Asset Prices and Unemployment Fluctuations

Patrick Kehoe, Pierlauro Lopez, Virgiliu Midrigan and Elena Pastorino

ASSA 2020 Annual Meeting

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-e 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
  - Hall (2005, 2017), Hall and Milgrom (2008), Kilic and Wachter (2018)

- 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 cyclicality 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 ϕ (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

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_t - X_t)^{1-\alpha}}{1-\alpha}$$

- In symmetric equilibrium individual consumption C_t equals aggregate $\bar{C}_t$
  - define *aggregate surplus consumption ratio*: $S_t = \frac{\bar{C}_t - X_t}{\bar{C}_t}$ so
  - aggregate $MU_t = \beta^t \bar{C}_t^{-\alpha} S_t^{-\alpha} \uparrow$ as $S_t \downarrow$ and so does relative risk aversion α / 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
  - $\log S_{t+1} = (1-\rho_s)\log S + \rho_s \log S_t + \lambda_a(\log S_t)\left(\Delta \log A_{t+1} - \mathbb{E}_t \Delta \log A_{t+1}\right)$
  - 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 α/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 $bA_t z$ 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 $m_t(z) = Bu_{bt}(z)^{\eta} v_t(z)^{1-\eta}$ ($u_{bt}(z)$ searchers)
  - market tightness, job-finding rates and job-filling rates defined in usual way

$$\theta_t(z) = \frac{v_t(z)}{u_{bt}(z)}, \qquad \lambda_{wt}(z) = \frac{m_t(z)}{u_{bt}(z)}, \qquad \lambda_{ft}(z) = \frac{m_t(z)}{v_t(z)}$$

- 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

$$Z_{et} = \int z e_t(z)\, dz \qquad \text{and} \qquad Z_{ut} = \int z u_t(z)\, dz$$

Important Property of Equilibrium

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

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

s.t. transition laws for human capital

$$\mu_{et} : Z_{et} = (1-\sigma)(1+g_e) Z_{et-1} + \overbrace{\lambda_{wt}(1+g_u) Z_{ut-1}}^{m_t\text{: HK of newly formed matches}}$$

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

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

- μ_{et} is (shadow) value of one unit of employed human capital

- μ_{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

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

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

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

$$\underbrace{\kappa A_t}_{\substack{\text{MC} \\ \text{of vacancy}}} = \underbrace{m_{vt}}_{\substack{\text{marginal increase} \\ \text{in matches}}} \cdot \underbrace{(\mu_{et} - \mu_{ut})}_{\substack{\text{match} \\ \text{value}}} \quad \underbrace{\Leftrightarrow}_{\substack{\text{using form} \\ \text{of matching fcn}}} \quad \log\lambda_{wt} = \chi + \frac{1-\eta}{\eta}\log\left(\frac{\mu_{et}-\mu_{ut}}{A_t}\right)$$

- That is, using matching function can show
  - this condition further implies λ_{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 $(\lambda_{wt+n} = \lambda_w$ 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}

$$\mu_{et} - \mu_{ut} = \sum_{n=0}^{\infty} (c_\ell \delta_\ell^n + c_s \delta_s^n) \underbrace{\mathbb{E}_t Q_{t,t+n} A_{t+n}}_{\text{price } P_{nt} \text{ of claim proportional (in short, claim) to future } A_{t+n}}$$

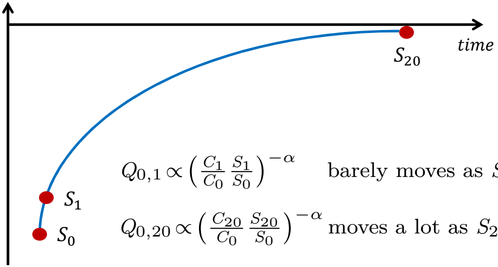
- So by optimality condition for θ_t: λ_{wt} proportional to this weighted average $(\eta = 0.5)$

$$\log \lambda_{wt} = \chi + \log\left(\frac{\mu_{et} - \mu_{ut}}{A_t}\right) = \chi + \log \sum_{n=0}^{\infty} (c_\ell \delta_\ell^n + c_s \delta_s^n) \frac{\mathbb{E}_t Q_{t,t+n} A_{t+n}}{A_t}$$

- Logic of mechanism then transparent: since risk-free rate $1/\mathbb{E}_t Q_{t,t+n} \approx$ constant
  - time-varying $Cov_t(Q_{t,t+n}, A_{t+n})$ source of fluctuations: how does it work?
  - $A_t \downarrow$, $S_t \downarrow$, $\alpha/S_t \uparrow$, risk premia $\uparrow$, value new vacancy $\downarrow$, 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



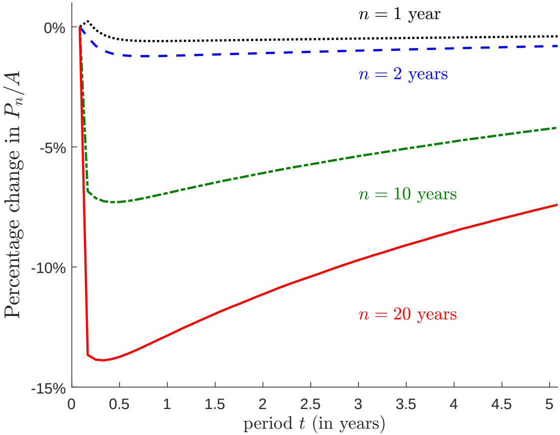
$Q_{0,1} \propto \left(\frac{C_1}{C_0}\frac{S_1}{S_0}\right)^{-\alpha}$ barely moves as S_1 close to S_0

$Q_{0,20} \propto \left(\frac{C_{20}}{C_0}\frac{S_{20}}{S_0}\right)^{-\alpha}$ moves a lot as S_{20} 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 ≈ 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 ...

Price of Claim to Productivity in n Periods

- 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 λ_{wt} sensitive

Formally: Volatility of Job-Finding Rate

- Using above affine approximation for log prices of claims, can express λ_{wt} as follows

$$\log \lambda_{wt} = \chi + \log \sum_{n=0}^{\infty} (c_\ell \delta_\ell^n + c_s \delta_s^n) e^{a_n + b_n(s_t - s)}$$

- So for λ_{wt} to be volatile its elasticity with respect to s_t must be large

$$\frac{d \log \lambda_{wt}}{ds_t} = \sum_{n=0}^{\infty} \underbrace{\frac{e^{a_n}(c_\ell \delta_\ell^n + c_s \delta_s^n)}{\sum_{n=0}^{\infty} e^{a_n}(c_\ell \delta_\ell^n + c_s \delta_s^n)}}_{\text{need large weight } \omega_n} \cdot \underbrace{b_n}_{\text{on long-horizon claims}}$$

- 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 ω_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 btw 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 λ_{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
σ_a: s.d. productivity growth (%p.a.)	1.84
β: time preference factor (p.a.)	0.99
S: mean of surplus consumption ratio	0.2066
α: inverse EIS	5
B: efficiency of matching technology	0.455
κ: hiring cost	0.975

Targets	Data	Model
Mean productivity growth (%p.a.)	2.22	2.22
S.d. productivity growth (%p.a.)	1.84	1.84
Mean risk-free rate (%p.a.)	0.92	0.92
S.d. risk-free rate (%p.a.)	2.31	2.31
Mean maximum Sharpe ratio* (p.a.)	0.45	0.45
Mean job-finding rate	46%	46%
Mean unemployment rate	5.9%	5.9%

* 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

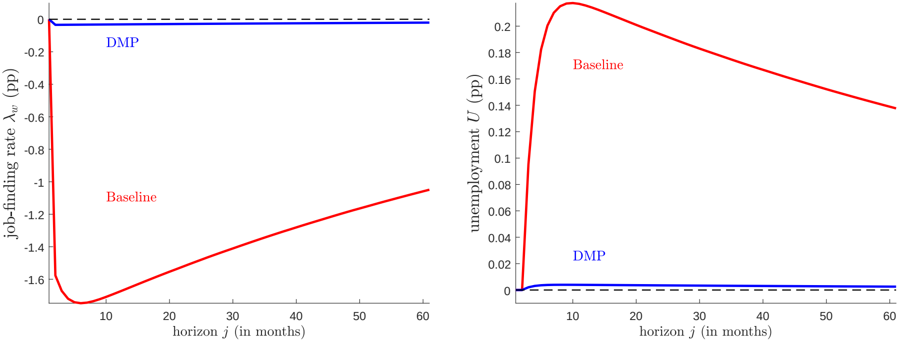
- Specifically, our model reproduces s.d. of job-finding rate and unemployment

	Data	Baseline
S.d. λ_w	6.66	6.60
S.d. u	0.75	0.75

- Successfully matches their autocorrelation

Next: show importance HK for result from impulse responses (λ_w, u) to negative A_t shock

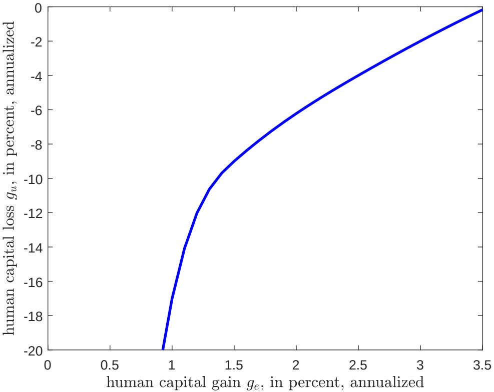
Impulse-Response of Job-Finding Rate and Unemployment



By comparing red to blue lines: responses of λ_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 κ to keep mean u constant
- Possible to trace out locus of values with *identical* implications for s.d. of λ_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

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

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

$$\begin{aligned}
&C_t + I_t \leq (A_t Z_{et})^{1-\gamma} K_{et}^{\gamma} + (bA_t Z_{ut})^{1-\gamma} K_{ut}^{\gamma} - \kappa A_t Z_{vt} \\
&K_{et} + K_{ut} \leq K_t \\
&K_{t+1} = (1-\delta) K_t + \Phi(I_t / K_t) K_t
\end{aligned}$$

- 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.)

	Data	Baseline	Model w/ Physical Capital
S.d. λ_w	6.66	6.60	6.45
S.d. u	0.75	0.75	0.71

- 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 reintegrating search and BC theory seems tractable/promising avenue of research