Asset Prices and Unemployment Fluctuations

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Traditionally Two Main Views of Business Cycles Exist

- **Keynesian**: interprets unemployment as *involuntary* phenomenon
  - but that arises from constrained inefficient contracts
  - thus subject to Barro and Lucas critiques: underlying frictions (*sticky w*)
    - prevent mutually beneficial arrangements (*Barro*)
    - unlikely to be invariant to changes in environment (*Lucas*)

- **Real business cycle**: interprets unemployment as *efficient* outcome
  - but idea of *voluntary non-* at core at odds w/ involuntary aspect of *u*
  - therefore subject to Solow critique
    - recessions episodes of “contagious attacks of laziness”
Promise of Search and Matching Models (DMP)

- Was to bridge these two views by proposing framework in which
  - unemployment is both involuntary and constrained efficient

- Shimer (2005) however has pointed out that textbook DMP model
  - generates much smaller employment fluctuations than in data

- Namely, it cannot reproduce observed business-cycle frequency movements
  - in either job vacancies or unemployment
  - in response to shocks of plausible magnitudes
In Response to Shimer’s Criticism

• Large literature has developed to reconcile DMP model w/ data

• Some important work has built on idea of ex ante inefficient wage contracts

• Other influential work has retained notion of efficient wage contracts
  ○ Hagedorn and Manovski (2005), Pissarides (2009)

• But existing models lead to three counterfactual predictions in that they imply
  ○ acyclical opp. cost of $e$: shown by Chodorow-Reich and Karabarbounis (2016)
  ○ low degree of cyclicalilty of $w$: proved by Kudlyak (2014), Basu and House (2016)
  ○ highly volatile risk-free rates: argued by Borovicka and Borovickova (2018)

All these predictions are greatly at odds with data
This Paper

• Goal: to solve Shimer puzzle by proposing framework that
  ◦ is consistent with key features of data
  ◦ does not rely on inefficient wage contracting (constrained efficient)
  ◦ is robust to all these critiques

• Our proposed solution
  ◦ based on idea recessions generated by *time-varying risk premia*
  ◦ emanating from productivity or other shocks

• Our mechanism is simple: main intuition is
  ◦ hiring workers akin to investing in “assets” with risky dividend flows
  ◦ higher risk premia in downturns make this investment unattractive
  ◦ induces firms to reduce substantially number of vacancies they create
  ◦ so leads $u$ in aggregate to increase as much as in data
Two Ingredients to Our Mechanism

- Preferences and human capital
  - we consider preferences leading to sharp increases in price of risk in recessions
  - we allow for human capital accumulation on the job
    - imparts persistent component to surplus from a firm-worker match
    - that accrues even after match ends
    - so that formally match surplus flows have long durations

- Both are critical

- In particular absent human capital: surplus flows have very short durations
  - hence even with high price of risk in recessions
  - PV of surplus flows barely declines
  - so model gives rise to essentially no fluctuations in $u$
To Summarize

• In data asset prices fluctuate (uncontroversial)
  ○ we introduce ingredient to make them fluctuate in our model: preferences

• In data also wages increase w/ experience (uncontroversial)
  ○ we introduce ingredient to reproduce this feature in our model: human capital

• Show once textbook model augmented w/ them: no u-volatility puzzle arises

• Importantly our results hold for various wage determination mechanisms
  ○ including competitive search, Nash bargaining, alternating-offer bargaining
  ○ do not rely on (real or nominal) wage rigidities or other inefficiencies
  ○ account for key patterns not only of job-finding rates, u but also asset prices, Y, I

• So overall view our findings as promising first step
  ○ toward developing integrated theory of real and financial business cycles
Model: Overview

- We consider economy subject to aggregate shocks (productivity in baseline)

- Economy populated by households
  - composed of employed and unemployed workers
  - who survive across periods with probability $\phi$ (today $\phi = 1$)
  - provide full insurance to their members against idiosyncratic shocks
  - have access to complete one-period contingent claims against aggregate risk
  - own firms (so firms share households’ discount factor)

- To illustrate our novel mechanism, abstract from physical capital from most of talk
  - but all of our results hold in its presence
Model: Preferences and Stochastic Structures

- We examine five specifications of preferences and stochastic processes
  - preferences with exogenous time-varying risk (in form of an exogenous habit)
  - Campbell-Cochrane preferences with external habit
  - Epstein-Zin preferences with long-run risk
  - Epstein-Zin preferences with variable disaster risk
  - reduced-form affine discount factor

- We can let any of these preference structures be our baseline
  - since all lead to very similar degrees of volatility for $u$
  - in accord with data

- We simply chose simplest specification
Model: Baseline Preferences

- Nearly identical to Campbell and Cochrane (1999) but w/o consumption externality
- Specifically, assume households have CC preferences with exogenous habit $X_t$
  \[
  E_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_t - X_t)^{1-\alpha}}{1 - \alpha}
  \]
- In symmetric equilibrium individual consumption $C_t$ equals aggregate $\bar{C}_t$
  - define aggregate surplus consumption ratio: $S_t = \frac{\bar{C}_t - X_t}{C_t}$ so
  - aggregate $MU_t = \beta^t \bar{C}_t^{-\alpha} S_t^{-\alpha}$ ↑ as $S_t$ ↓ and so does relative risk aversion $\alpha / S_t$
- One-period ahead and $t$-period ahead discount factors defined accordingly
  \[
  Q_{t,t+1} = \beta \left( \frac{C_{t+1}}{C_t} \frac{S_{t+1}}{S_t} \right)^{-\alpha} \quad \text{and} \quad Q_{0,t} = \beta^t \left( \frac{C_t}{C_0} \frac{S_t}{S_0} \right)^{-\alpha}
  \]
- Here productivity growth is random walk w/ drift $g_a$: $\log A_{t+1} = g_a + \log A_t + \sigma_a \varepsilon_{t+1}$
Model: Process for State

• As in Campbell and Cochrane (1999), choose law of motion for $S_t$ to generate
  ○ high and volatile equity premia but low and fairly constant risk-free rates

• We do so by positing following law of motion for $S_t$
  ○ $\log S_{t+1} = (1 - \rho_s) \log S + \rho_s \log S_t + \lambda_a (\log S_t) (\Delta \log A_{t+1} - \mathbb{E}_t \Delta \log A_{t+1})$
  ○ akin to AR(1) driven by productivity growth innovations weighted by $\lambda_a (\log S_t)$

• Sensitivity function $\lambda_a (\log S_t) = \frac{1}{S} [1 - 2(\log S_t - \log S)]^{1/2} - 1$ key: it implies
  ○ fall in $A_t$ reduces $S_t$ so increases risk aversion $\alpha / S_t$ and $\lambda_a (\log S_t)$ i.e. variability $S_t$
  ○ so overall leads to time-varying risk premia yet associated w/ stable risk-free rates
  ○ subtle: stable $r_t$ accomplished by spec’n balancing inter. subs./prec. saving motives
Model: Human Capital and Output Technologies

- Workers endowed w/ general human capital $z$ that evolves deterministically
  - increases when employed at rate $g_e \geq 0$: $z' = (1 + g_e)z$
  - decreases when unemployed at rate $g_u \leq 0$: $z' = (1 + g_u)z$

- In paper also consider more general human capital process
  - w/ stochastic accumulation-depreciation rates varying w/ acquired capital
  - this version better reproduces empirical wage-experience profiles
  - but yields results very similar to those will present

- As for production
  - employed worker with human capital $z$ produces $A_t z$ units of output
  - unemployed with $z$ produces $b A_t z$ units $b < 1$ (consistent w/ CRK finding)
  - cost to post vacancy to hire worker with $z$ is $\kappa A_t z$ (Shimer 2010)
Competitive Search Equilibrium (CSE)

- Matching between workers and firms governed by competitive search

- Find CSE concept appealing since naturally gives rise to efficient wage setting
  - features no *free parameters* as in typical bargaining schemes
  - that lead to inefficiencies unless set appropriately

- In particular: this eq. notion implies our results do *not* depend on rigid wages
Matching and Linearity

- Matches created according to fcn
  \[ m_t(z) = B u_{bt}(z)^\eta v_t(z)^{1-\eta} \] (\( u_{bt}(z) \) searchers)
  - market tightness, job-finding rates and job-filling rates defined in usual way
    \[ \theta_t(z) = \frac{v_t(z)}{u_{bt}(z)}, \quad \lambda_{wt}(z) = \frac{m_t(z)}{u_{bt}(z)}, \quad \lambda_{ft}(z) = \frac{m_t(z)}{v_t(z)} \]

- Key linearity result holds in this framework
  - that production functions are linear in \( z \) implies all values are linear in \( z \)
  - so market tightness and contact rates independent of \( z \)

- Yields in addition to \( S_t \) need only record total human capitals as part of state
  \[ Z_{et} = \int z e_t(z) \, dz \quad \text{and} \quad Z_{ut} = \int z u_t(z) \, dz \]
Important Property of Equilibrium

- Allocations solve restricted planning problem given pricing kernel $Q_{0,t}$

$$\max_{\{Z_{et}, Z_{ut}, \theta_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} Q_{0,t} C_t$$

s.t. transition laws for human capital

$$\mu_{et} : Z_{et} = (1 - \sigma) (1 + g_e) Z_{et-1} + \lambda_{wt} (1 + g_u) Z_{ut-1}$$

$$\mu_{ut} : Z_{ut} = \sigma (1 + g_e) Z_{et-1} + (1 - \lambda_{wt}) (1 + g_u) Z_{ut-1}$$

and aggregate resource constraint $C_t = A_t Z_{et} + b A_t Z_{ut} - \kappa A_t (1 + g_u) \theta_t Z_{ut-1}$

- $\mu_{et}$ is (shadow) value of one unit of employed human capital

- $\mu_{ut}$ is (shadow) value of one unit of unemployed human capital
Three Optimality Conditions for This Problem

- Optimality for human capital of employed and unemployed workers

\[ \mu_{et} = A_t + (1 + g_e) \mathbb{E}_t Q_{t,t+1} [(1 - \sigma) \mu_{et+1} + \sigma \mu_{ut+1}] \]

\[ \mu_{ut} = bA_t + (1 + g_u) \mathbb{E}_t Q_{t,t+1} [m_{ut+1} \mu_{et+1} + (1 - m_{ut+1}) \mu_{ut+1}] \]

- Optimality for market tightness: relates MC posting vacancy to corresponding MB

\[ \kappa A_t = m_{vt} \cdot (\mu_{et} - \mu_{ut}) \]

\[ \because \log \lambda_{wt} = \chi + \frac{1 - \eta}{\eta} \log \left( \frac{\mu_{et} - \mu_{ut}}{A_t} \right) \]

- That is, using matching function can show
  - this condition further implies \( \lambda_{wt} \) depends only on the scaled match value \( \mu_{et} - \mu_{ut} \)
  - this relationship is central to our propagation mechanism (will show next)
Intuition for Our Mechanism Is Simple

- First two optimality conditions form system of difference equations
  - can be approximately solved in closed form \((\lambda_{wt+n} = \lambda_w \text{ and } g_u = 0)\)
  - admits two roots \(\delta_s < 1 < \delta_\ell\) with \(c_\ell > 0\) weight on large root iff \(g_e > 0\)

- Solution implies the match value is weighted avg. of the prices of claims to future \(A_{t+n}\)

\[
\mu_{et} - \mu_{ut} = \log \frac{\mu_{et} - \mu_{ut}}{A_t} = \chi + \log \sum_{n=0}^{\infty} (c_\ell \delta_\ell^n + c_s \delta_s^n) \frac{E_t Q_{t,t+n} A_{t+n}}{A_t} 
\]

- So by optimality condition for \(\theta_t\): \(\lambda_{wt}\) proportional to this weighted average \((\eta = 0.5)\)

- Logic of mechanism then transparent: since risk-free rate \(1/E_t Q_{t,t+n} \approx \text{constant}\)
  - time-varying \(\text{Cov}_t(Q_{t,t+n}, A_{t+n})\) source of fluctuations: how does it work?
  - \(A_t \downarrow, S_t \downarrow, \alpha/S_t \uparrow, \text{risk premia} \uparrow, \text{value new vacancy} \downarrow, \text{ hiring} \downarrow, u \uparrow\)
Crucial Step: Prices of Long-Horizon Claims More Sensitive To Changes In Surplus Consumption

- Why? Consider effect of drop in current $A_t$ on pricing kernels of short/long claims
- Such a drop causes $S_t$ to fall and then mean revert

\[
Q_{0,1} \propto \left( \frac{C_1}{C_0} \frac{S_1}{S_0} \right)^{-\alpha} \quad \text{barely moves as } S_1 \text{ close to } S_0
\]

\[
Q_{0,20} \propto \left( \frac{C_{20}}{C_0} \frac{S_{20}}{S_0} \right)^{-\alpha} \quad \text{moves a lot as } S_{20} \text{ far from } S_0
\]

- Intuitively, as HHs value current $C_t$ more, willing to pay more for claims in near future
- Formally, the log prices of claims $\approx$ affine in log $S_t$: $\log(P_{nt}/A_t) = a_n + b_n(s_t - s)$
- With elasticities $b_n$ w.r.t. $s_t$ monotonically increasing with horizon $n$ so that ...
The longer the horizon, the more sensitive the prices of claims.

Can see from response $P_{nt}$ to $1\% \downarrow A_t$ by maturity: price long claims drops much more.

Hence weights on long claims need to be large for PV surplus flows and $\lambda_{wt}$ sensitive.
Formally: Volatility of Job-Finding Rate

- Using above affine approximation for log prices of claims, can express $\lambda_{wt}$ as follows:

$$\log \lambda_{wt} = \chi + \log \sum_{n=0}^{\infty} \left( c_\ell \delta^n_\ell + c_s \delta^n_s \right) e^{a_n + b_n (s_t - s)}$$

- So for $\lambda_{wt}$ to be volatile its elasticity with respect to $s_t$ must be large:

$$\frac{d \log \lambda_{wt}}{ds_t} = \sum_{n=0}^{\infty} \frac{e^{a_n} (c_\ell \delta^n_\ell + c_s \delta^n_s)}{\sum_{n=0}^{\infty} e^{a_n} (c_\ell \delta^n_\ell + c_s \delta^n_s)} \cdot b_n$$

- Apparent from formula: elasticity large iff weights on long-horizon claims large:
  - equivalently, iff surplus flows have long Macaulay duration $\sum_{n=0}^{\infty} \omega_n n$
  - w/ human capital: surplus flows have *long duration* (system: large root)
  - the larger $g_e - g_u$, slower decay $\omega_n$, longer duration, more sensitive $P_{nt}$, larger $\uparrow u$
Parametrization: Human Capital Process

- In baseline we set $g_e$ to 3.5% and $g_u$ to 0%
  - to match average annual growth of real hourly wages
  - for workers with up to 25 years of experience in NLSY (Rubinstein-Weiss 2006)

- Param. also consistent w/ evidence on cross-sectional growth (Elsby-Shapiro 2012)
  - log wage difference btwn workers w/ 1 and 30 yrs: 1.1 (data), 0.98 (model)

- We further show locus of values for $(g_e, g_u)$ exists w/ identical predictions for $\lambda_{wt}$
  - in short: the greater the depreciation $g_u < 0$ the lower the required $g_e$
  - e.g. $g_e = 2\%$ and $g_u = -6.5\%$ (conservative) equivalent to baseline

- In particular: our results not only are robust to wide range of returns
  - but also hold for modest growth rates
**Parametrization: Choose Asset Pricing Parameters**

- \( g_a \): mean productivity growth (%p.a.) 2.22
- \( \sigma_a \): s.d. productivity growth (%p.a.) 1.84
- \( \beta \): time preference factor (p.a.) 0.99
- \( S \): mean of surplus consumption ratio 0.2066
- \( \alpha \): inverse EIS 5
- \( B \): efficiency of matching technology 0.455
- \( \kappa \): hiring cost 0.975

**Targets**

<table>
<thead>
<tr>
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<th>Data</th>
<th>Model</th>
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<tbody>
<tr>
<td>Mean productivity growth (%p.a.)</td>
<td>2.22</td>
<td>2.22</td>
</tr>
<tr>
<td>S.d. productivity growth (%p.a.)</td>
<td>1.84</td>
<td>1.84</td>
</tr>
<tr>
<td><strong>Mean risk-free rate (%p.a.)</strong></td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>S.d. risk-free rate (%p.a.)</td>
<td>2.31</td>
<td>2.31</td>
</tr>
<tr>
<td><em><em>Mean maximum Sharpe ratio</em> (p.a.)</em>*</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Mean job-finding rate</td>
<td>46%</td>
<td>46%</td>
</tr>
<tr>
<td>Mean unemployment rate</td>
<td>5.9%</td>
<td>5.9%</td>
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* ratio of log cond. mean excess return to cond. st. dev. of log excess return

Rest of parameters fairly standard
Main Result: Solve Shimer Puzzle

- Namely, in environment that
  - satisfies constrained efficiency
  - is consistent with critiques discussed (CRK, K and BB)
  - job-finding rate and unemployment as volatile as in data

- Specifically, our model reproduces s.d. of job-finding rate and unemployment

<table>
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<tbody>
<tr>
<td>S.d. $\lambda_w$</td>
<td>6.66</td>
<td>6.60</td>
</tr>
<tr>
<td>S.d. $u$</td>
<td>0.75</td>
<td>0.75</td>
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- Successfully matches their autocorrelation

Next: show importance HK for result from impulse responses ($\lambda_w$, $u$) to negative $A_t$ shock
Impulse-Response of Job-Finding Rate and Unemployment

By comparing red to blue lines: responses of $\lambda_w$ and $u$ much larger in presence of HK
Results Robust to Range of Rates of Human Capital Accumulation and Depreciation

- By varying \((g_e, g_u)\) and adjusting \(\kappa\) to keep mean \(u\) constant
- Possible to trace out locus of values with *identical* implications for s.d. of \(\lambda_w\) and \(u\)

- Upward-sloping locus implies the greater the depreciation \(g_u\), the lower required \(g_e\)
Implications for Stock Prices

- Not obvious current model of firm behavior rich enough to match stock prices
  - for instance: does not feature physical capital
  - but as it stands, is it at odds with data?

- To address question, we proceed by interpreting equity flows in data
  - as consumption flows in model (Mehra-Prescott, Campbell-Cochrane)
  - and compare these consumption flows to observed stock prices

- By following this approach we find model consistent w/ data in that it matches
  - mean-s.d. of excess return, their ratio and mean-s.d. of log price-dividend ratio
Augment Model with Physical Capital

- We retain our baseline preferences

- We introduce capital by assuming it is used in market and home production
  - whereas vacancies are created only with labor (Shimer 2010)

- We maintain capital is subject to adjustment costs in the aggregate
  - but can move freely between market and home production
  - without adjustment costs: consumption too smooth (Jermann 1998)
Augment Model with Physical Capital

- Planning problem is as before

\[
\max_{\{Z_{et}, Z_{ut}, \theta_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} Q_{0,t} C_t
\]

s.t. resource constraint, aggregate \( K_t \) constraint and law of motion of \( K_t \)

\[
C_t + I_t \leq (A_t Z_{et})^{1-\gamma} K_{et}^\gamma + (b A_t Z_{ut})^{1-\gamma} K_{ut}^\gamma - \kappa A_t Z_{vt}
\]

\[
K_{et} + K_{ut} \leq K_t
\]

\[
K_{t+1} = (1 - \delta) K_t + \Phi(I_t/K_t) K_t
\]

- Parameters \( \gamma = 1/4, \delta = 10\% \) p.a. and \( \xi = 0.25 \) to match investment volatility

\[
\Phi\left(\frac{I}{K}\right) = \frac{\delta}{1 - \frac{1}{\xi}} \left[ \left(\frac{I}{\delta K}\right)^{1-\frac{1}{\xi}} - 1 \right]
\]
Augment Model with Physical Capital

- We find this model yields results similar to our baseline (only slightly lower s.d.)

<table>
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<th>Model w/ Physical Capital</th>
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<tr>
<td>S.d. $\lambda_w$</td>
<td>6.66</td>
<td>6.60</td>
<td>6.45</td>
</tr>
<tr>
<td>S.d. $u$</td>
<td>0.75</td>
<td>0.75</td>
<td>0.71</td>
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</table>

- Also matches ratio of st. dev. of investment growth to consumption growth
  - 4.5 in both data and model
Conclusion

- We propose new mechanism that allows search models
  - to reproduce the observed fluctuations in $u$
  - and is immune to the critiques of existing mechanisms
  - by formalizing idea hiring worker risky investment w/ long-duration dividend flows

- Our model also matches
  - observed movements in risk-free rates, equity flows and asset prices
  - as well as salient patterns of $Y$ and $I$ once physical capital is incorporated

- So re-integrating search and BC theory seems tractable/promising avenue of research