0.61]	[-2.25]	[2.81]	[2.99]	[-0.71]	[0.72]	[-2.59]

Intra and Inter Industry Portfolios

	Intra-industry Portfolios				Inter-industry Portfolios			
	Raw	Unconditional Alphas			Raw	Unconditional Alphas		
Decile	Return	CAPM	3-Factor	4-Factor	Return	CAPM	3-Factor	4-Factor
Low	1.14	0.09	0.05	0.02	1.28	0.32	0.19	0.11
2	1.08	0.10	0.07	0.07	1.17	0.20	0.09	0.13
3	1.03	0.08	0.06	0.11	1.13	0.18	0.07	0.03
4	1.04	0.09	0.06	0.08	1.10	0.15	0.06	0.07
5	0.98	0.04	0.03	0.04	1.08	0.13	0.06	0.08
6	0.99	0.05	0.05	0.05	1.08	0.12	0.03	0.06
7	0.97	0.02	0.01	0.01	1.04	0.06	-0.03	0.00
8	0.94	-0.02	-0.04	-0.05	1.01	0.04	-0.06	0.02
9	0.94	-0.07	-0.11	-0.07	1.00	0.00	-0.10	-0.06
High	0.82	-0.22	-0.27	-0.26	0.88	-0.11	-0.25	-0.22
Low-High	0.33	0.31	0.32	0.28	0.40	0.43	0.44	0.34
t-statistic	[3.70]	[3.53]	[3.65]	[3.12]	[2.69]	[2.86]	[2.87]	[2.13]

Model

Model Overview

- Labor search and matching friction, Mortensen and Pissarides 1994
- Heterogeneous firms (employee size, idiosyncratic productivity)
  - Mortensen 2010, Elsby and Michaels 2013, Fujita and Nakajima 2013
- Exogenous pricing kernel
  - Berk, Green, and Naik 1999
- Two aggregate shocks (productivity, matching efficiency)
  - Andolfatto 1996
- Equilibrium in the labor market
  - Elsby and Michaels 2013

Output

- Firms with workforce $N_{i,t}$ generate revenue

$$Y_{i,t} = e^{x_t + z_{i,t}} N_{i,t}^{\alpha}$$

  - Aggregate TFP: $x_t = \rho_x x_{t-1} + \sigma_x \varepsilon_t^x$
  - Idiosyncratic TFP: $z_{i,t} = \rho_z z_{i,t-1} + \sigma_z \varepsilon_{i,t}^z$

- Firms can post vacancies $V_{i,t}$ or fire workers $F_{i,t}$ so the size of the workforce evolves by

$$N_{i,t+1} = (1 - s) N_{i,t} + q(\theta_t, p_t) V_{i,t} - F_{i,t}$$

  - $q(\theta_t, p_t)$ is job filling rate
  - p_t is shock to the efficiency of matching technology

$$p_t = \rho_p p_{t-1} + \sigma_p \epsilon_t^p$$

Matching

- Labor market tightness is the ratio of aggregate vacancies to aggregate unemployment

$$\theta_t = \frac{\bar{V}_t}{\bar{U}_t} = \frac{\int V_{i,t} d\mu_t}{L - \int N_{i,t} d\mu_t}.$$

  - μ_t is firm-level distribution of workforce and productivity

- The filling rate of vacancies is

$$q(\theta_t, p_t) = \frac{\mathcal{M}(\bar{U}_t, \bar{V}_t, p_t)}{\bar{V}_t} = e^{p_t} \left(1 + \theta_t^{\xi}\right)^{-1/\xi}.$$

Firm's Optimization

- Firm's Bellman equation is

$$S_{i,t} = \max_{V_{i,t} \geq 0, F_{i,t} \geq 0} \{D_{i,t} + \mathbb{E}_t[M_{t+1} S_{i,t+1}].\}$$

- Dividends are

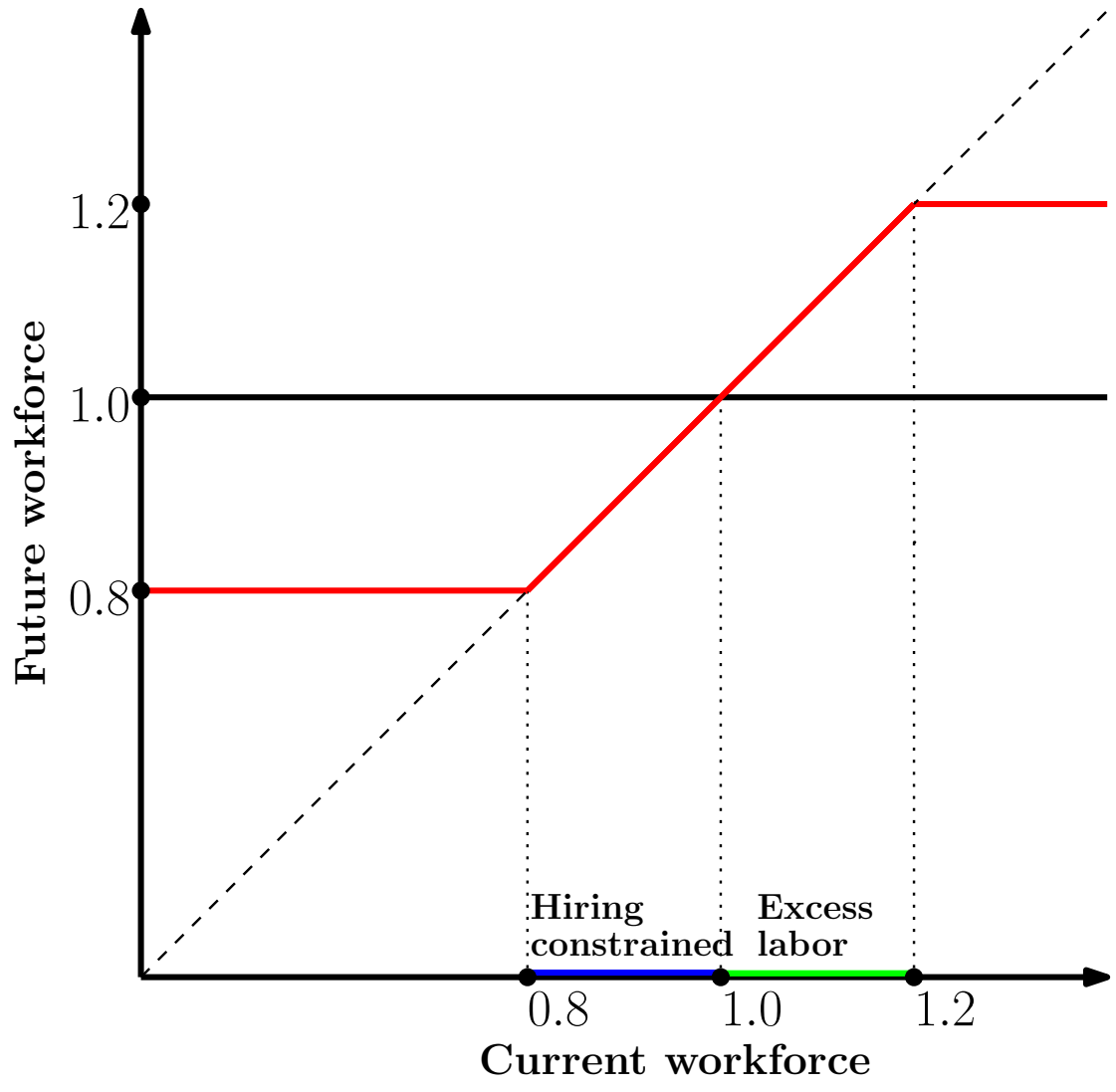
$$D_{i,t} = Y_{i,t} - \kappa_h V_{i,t} - \kappa_f F_{i,t} - f - w_{i,t} N_{i,t}.$$

- Firms pay proportional hiring and firing costs, fixed operating costs

- Individual Nash bargaining wage rate

$$w_{i,t} = \eta \left[\frac{\alpha}{1 - \eta(1-\alpha)} \frac{Y_{i,t}}{N_{i,t}} + \kappa_h \theta_t \right] + (1-\eta) b.$$

Firm Policy: hiring and firing



Pricing Kernel

- The log pricing kernel is

$$m_{t+1} = -r_f - \gamma_x \varepsilon^x_{t+1} - \tfrac{1}{2}\gamma_x^2 - \gamma_p \varepsilon^p_{t+1} - \tfrac{1}{2}\gamma_p^2,$$

  - r_f is the constant log risk-free rate
  - γ_x is price of risk of aggregate productivity shocks
  - γ_p is price of risk of matching efficiency shocks

- Expected excess returns are

$$\mathbb{E}_t[R^e_{i,t+1}] = \frac{\mathbb{E}_t[S_{i,t+1}]}{S_{i,t} - D_{i,t}} - r_f.$$

Labor Market Equilibrium

- Equilibrium labor market tightness is defined as the fixed point in

$$\theta_t = \frac{\int V(\Omega_{i,t}) d\mu_t}{L - (1-s)\int N_{i,t} d\mu_t}$$

  $\Omega_{i,t} = (N_{i,t}, z_{i,t}, x_t, p_t, \theta_t)$ is the state vector

- Approximate aggregation of Krusell and Smith (1998)

- Log-linear law of motion for labor market tightness

$$\log \theta_{t+1} = \tau_0 + \tau_\theta \log \theta_t + \tau_x \varepsilon^x_{t+1} + \tau_p \varepsilon^p_{t+1};$$

- Affine dynamics for the market excess return

$$R^M_{t+1} = \nu_0 + \nu_x \varepsilon^x_{t+1} + \nu_p \varepsilon^p_{t+1}.$$

Labor Capital Asset Pricing Model

- Labor market augmented CAPM

$$\mathbb{E}_t[R^e_{i,t+1}] = \beta^M_{i,t}\lambda^M_t + \beta^\theta_{i,t}\lambda^\theta_t$$

  - $\beta^M_{i,t}$ and $\beta^\theta_{i,t}$ are factor loadings on MKT and LMT
  - λ^M_t and λ^θ_t are factor risk premia.

- CAPM mispricing alphas

$$\alpha^{CAPM}_{i,t} = \left(\lambda^x - \frac{\nu_0\nu_x}{\nu_x^2+\nu_p^2}\right)\beta^x_{i,t} + \left(\lambda^p - \frac{\nu_0\nu_p}{\nu_x^2+\nu_p^2}\right)\beta^p_{i,t}.$$

  - $\beta^x_{i,t}$ and $\beta^p_{i,t}$ are factor loadings on x and p

Quantitative Analysis

Parameter Calibration

Labor Market		
Size of the labor force	L	1.55
Matching function elasticity	ξ	1.27
Bargaining power of workers	η	0.115
Benefit of being unemployed	b	0.71
Returns to scale of labor	α	0.75
Workers quit rate	s	0.022
Flow cost of vacancy posting	κ_h	0.8
Flow cost of firing	κ_f	0.4
Fixed operating costs	f	0.275
Shocks		
Persistence of productivity shock	ρ_x	0.983
Volatility of productivity shock	σ_x	0.007
Persistence of matching efficiency shock	ρ_p	0.958
Volatility of matching efficiency shock	σ_p	0.029
Persistence of idiosyncratic productivity shock	ρ_z	0.965
Volatility of idiosyncratic productivity shock	σ_z	0.095
Pricing Kernel		
Risk-free rate	r_f	0.001
Price of risk of productivity shock	γ_x	0.28
Price of risk of matching efficiency shock	γ_p	-1.015

Aggregate and Firm-Specific Moments

Moments	Data	Model
Aggregate Labor Market		
Unemployment rate	0.059	0.059
Hiring rate	0.035	0.035
Layoff rate	0.013	0.013
Job creation rate	0.026	0.029
Job destruction rate	0.025	0.029
Labor market tightness (LMT)	0.634	0.653
Correlation of LMT and vacancy	0.820	0.803
Correlation of LMT and unemployment rate	-0.830	-0.858
Employment-Unemployment transition rate	0.015	0.012
Labor share of income	0.717	0.718
Volatility of aggregate wages to aggregate output	0.520	0.509
Aggregate profits to aggregate output	0.110	0.097
Firm-Level Employment		
Volatility of annual employment growth rates	0.239	0.240
Fraction of firms with zero annual employment growth rates	0.095	0.091
Asset Prices		
Average risk-free rate	0.010	0.012
Average market return	0.081	0.082

Equilibrium Forecasting Rules

- Equilibrium labor market tightness dynamics, $R^2 > 0.99$

$$\log \theta_{t+1} = -0.0165 + 0.966 \log \theta_t + 0.0458 \varepsilon^x_{t+1} + 0.0682 \varepsilon^p_{t+1}$$

- Tension: cash flow vs. discount rate effect
  - Cash flow effect: $p_{t+1} \uparrow$ reduces marginal cost of hiring
  - Discount rate effect: $p_{t+1} \uparrow$ reduces marginal value of job creation

☞ Cash-flow effect dominates → Loadings on labor market tightness positively relate to loadings on matching efficiency shocks.

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- Equilibrium dynamics of market excess return

$$R^e_{M,t+1} = 0.0056 + 0.0058 \varepsilon^x_{t+1} + 0.0063 \varepsilon^p_{t+1}.$$

Cross Section of Stock Returns

	Data				Model			
Decile	β^{θ}	Return	α^{CAPM}	β^{CAPM}	β^{θ}	Return	α^{CAPM}	β^{CAPM}
Low	-0.80	1.14	0.02	1.25	-0.84	1.13	0.10	1.00
2	-0.38	1.10	0.11	1.03	-0.33	1.00	-0.08	1.00
3	-0.23	1.07	0.12	0.97	-0.10	0.94	-0.14	1.00
4	-0.12	1.02	0.10	0.93	0.07	0.90	-0.20	1.02
5	-0.02	1.01	0.09	0.92	0.21	0.86	-0.25	1.00
6	0.06	0.98	0.06	0.93	0.34	0.83	-0.27	1.00
7	0.16	0.99	0.05	0.96	0.45	0.80	-0.32	1.01
8	0.28	0.97	-0.02	1.04	0.56	0.77	-0.35	1.02
9	0.46	0.89	-0.18	1.17	0.70	0.73	-0.40	0.99
High	0.92	0.66	-0.52	1.35	0.88	0.68	-0.44	0.99
Low-High	-1.72	0.48	0.54	-0.10	-1.72	0.45	0.54	0.02

Mechanism: cyclical labor characteristics

☞ Cyclicality of firms' labor decisions wrt θ determine their risk loadings.

	Positive β_θ: hedging firms	Negative β_θ: risky firms
$p \uparrow \quad \theta \uparrow$	Productive, small hire $\rightarrow D \uparrow$	Non-productive, big do not hire $\rightarrow D \downarrow$

Mechanism: cyclical labor characteristics

☞ Cyclicality of firms' labor decisions wrt θ determine their risk loadings.

	Positive β_θ: hedging firms	Negative β_θ: risky firms
$p \uparrow \quad \theta \uparrow$	Productive, small hire ➞ $D \uparrow$	Non-productive, big do not hire ➞ $D \downarrow$
$p \downarrow \quad \theta \downarrow$	Non-productive, big no hire ➞ $D \downarrow$	Productive, small hire ➞ $D \uparrow$
	high $Corr(V, \theta)$ high $Corr(D, \theta)$	low $Corr(V, \theta)$ low $Corr(D, \theta)$

Evidence for Mechanism: cyclical labor characteristics

- Job Openings and Labor Turnover Survey (JOLTS)
  - monthly vacancy posting rate and hiring rate, 2-digit NAICS
- Mass Layoff Statistics (MLS): monthly mass layoff rate, 2-digit NAICS
- Quarterly Census of Employment and Wages (QCEW)
  - annual hiring rate, employment growth rate, 6-digit NAICS $\times$ state
- Quarterly Workforce Indicators (QWI)
  - quarterly hiring rate, wage, 4-digit NAICS $\times$ state
- COMPUSTAT: profitability, labor share

Evidence for Mechanism: cyclical labor characteristics

Model: correlation with aggregate labor market tightness

β^θ decile	VR	HR	FR	HRA	EGR	HRQ	WAGE	PROF	LS
Low	-0.04	-0.05	0.15	-0.04	-0.08	-0.03	0.19	-0.05	0.13
Decile 5	0.13	0.12	0.07	0.09	0.05	0.14	0.21	-0.01	0.13
High	0.21	0.20	-0.09	0.16	0.15	0.20	0.23	0.05	-0.05
Low-High	-0.25	-0.26	0.24	-0.20	-0.23	-0.23	-0.04	-0.10	0.17

Data: correlation with residual aggregate labor market tightness

	JOLTS		MLS	QCEW		QWI		COMPUSTAT	
β^θ decile	VR	HR	FR	HRA	EGR	HRQ	WAGE	PROF	LS
Low	0.16	0.05	0.09	-0.13	0.00	-0.08	0.22	0.01	0.09
Decile 5	0.41	0.19	-0.26	-0.01	0.12	0.16	0.19	0.02	-0.17
High	0.51	0.15	-0.17	0.02	0.14	0.15	0.29	0.11	-0.12
Low-High	-0.35	-0.10	0.26	-0.15	-0.14	-0.23	-0.07	-0.10	0.21

Conclusion

- Dynamics in the labor market are important for asset valuation.
- Loadings on labor market tightness are priced in the cross section with a negative price of risk.
- A labor capital asset pricing model with labor search frictions reproduces the empirical results.
- Cyclical labor policies wrt labor market tightness capture risk exposures.