Noisy Business Cycles

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Motivation

• revisit *sources* of business cycles
  
  - RBC: technology shocks (highly implausible!)
  
  - NK: monetary shocks (only worse!)
dispersed information in an RBC setting

⇒ ⇒

★ a real theory of “demand shocks”
This paper

dispersed information in an RBC setting

↓    ↓

* a real theory of “demand shocks”

* fluctuations with “Keynesian” flavor

but “anti-Keynesian” policy implications
RBC with multiple goods, dispersed info about TFP
- RBC with multiple goods, dispersed info about TFP

- TFP shocks
  - explain small fraction of SR fluctuations
  - employment may fall with TFP
RBC with multiple goods, dispersed info about TFP

TFP shocks
- explain small fraction of SR fluctuations
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noise shocks
- induce positive co-movement in $C$, $N$, $Y$, etc
- induce countercyclical labor wedges
- identified as “demand shocks” by Blanchard-Quah, Gali, etc
key is heterogeneity, not uncertainty

- noise may drive bulk of SR fluctuations even if tiny uncertainty about TFP
• key is heterogeneity, not uncertainty
  - noise may drive bulk of SR fluctuations even if tiny uncertainty about TFP

• equilibrium is constrained efficient
  - no room for stabilization policies
Related literature

- **dispersed info about MP**: Phelps (1970), Lucas (1972, 1975), Barro (1976), King (1982), Townsend (1983), ... Mankiw & Reis (2002), Sims (2003), Woodford (2003), Mackowiak and Wiederholt (2008), ...


- **companion work**: Angeletos and La’O (2008, 2009b)
Model

- Dixit-Stiglitz, but flexible prices
- competitive
- TFP shocks

... with a geography similar to Lucas, Townsend, etc.
- continuum of islands, $i \in I$
- continuum of firms on each island, $(i, j) \in I \times J$
- continuum of households (big families) in mainland, $h \in H$
- different islands have different info about aggregate TFP
Model

- a multi-good RBC economy...
  - Dixit-Stiglitz, but flexible prices
  - competitive
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preferences

\[ \mathcal{U}_h = \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_{h,t}^{1-\gamma}}{1-\gamma} - \int_{\text{islands}} \frac{n_{hi,t}^{1+\varepsilon}}{1+\varepsilon} \, di \right] \]

\[ C_{h,t} = \left[ \int_{\text{islands}} c_{hi,t}^{\frac{\rho}{\rho-1}} \, di \right] \frac{\rho}{\rho-1} \quad c_{hi,t} = \left[ \int_{\text{firms}} c_{hij,t}^{\frac{\eta}{\eta-1}} \, dj \right] \frac{\eta}{\eta-1} \quad (\eta \to \infty) \]
Model: households

- preferences

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- budgets

\[ \int_{\text{islands} \times \text{firms}} p_{ij,t} c_{hij,t} \, d(ij) + B_{h,t+1} \leq \]

\[ \leq \int_{\text{islands} \times \text{firms}} \pi_{ij,t} \, d(ij) + \int_{\text{islands}} w_{i,t} n_{hi,t} \, dk + R_t B_{h,t} \]
Model: firms

- technology
  \[ q_{ij,t} = A_{i,t} \theta n_{ij,t} \]

- profit
  \[ \pi_{ij,t} = p_{ij,t} q_{ij,t} - w_{i,t} n_{ij,t} \]

- objective
  \[ \max \mathbb{E}_{ij,t} \left[ U'(C_t) \pi_{ij,t} \right] \]
Model: shocks and info

- local fundamentals

\[ a_{it} \equiv \log A_{it} = \bar{a}_t + \xi_{it} \]

- aggregate fundamentals

\[ \bar{a}_t = \rho \bar{a}_{t-1} + \nu_t \]

- imperfect, and asymmetric, info about aggregate fundamentals

\[ x_{it} = \bar{a}_t + \zeta_{it} \]
\[ z_t = \bar{a}_t + \varepsilon_t \]
Model: flow of information

1 stage 1: employment and production with dispersed info
   - each household sends a worker to each of the islands
   - nature draws aggregate and idiosyncratic shocks
   - local info is revealed to each island
   - local labor markets operate
   - employment and production choices take place

2 stage 2: consumption and saving with common info
   - workers return home
   - aggregate state becomes commonly known
   - centralized commodity and financial markets
   - consumption, saving and portfolio choices take place
characterizing the equilibrium...

- from stage 2, solve out (relative) prices as functions of quantities
- substitute this into firm’s profit, take their FOC
- take FOC of workers, use this to solve out the wage
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... key equilibrium condition:

\[ n_{it}^{e} = \mathbb{E}_{it} \left[ U'(Q_t) \left( \frac{q_{it}}{Q_t} \right)^{-\frac{1}{\rho}} \left( \theta A_{it} n_{it}^{\theta-1} \right) \right] \]

local MC of labor = \mathbb{E}_{\text{local}} [\text{MU of local commodity} \times \text{local MP of labor}]
Equilibrium: Game representation

Proposition

The equilibrium levels of output solve the following fixed-point problem:

\[ \log q_{it} = \text{const} + (1 - \alpha) f_{it} + \alpha \mathbb{E}_{it} [\log Q_t] \]

where

\[ f_{it} \equiv \log \left\{ \theta \left( \frac{1}{1 - \theta + \epsilon + \gamma \theta} \right)^{A_{it}} \right\} \quad \alpha \equiv \frac{\frac{1}{\rho} - \gamma}{\frac{1}{\rho} + \frac{1 - \theta + \epsilon}{\theta}} < 1 \]
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f_{it} \equiv \log \left\{ \theta \frac{1}{1 - \theta + \epsilon + \gamma \theta} A_{it}^{\frac{1 + \epsilon}{1 - \theta + \epsilon + \gamma \theta}} \right\}
\]

\[
\alpha \equiv \frac{\frac{1}{\rho} - \gamma}{\frac{1}{\rho} + \frac{1 - \theta + \epsilon}{\theta}} < 1
\]

- general equilibrium = PBE of a fictitious game across islands
- \( \alpha \) = degree of strategic complementarity (monotone in \( \rho \))
complementarity originates in specialization and trade

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irrelevant for aggregate fluctuations when info is common

- common info $\Rightarrow \log Q_t = const + \tilde{f}_t$
complementarity originates in specialization and trade


irrelevant for aggregate fluctuations when info is common

- common info \( \Rightarrow \log Q_t = const + \bar{f}_t \)

but crucial when info is dispersed!

- \( \alpha \) regulates impact of info heterogeneity on aggregate fluctuations
striking resemblance with New-Keynesian pricing condition ...

NK: $\log p_{it} \approx (1 - \xi) Y_t + \xi \log P_t$

AL: $\log q_{it} \approx (1 - \alpha) f_{it} + \alpha \log Q_t$
Trade and complementarity

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  \[ \text{AL: } \log q_{it} \approx (1 - \alpha) f_{it} + \alpha \log Q_t \]

  ... but only superficial
striking resemblance with New-Keynesian pricing condition ...

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comparative statics: high \( \alpha \) requires

- low \( \rho \) (strong trade links)
- low \( \epsilon \) and high \( \theta \) (as in Hansen, Rogerson, King-Rebelo, etc)
define "high-frequency" components as the residuals of regressing log $Q_t$ and log $N_t$ on past fundamentals $\tilde{f}_{t-1}$

consider variance decomposition between fundamentals $\tilde{f}_t$ and noise
define "high-frequency" components as the residuals of regressing $\log Q_t$ and $\log N_t$ on past fundamentals $\tilde{f}_{t-1}$

calculate variance decomposition between fundamentals $\tilde{f}_t$ and noise

Proposition

There exist economies in which

- agents are arbitrarily well informed about the fundamentals
- TFP innovations account for nearly zero of SR variation in $Q_t$
- $N_t$ falls with positive innovation in TFP
Extension with slow learning

[Equation]

\[ \log q_{it} = (1 - \alpha) f_{it} + \alpha E_t [\log Q_t] \]

but now learning is slow → Kalman filter on \((\bar{a}_t, \log Q_t)\)

"calibration": familiar, except for moderate noise and free

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Extension with slow learning

- relax assumption $\Omega_t$ is revealed at end of each $t$
  - firms and workers learn only through exogenous signals

- equilibrium is still determined by

$$\log q_{it} = (1 - \alpha) f_{it} + \alpha E_{it} [\log Q_t]$$

but now learning is slow $\rightarrow$ Kalman filter on $(\bar{a}_t, \log Q_t)$

- "calibration": familiar, except for moderate noise and free $\alpha$
Impulse responses: TFP

Figure: positive innovation in productivity
Impulse responses: TFP


- Christiano et al (2003), McGrattan (2004): maybe not a fact

- NK success to match this "fact" only a measure of MP failure!
Impulse responses: TFP

- Christiano et al (2003), McGrattan (2004): maybe not a fact
- NK success to match this "fact" only a measure of MP failure!
- dispersed information can explain this fact without either sticky prices or inefficiency
Impulse responses: noise

Impulse Response of Output to Noise Shock

Impulse Response of Employment to Noise Shock

Figure: positive noise shock
Variance decomposition

Figure: variance decomposition
implausible that SR fluctuations driven by technology; rather some form of expectation- or demand-driven shocks
Keynesian-like fluctuations without money or sticky prices

- implausible that SR fluctuations driven by technology; rather some form of expectation- or demand-driven shocks

- our approach is consistent with this view, but doesn’t require sticky prices
  - our noise fluctuations resemble "demand shocks"
  - SVARs a la Blanchard-Quah or Gali will identify them as such
  - but they are neoclassical in their nature
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noise might dominate the business cycle even it is small
Figure: noise $\rightarrow$ countercyclical labor wedges
large effects are consistent with small uncertainty about fundamentals

also with small uncertainty about economic activity?
Forecast errors

Figure: forecast errors in response to a positive noise shock
Efficiency

An allocation is (constrained) efficient iff it maximizes ex-ante utility subject to:
- resource feasibility
- geographical segmentation of info

Proposition:
The equilibrium is efficient $\rightarrow$ no room for stabilization policy $\rightarrow$ more info is welfare improving

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  - resource feasibility
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**Proposition**

*The equilibrium is efficient*

→ no room for stabilization policy

→ more info is welfare improving
Conclusion

dispersed information ⇒ inertia in response to fundamentals
noise can dominate business cycle even if small uncertainty
a notion of demand shocks without money or sticky prices
not symptoms of inefficiency
dispersed information $\Rightarrow$

- inertia in response to fundamentals
- noise can dominate business cycle even if small uncertainty
- a notion of demand shocks without money or sticky prices
dispersed information ⇒

- inertia in response to fundamentals
- noise can dominate business cycle even if small uncertainty
- a notion of demand shocks without money or sticky prices

not symptoms of inefficiency
there exist shocks that are

- orthogonal to fundamentals

- orthogonal to expectations of fundamentals

Sentiments (Angeletos and La’O, 2009b)
there exist shocks that are

- orthogonal to fundamentals
- orthogonal to expectations of fundamentals
- cause variation in (expectations of) macroeconomic activity and asset prices
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a theory of "animal spirits" consistent with
- rationality
- unique equilibrium
- constrained efficiency