Welfare Costs of Fluctuations when Labor Market Search Interacts with Financial Frictions

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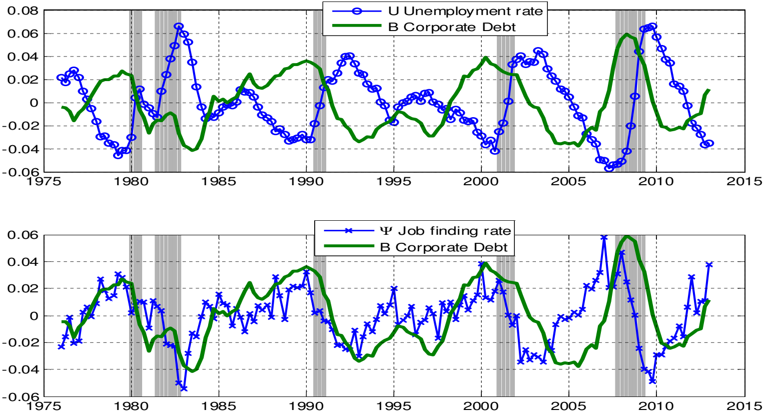
Motivation

Should we care about the costs of the business cycle ?

- Lucas finds that the welfare gain from eliminating consumption fluctuations is 0.005% of permanent consumption per capita (i.e., an annual consumption compensation of 17 US dollars per capita)
- The Great Recession leads us to reassess this result
  - Dramatic effect on the real economy.
    Unemployment rate of the 25-54 has risen by 5 percentage points, from 4% at the end of 2007 to 9% in April 2010.
    We should worry if pains from recessions are not compensated by gains in booms
  - Renewed interest on empirical evidence of effects of financial frictions on employment (Micro evidence and macro evidence)

FIGURE: Cyclicality of US unemployment rate U, job finding rate Ψ and debt stock B. Nonfinancial corporate business liabilities (corporate bonds, depository institution loans, commercial paper and other loans and advances, total mortgages, as in Jermann Quadrini, 2012). HP Filtered, logged, quarterly data. Recessions in shaded area (NBER dates). HP filtered data on U and Ψ have been divided by 4 for the purpose of scale consistency. Smoothing parameter 1600.



Motivation

We propose a model in which business cycle costs are sizeable

- In a linear world (Lucas, log-linearized DSGEs) :
  - costs of recessions are compensated by gains from expansions
  - steady state consumption = average consumption
    $\Rightarrow$ low business cycle costs
- If we take non-linearities seriously :
  - costs of recessions $>$ gains from expansion
  - steady state consumption $>$ average consumption
    $\Rightarrow$ sizeable and asymmetric welfare costs
- Which type of non linearities ?
  - Easier to reduce employment than to increase it
  - Because investment in new jobs requires external funding
  - interaction between labor and financial frictions

Paper

- Model with
  - Search and Matching frictions (Mortensen-Pissarides, 1989)
  - and financial frictions (Kiyotaki and Moore, 1997)
- Mechanisms at work
  - SaM model : non-linear economy
    Hairault, Langot and Osotimehin, 2010 ; Jung and Kuester, 2011 ; Petrosky-Nadeau Zhang, 2013
  - financial frictions : amplify these non-linearities
    - level effect
    - business-cycle effect

Contribution to the literature

- Literature on BC fluctuations in a search model with financial frictions
  - Petrosky-Nadeau and Wasmer (2013), Petrosky-Nadeau (2013), among others
- Literature on welfare costs of business cycle
  - Krebs (2007), Hairault, Langot and Osotimehin (2010), Jung and Kuester, (2011), Hairault and Langot (2012), Petrosky-Nadeau and Zhang (2013), Cacciatore and Fiori (2014)
- Our paper : Welfare cost, interaction between financial and labor market frictions, endogenous wage sluggishness

Part I
Intuitions
in a Mickey-Mouse example

At the steady state, unemployment outflows equal unemployment inflows :

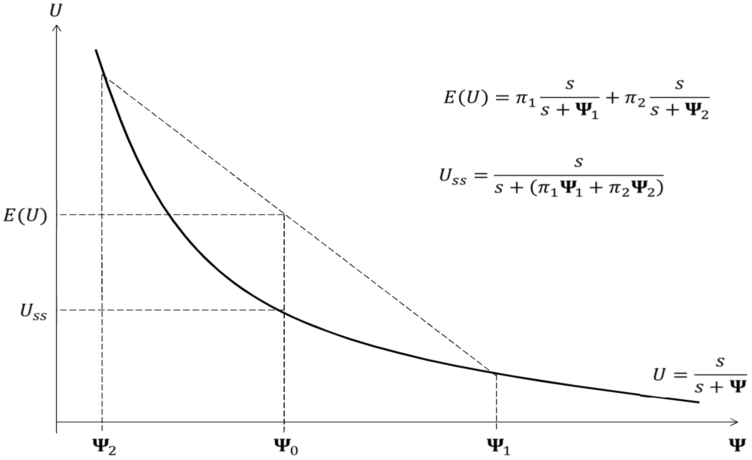
$$\Psi U = sN$$

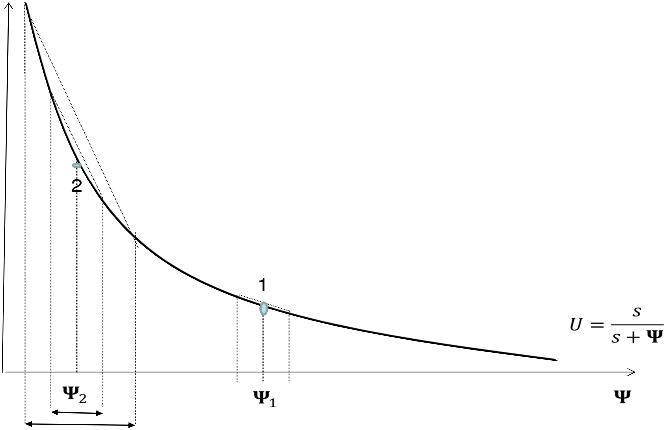
U is a convex function of the job finding rate Ψ :

$$U = \frac{s}{s + \Psi}$$

s exogenous destruction rate.
Assume that Ψ follows a Markov process.

- conditional (on Ψ_i) ss unemployment : $\tilde{u}_i = \frac{s}{s+\Psi_i}$
- stabilized unemployment : $\bar{u} = \frac{s}{s+\sum_i \pi_i \Psi_i} < \sum_i \pi_i \tilde{u}_i = \tilde{u} \approx E\left(u\right)$


U
$E(U) = \pi_1 \frac{s}{s+\mathbf{\Psi}_1} + \pi_2 \frac{s}{s+\mathbf{\Psi}_2}$
$U_{ss} = \frac{s}{s+(\pi_1\mathbf{\Psi}_1+\pi_2\mathbf{\Psi}_2)}$
$E(U)$
U_{ss}
$U = \frac{s}{s+\mathbf{\Psi}}$
$\mathbf{\Psi}_2$
$\mathbf{\Psi}_0$
$\mathbf{\Psi}_1$
$\mathbf{\Psi}$



Level effect : move from Ψ_1 to Ψ_2
Business cycle effect : more fluctuations around Ψ_2
Asymmetry : recessions versus expansion

Non linearity

$$\tilde{u} - \bar{u} \approx u''(\Psi) \frac{\sigma_\Psi^2}{2} \approx \frac{s}{(s+\Psi)^3} \sigma_\Psi^2$$

The larger this gap, the larger the business cycle costs.

- Level effect :
  - This gap decreases with Ψ
  - Our paper : **financial frictions lower** Ψ
- Business cycle effect :
  - This gap increases with σ_Ψ^2
  - Our paper : **financial frictions increase** σ_Ψ^2

Part II
SaM model with financial frictions

The model's key elements : Mortensen-Pissarides model with financial frictions à la Kiyotaki-Moore

A streamlined model

- Kiyotaki-Moore : Financial frictions
  - Impatient firm, patient household-banker
  - Working capital assumption (Jermann and Quadrini 2012)
  - Financial constraint, collateral on land in fixed supply
  - precautionary savings (workers) but no physical capital
- Mortensen-Pissarides : Search and Matching
  - Extensive margin only (employment stock is not a pre-determined variable as in Blanchard Gali (2010))
  - Nash bargaining with impatient firm and patient worker $\rightarrow$ endogenous wage sluggishness
  - Technological shocks only

Endogenous U, Ψ, B

The model's key elements : Mortensen-Pissarides model with financial frictions à la Kiyotaki-Moore

Intuitions

- Large elasticity of θ w.r.t net labor productivity : volatile economy
  - Financial frictions lower the surplus
  - With financial frictions, cyclical wedge on labor productivity : more surplus in booms
- Check that debt and land price volatility is in line with data
- Welfare costs
  - Sizable : level effect and business cycle effect
  - Asymmetric

$$E_0\left[\sum_{t=0}^{\infty}\mu^t\{N_tU^n(C_t^n)+(1-N_t)U^u(C_t^u)\}\right] \quad (1)$$

where $0<\mu<1$ is the discount factor.

$$U(C_t^z)=\frac{(C_t^z+\Gamma^z)^{1-\sigma}}{1-\sigma}\equiv\tilde{U}_t^z \quad z=n,u. \quad \Gamma^n=0.$$

Households labor opportunities evolves as follows :

$$N_t=(1-s)N_{t-1}+\Psi_tS_t \quad (2)$$

Budget constraint

$$[N_tC_t^n+(1-N_t)C_t^u]+B_t\leq R_{t-1}B_{t-1}+N_tw_t+(1-N_t)b_t+T_t \quad (3)$$

$$E_0\left[\sum_{t=0}^{\infty}\beta^t U\left(C_t^F\right)\right] \tag{4}$$

where $\beta < \mu$. Impatient firm

$$C_t^F + R_{t-1}B_{t-1} + q_t\left[L_t - L_{t-1}\right] + w_t N_t + \bar{\omega}V_t \leq Y_t + B_t \tag{5}$$

$$Y_t = A_t L_{t-1}^{1-\alpha} N_t^{\alpha} \tag{6}$$

Technological shock A.
Evolution of labor :

$$-N_t + (1-s)N_{t-1} + \Phi_t V_t = 0 \tag{7}$$

where $\Phi_t \equiv M_t / V_t$. $\theta_t = \frac{V_t}{S_t}$

Collateral constraint

multiplier φ_t

$$B_t + \bar{\omega} V_t \leq m E_t \left[q_{t+1} \right] L_t \tag{8}$$

- Limited enforceability
  - Firms can default on debt. In case of default, asset available for liquidation is a stock. The firm is be subject to the enforcement constraint (micro foundations JQ AER 2012)
  - Land provides important collateral value for business spending (Liu et al. Ecta 2013)
- Working capital JQ AER 2012
  - Entrepreneurs need to pay vacancy posting costs before the realization of revenues
  - intraperiod loan

Job Creation

$$\bar{\omega}\frac{(1+\varphi_t)}{\Phi_t} = \frac{\partial Y_t}{\partial N_t} - w_t + (1-s)\,\beta E_t\left[\frac{\lambda^F_{t+1}}{\lambda^F_t}\frac{\bar{\omega}}{\Phi_{t+1}}(1+\varphi_{t+1})\right]$$

Without financial frictions, recover the usual JC condition

Nash Bargaining

$$w_t = \epsilon(b + \Gamma) + (1 - \epsilon)\left[\frac{\partial Y_t}{\partial N_t} + \Sigma_t\right]$$

- Without financial frictions (standard solution, with $\mu = \beta$)

$$\Sigma_t = (1 - s)\beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\bar{\omega}\theta_{t+1}\right]$$

- With financial frictions

$$\Sigma_t = (1 - s)E_t\left[(1 + \varphi_{t+1})\left\{\begin{array}{l} \frac{\bar{\omega}}{\Phi_{t+1}}\left(\beta\frac{\lambda^F_{t+1}}{\lambda^F_t} - \mu\frac{\lambda_{t+1}}{\lambda_t}\right) \\ +\mu\frac{\lambda_{t+1}}{\lambda_t}\bar{\omega}\theta_{t+1} \end{array}\right\}\right]$$

Elasticity of θ w.r.t. TFP shocks

At the Steady State, we have

$$\left.\begin{array}{rcl} \frac{\bar{\omega}}{\Phi(\theta)} & = & \frac{y-w}{(1-\beta(1-s))(1+\varphi)} \\ w & = & \epsilon(b+\Gamma)+(1-\epsilon)(y+\Sigma) \\ \Sigma & = & (1-s)(1+\varphi)\left\{\frac{\bar{\omega}}{\Phi(\theta)}(\beta-\mu)+\mu\bar{\omega}\theta\right\} \end{array}\right\} \Rightarrow$$

By linearizing :

$$\begin{array}{rcl} b_0\widehat{\theta} & = & b_1\widehat{y} - b_2\widehat{w} - b_3\widehat{\varphi} \\ \hat{w} & = & \omega_0\hat{y} + \omega_1\hat{\Sigma} \\ \text{with} \quad \hat{\Sigma}_t & = & s_1\widehat{\varphi} + (b_4 - s_2)\widehat{\theta} \end{array}$$

$$\text{thus} \quad w = \omega_0\hat{y} + \omega_1 s_1\widehat{\varphi} + \omega_1(b_4 - s_2)\widehat{\theta}$$

Elasticity of θ w.r.t. TFP shocks

This leads to

$$\begin{array}{rclcll} \widehat{\theta} & = & \underbrace{\frac{b_1 - b_2\omega_0}{b_0 + b_2\omega_1 b_4 - b_2\omega_1 s_2}\widehat{y}}_{\gtrless} & - & \underbrace{\frac{b_3 + b_2\omega_1 s_1}{b_0 + b_2\omega_1 b_4 - b_2\omega_1 s_2}\widehat{\varphi}}_{>0} & \text{our model} \\ \widehat{\theta} & = & \frac{b_1 - b_2\omega_0}{b_0 + b_2\omega_1 b_4}\widehat{y} & & & \text{DMP} \end{array}$$

Notice that in HM, 2008 : $\omega_0 \to 0$, $\omega_1 \to 0$, $b \to 1$, $\epsilon \to 1$

Part III
Quantitative assessment

TABLE: Calibration

Notation	Label	value	Reference
(a) External information			
Notation	Label	value	Reference
β	discount factor (impatient)	0.99	Iacoviello (2005)
α	production function	0.99	Iacoviello (2005)
σ_W	risk aversion, worker	2	
σ_F	risk aversion, firm	1	Iacoviello (2005)
s	Job separation rate	0.1	Shimer (2005)
N	Employment	0.88	Hall (2005)
ψ	Elasticity of the matching function	0.5	Petrongolo and Pissarides (2001) $\epsilon = \psi$
ω	cost of job posting	0.17	Barron et al. (1997)
$\frac{b}{w}$	replacement ratio	0.72	Hall and Milgrom (2008)
A	average TFP	1	Normalization
ρ_A	Persistence	0.95	Hairault et al. (2010)
(b) Empirical target			
Notation	Label	value	Empirical target
μ	discount factor (patient)	$1/(1.04^{\frac{1}{4}})$	Annual real rate of 0.04
χ	scale parameter of matching function	0.63397	Probability of filling a vacancy $\Phi = 0.95$
m	collateral constraint	0.61	corporate debt to GDP ratio $B/Y = 0.595$
σ_A	Standard deviation	0.0046	Observed σ_Y
(c) Derived parameter values			
Notation	Label	value	
Ψ	Job finding rate	0.423	
Γ	preference	0.19	

H&M (2008) : $b/w = 0.955$ *and* $\epsilon = 0.9480$, thus $1-(b\epsilon)/w = 0.10$. In this paper, $1-\epsilon(b+\Gamma)/w = 0.55$.

TABLE: Business cycle volatility : Model versus data (logged HP filtered US quarterly data. 1976Q1-2013Q1.Smoothing parameter 1600)

	1 Data std(.)		2 Model with FF std(.)	
Y	1.44	**	1.43	**
C	0.81	*	0.92	*
N	0.72	*	0.59	*
Y/N	0.54	*	0.42	*
w	0.63	*	0.68	*
U	7.90	*	4.26	*
Job finding rate Ψ	5.46	*	4.35	*
V	9.96	*	8.51	*
Corporate debt B	1.68	*	1.52	*
Bank business loan R	0.92	*	0.25	*
Real land price q	3.20	*	2.97	*
$corr(U, \Psi)$	-0.91		-0.86	
$corr(U, V)$	-0.97		-0.71	

** std (in percentage) ; * relative to GDP std

Expected lifetime utility in the fluctuating economy (for workers)

$$\tilde{U}^w = E_0 \sum_{t=0}^{\infty} \mu^t [N_t U(C_t^n) + (1 - N_t) U(C_t^u + \Gamma)]$$

Expected lifetime utility in the stabilized economy

$$\bar{U}^w = \sum_{t=0}^{\infty} \mu^t [\bar{N} U(\bar{C}^n(1-\tau)) + (1-\bar{N}) U((\bar{C}^u + \Gamma)(1-\tau))]$$

Welfare cost of fluctuations : τ, how much steady state consumption would workers give up to be indifferent between the 2 economies ?

$$\tau = 1 - \left[\tilde{U}^w \frac{(1-\mu)(1-\sigma)}{(\bar{C} + (1-\bar{N})\Gamma)^{1-\sigma}}\right]^{\frac{1}{1-\sigma}}$$

2nd-order Taylor expansion of welfare in volatile economy :

$$\tau \approx \tau_1 + \tau_2$$

Lucas' measure (with unemployment), BC effect :

$$1-\tau_1 = \left[1 - \frac{1}{2}\sigma(1-\sigma)\left(\gamma_c Var(\widehat{c}) + \gamma_u Var(\widehat{u}) + \gamma_{cu} Cov(\widehat{c}, \widehat{u})\right)\right]^{\frac{1}{1-\sigma}}$$

Mean differs from steady state (level effect) :
(in a linear world, $\tau_2 = 0$)

$$(1-\tau_2) = \frac{E_0[C + (1-N)\Gamma]}{\bar{C} + (1-\bar{N})\Gamma}$$

$\widehat{x} = \frac{X_t - E_0[X]}{E_0[X]}$, for $x = C, U$ $\gamma_c = \frac{E_0[C^2]}{E_0[(C+(1-N)\Gamma)^2]}$ $\gamma_u = \frac{\Gamma^2 E_0[(1-N)^2]}{E_0[(C+(1-N)\Gamma)^2]}$ $\gamma_{cu} = \frac{2\Gamma E_0[C(1-N)]}{E_0[(C+(1-N)\Gamma)^2]}$

TABLE: Decomposition of welfare costs of business cycle

	Worker with fin. frictions A	Worker without fin. frictions B
Total welfare cost		
1. $\tau \times 100$	2.50	0.30
Decomposing the welfare cost		
2. $\tau_2 \times 100$ Level	2.45	0.24
3. $\tau_1 \times 100$ Business cycle	0.05	0.06
4. $100 \times \frac{\bar{N}-E(N)}{\bar{N}}$ (# of jobs)	3.3% 4m	300 000
5. $100 \times \frac{\bar{Y}-E(Y)}{\bar{Y}}$ (dollars per capita)	1600	104

line 1 $\approx$ line 2 + line 3

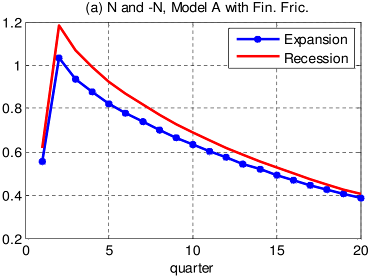
- Even in a volatile economy, τ_1 is small
- Model A : 98% of the welfare costs come from the gaps between mean and SS
- Model B : only 80%, because non-linearities are smaller.

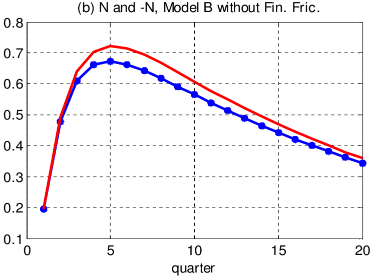
Welfare costs and Efficiency

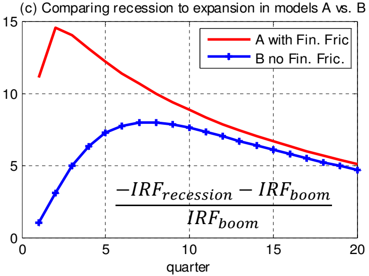
- Lucas' work is based on the idea that the sources of fluctuations are technological shocks.
- The policy maker cannot change this exogenous source of fluctuations.

$\Rightarrow$ So why care ?

- Our model economy transforms shocks into fluctuations :
  - this transformation leads to a large multiplier effect.
  - this transformation is suboptimal :
    - Model B with same σ_Y as model A, $\tau \times 100 = 0.41$
      $\Leftrightarrow$ without suboptimal financial constraints
    - Model B with $b = 0$ and Hosios, $\tau \times 100 = 0.03$
      $\Leftrightarrow$ the efficient allocation



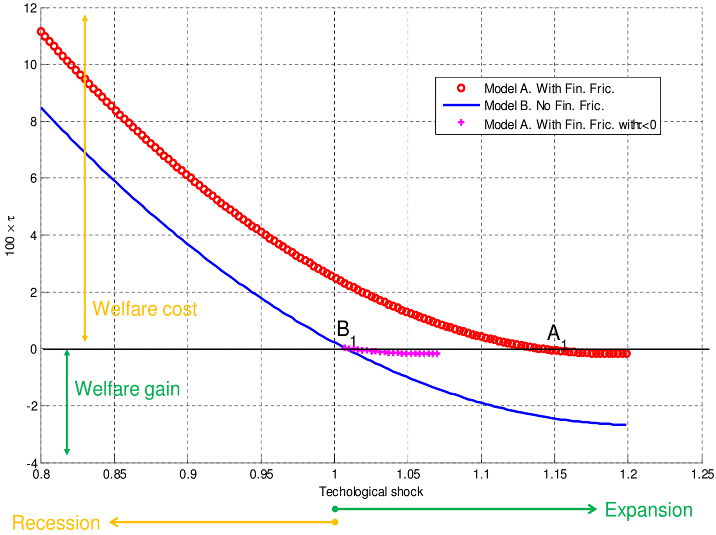




Asymmetric responses to business cycle shocks :

- HLO (2010), Jung and Kuester (2011), Petrosky-Nadeau and Zhang (2014)
- recessions (expansions) are characterized by severe and rapid rises (gradual decline) in unemployment

Asymmetric welfare costs :
cost of recessions > gains from expansions


12
10
8
6
4
2
0
-2
-4
100 × τ
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
Techological shock
Model A. With Fin. Fric.
Model B. No Fin. Fric.
Model A. With Fin. Fric. with τ<0
Welfare cost
Welfare gain
B1
A1
Recession
Expansion

Conclusion

- Sizeable business cycle costs
- due to the interaction between labor market and financial frictions
- A call to study stabilizing policies in models in which business cycle matters

Appendix

- Aggregate data : The following quarterly time series come FRED database, from the Federal Reserve Bank of Saint Louis' website (1976Q1-2013Q1). y is Real Gross Domestic Product from the FRED database (mnemonicsGDPC96) divided by the Civilian Non institutional Population from the FRED database (mnemonics CNP16OV). c is Real Personal Consumption Expenditures from the FRED data-base (mnemonics PCECC96) divided by the Civilian Non institutional Population from the FRED database (mnemonics CNP16OV)
- Labor market data : w is Compensation of Employees : Wages & Salary Accruals from the FRED database (mnemonics WASCUR) divided by Civilian Employment (CE16OV). N is Civilian Employment (CE16OV) divided by Civilian Non institutional Population. U is FRED, Civilian Unemployment Rate (UNRATE), Percent, quarterly, Seasonally Adjusted. The previous time series are taken from the FRED database. As for the time series of job finding rate, we use monthly CPS data from January 1976 to March 2013. We follow all the steps described in Shimer(2012). As in Shimer(2012), we correct for time aggregation and take quarterly averages of monthly observations. V are vacancies Total Nonfarm, Total US Job Openings $JTS00000000JOL$, Seasonally Adjusted Monthly data from BLS. We take quarterly averages of this time series that is available only from December 2000 onwards.

Cyclical components of the data :

- All data are quarterly (from 1976 :Q1 through 2013 :Q1), in logs, $HP(\lambda = 1600)$ filtered and multiplied by 100 in order to express them in percent deviation from steady state.
- Ψ is the job finding rate computed from Monthly CPS data from January 1976 to March 2013 using Shimer (2012)'s methodology. It measures the probability for an unemployed worker to find a job.
- As for financial data on debt B and interest rate $R - 1$, we follow Jermann and Quadrini (2012).
- Relative price of land q from Liu et al. (2013). 1975Q1-2010Q3. Liquidity-adjusted price index for residential land divided by consumption deflator (weighted aggregate index from nondurables consumption and services, housing services excluded).
- w is Compensation per employee = Total Compensation of employees received / Civilian Employment
- V vacancies BLS JOLTS JTS00000000JOL,Job Openings and Labor Turnover : Total Nonfarm : Total US : Job Openings JTS00000000JOL : Seasonally Adjusted Monthly data from BLS, 2000 Dec -2013 Feb.

Debt :

- We follow Jermann and Quadrini (2012). Financial data come from the Flow of Funds Accounts of the Federal Reserve Board. Nonfinancial corporate business ; liability ; corporate bonds ; depository institution loans ; commercial paper and other loans and advances ;
- The debt stock is constructed using the cumulative sum of net new borrowing measured by the 'Net increase in credit markets instruments of non financial business'(Nonfinancial business ; credit market instruments ; liability ; Net increase in credit markets instruments of non financial business, millions of dollars (nominal)). FA144104005.Q, F.101 Line 28. Since the constructed stock of debt is measured in nominal terms, it is deflated by the price index for business value added from NIPA.
- The initial (nominal) stock of debt is set to 94.12, which is the value reported in the balance sheet data from the Flow of Funds in 1952.I for the nonfarm non financial business. The cumulative sum starts in 1952, which, as in Jermann and Quadrini (2012), is not likely to affect our data starting on January 1976.
- R is the log of 1+ the Bank Prime Loan Rate (MPRIME) (used as a reference for short-term business loan) from the FRED database.

Let N_t and M_t respectively denote the number of workers and the total number of new hires, and s the exogenous job destruction rate.

$$N_t = (1-s)N_{t-1} + M_t \tag{9}$$

with M_t such that

$$M_t = \chi V_t^{\psi} S_t^{1-\psi}, \quad 0 < \psi < 1$$

Pool of jobless individuals, S_t, who are available for hire.

$$S_t = U_{t-1} + sN_{t-1} = 1 - (1-s)N_{t-1} \tag{10}$$

where $U_t = 1 - N_t$ is the stock of unemployed workers when the size of the population is normalized to 1.

- Job finding rate : $\Psi_t \equiv M_t / S_t$
- Labor market tightness : $\theta_t \equiv \frac{V_t}{S_t}$ hence $\Psi_t = \chi \theta_t^{\psi}$

Each household knows that the evolution of S follows (10), so that (2) can be written as :

$$N_t = (1-s)N_{t-1} + \Psi_t\left(1-(1-s)N_{t-1}\right) \tag{11}$$

The dynamic problem of a typical household can be written as follows

$$\mathcal{W}(\Omega_t^H) = \max_{C_t^n, C_t^u, B_t} \left\{ N_t U(C_t^n) + (1-N_t)U(C_t^u+\Gamma) + \mu E_t \mathcal{W}(\Omega_{t+1}^H) \right\}$$

subject to (11) and (3), given the initial conditions on state variables (N_0, K_0, B_0) and $\Omega_t^H = \{N_{t-1}, \Psi_t, w_t, b_t, T_t, B_{t-1}\}$, the vector of variables taken as given by households. Let λ_t be he shadow price of the budget constraint. The first order conditions associated with consumption choices are

$$(C_t^n)^{-\sigma} = (C_t^u+\Gamma)^{-\sigma} = \lambda_t$$

Hence $\tilde{U}_t^n = \tilde{U}_t^u$. The first order condition associated to bond holdings reads :

$$-\lambda_t + \mu E_t\left[R_t \lambda_{t+1}\right] = 0 \tag{12}$$

The firm's program is

$$\mathcal{W}(\Omega_t^F) = \max_{C_t^F, L_t, B_t, V_t, N_t} \left\{ U\left(C_t^F\right) + \beta E_t \left[\mathcal{W}(\Omega_{t+1}^F)\right]\right\} \tag{13}$$

$$s.t. \quad \begin{cases} -C_t^F - R_{t-1}B_{t-1} - q_t\left[L_t - L_{t-1}\right] - w_t N_t - \bar{\omega} V_t & \\ \qquad +Y_t\left(A_t, L_{t-1}, N_t\right) + B_t = 0 & (\lambda_t^F) \\ -B_t - \bar{\omega} V_t + mE_t\left[q_{t+1}L_t\right] = 0 & (\lambda_t^F \varphi_t) \\ -N_t + (1-s)N_{t-1} + \Phi_t V_t = 0 & (\xi_t) \end{cases}$$

given the initial conditions N_0, B_0, where $\Omega_t^F = \{N_{t-1}, \Psi_t, w_t, b_t, \pi_t, T_t, B_{t-1}, L_{t-1}\}$ is the vector of variables taken as given by firms.

$$U'\left(C_t^F\right) = \lambda_t^F \tag{14}$$

$$\lambda_t^F q_t = \beta E_t \left[\lambda_{t+1}^F \left(q_{t+1} + \frac{\partial Y_{t+1}}{\partial L_t}\right)\right] + \lambda_t^F \varphi_t m E_t\left[q_{t+1}\right] \tag{15}$$

$$(1-\varphi_t)\lambda_t^F = \beta E_t \lambda_{t+1}^F R_t \tag{16}$$

$$\xi_t = \lambda_t^F \bar{\omega} \frac{(1+\varphi_t)}{\Phi_t} \tag{17}$$

$$\xi_t = \lambda_t^F \left[\left(\frac{\partial Y_t}{\partial N_t}\right) - w_t\right] + (1-s)\beta E_t\left[\xi_{t+1}\right] \tag{18}$$

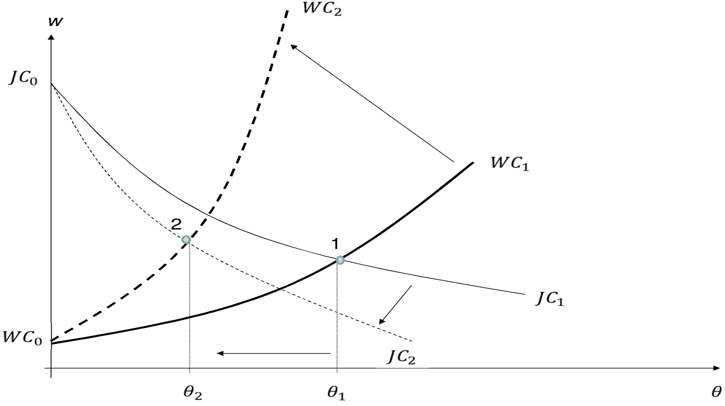
Firms optimality conditions

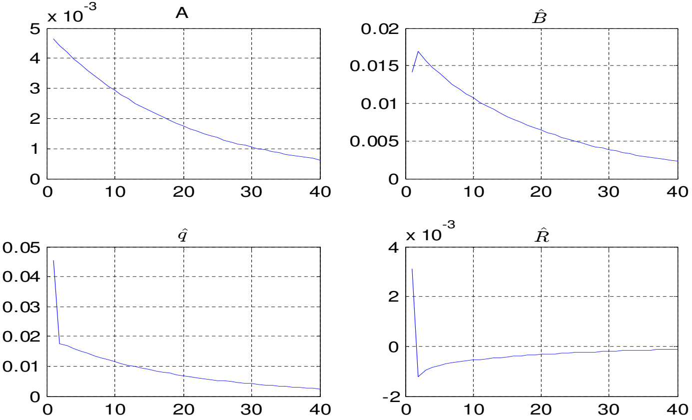
$$\lambda_t^F q_t = \beta E_t \left[\lambda_{t+1}^F \left(q_{t+1} + \frac{\partial Y_{t+1}}{\partial L_t} \right) \right] + \lambda_t^F \varphi_t m E_t \left[q_{t+1} \right]$$

$$1 - \beta E_t(\lambda_{t+1}^F R_t) = \lambda_t^F (1 - \varphi_t)$$

$$\bar{\omega} \frac{(1+\varphi_t)}{\Phi_t} = \frac{\partial Y_t}{\partial N_t} - w_t + (1-s)\,\beta E_t \left[\frac{\lambda_{t+1}^F}{\lambda_t^F} \frac{\bar{\omega}}{\Phi_{t+1}} (1+\varphi_{t+1}) \right]$$

demand for land
firm's Euler
job creation


WC_2
w
JC_0
WC_1
2
1
JC_1
WC_0
JC_2
θ_2
θ_1
θ


x 10^-3
A
5
4
3
2
1
0
0
10
20
30
40
$\hat{B}$
0.02
0.015
0.01
0.005
0
$\hat{q}$
0.05
0.04
0.03
0.02
0.01
x 10^-3
$\hat{R}$
4
2
0
-2

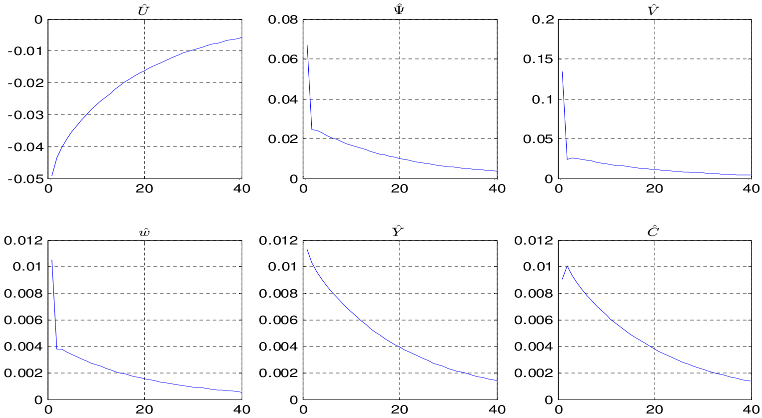

$\hat{U}$
$\hat{\Psi}$
$\hat{V}$
$\hat{w}$
$\hat{Y}$
$\hat{C}$
0
-0.01
-0.02
-0.03
-0.04
-0.05
0.08
0.06
0.04
0.02
0.2
0.15
0.1
0.05
0.012
0.01
0.008
0.006
0.004
0.002
20
40

TABLE: Simulations

	1 Data std(.)		2 Model A (with FF) std(.)		3 Model B (no FF) std(.)	
Y	1.44	**	1.43	**	1.07	**
C	0.81	*	0.91	*	1.01	*
N	0.72	*	0.59	*	0.49	*
Y/N	0.54	*	0.42	*	0.60	*
w	0.63	*	0.68	*	0.52	*
U	7.90	*	4.26	*	3.9	*
Psi	5.46	*	4.35	*	3	*
V	9.96	*	8.51	*	4.9	*
B	1.68	*	1.52	*		*
R	0.92	*	0.25	*		*
q	3.20	*	2.97	*		*
corr(U,Psi)	-0.91		- 0.86		- 0.92	
corr(U,V)	-0.97		-0.71		- 0.76	

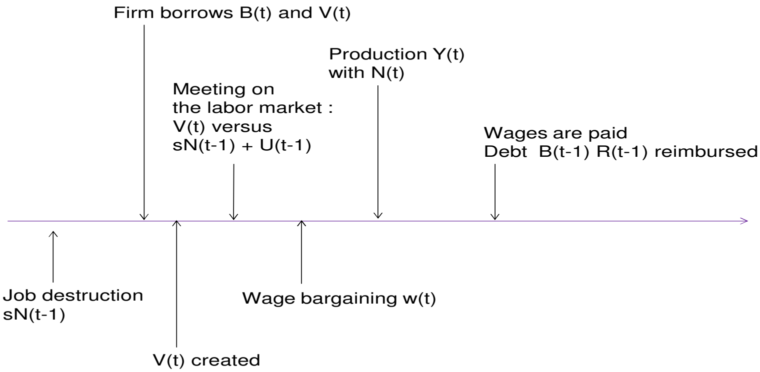
** std (in percentage) ; * relative to GDP std

Nash bargaining : the wage curve WC

$$\max_{w_t} \mathcal{S}_t = \left(\frac{\mathcal{V}_t^F}{\lambda_t^F}\right)^{\epsilon} \left(\frac{\mathcal{V}_t^H}{\lambda_t}\right)^{1-\epsilon}$$

- $\mathcal{V}_t^F = \frac{\partial \mathcal{W}(\Omega_t^F)}{\partial N_{t-1}}$ the marginal value of a match for a firm
- $\mathcal{V}_t^H = \frac{\partial \mathcal{W}(\Omega_t^H)}{\partial N_{t-1}}$ the marginal household's surplus from an established employment relationship.
- ϵ denotes the firm's share of a job's value, i.e., firms' bargaining power.

FIGURE: Sequence of events



$$\tilde{U}^w \approx \frac{1}{1-\mu} U\left(E_0[C+(1-N)\Gamma]\right)\left[1-\frac{1}{2}\sigma(1-\sigma)\left(\gamma_c Var(\widehat{c})+\gamma_u Var(\widehat{u})+\gamma_{cu} Cov(\widehat{c},\widehat{u})\right)\right.$$

with

- $\widehat{x} = \frac{X_t - E_0[X]}{E_0[X]}$, for $x = C, U$
- $\gamma_c = \frac{E_0[C^2]}{E_0[(C+(1-N)\Gamma)^2]}$
- $\gamma_u = \frac{\Gamma^2 E_0[(1-N)^2]}{E_0[(C+(1-N)\Gamma)^2]}$
- $\gamma_{cu} = \frac{2\Gamma E_0[C(1-N)]}{E_0[(C+(1-N)\Gamma)^2]}$