Noisy Business Cycles

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Question: How does heterogeneous information affect the business cycle?

Main findings:
- Noise shocks formalize demand shocks in a real setting
- Employment may fall with TFP
- Noise can drive bulk of fluctuations even with minimal uncertainty about fundamentals

Key: strategic complementarities
Model: Geography

- Continuum of islands $i \in I = [0, 1]$
- Continuum of firms on each island, $(i, j) \in I \times J$
- Continuum of households on mainland, $h \in H = [0, 1]$
- Different islands have different info about TFP $\rightarrow$ dispersed info affects production and labor supply decisions
Model: Households

- Preferences:

\[ u_h = \sum_{t=0}^{\infty} \beta^t \left[ U(C_{h,t}) - \int I V(n_{h,i}) di \right] \]

\[ C_{h,t} = \left[ \int J c_{hi,t}^{\rho \rho^{-1}} \right]^{\rho \rho^{-1}} \]

\[ c_{hi,t} = \left[ \int J c_{hij,t}^{\eta \eta^{-1}} \right]^{\eta \eta^{-1}} \]

- Budget constraint:

\[ \int_{I \times J} p_{ij,t} c_{hij,t} d(i,j) + B_{h,t+1} \leq \int_{I \times J} \pi_{ij,t} d(i,j) + \int w_{i,t} n_{hi,t} di + R_t B_{h,t} \]
Model: Households

Preferences:

\[ u_h = \sum_{t=0}^{\infty} \beta^t \left[ U(C_{h,t}) - \int_{I} V(n_{h,i}) di \right] \]

\[ C_{h,t} = \left[ \int_{I} c_{hi,t}^\rho \, di \right]^{\frac{\rho}{\rho-1}} \]

\[ c_{hi,t} = \left[ \int_{J} c_{hij,t}^\eta \, dj \right]^{\frac{\eta}{\eta-1}} \]

Budget constraint:

\[ \int_{I \times J} p_{ij,t} c_{hij,t} d(i, j) + B_{h,t+1} \leq \int_{I \times J} \pi_{ij,t} d(i, j) + \int w_{i,t} n_{hi,t} di + R_t B_{h,t} \]
Model: Firms

- Output:

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

- Profits:

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

- Objective:

\[ \max_{E_{ij,t}} [U'(C_t) \pi_{ij,t}] \]
Fundamentals

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

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

Signals:

- Island-specific:
  \[ x_{it} = \bar{a}_t + \varsigma_{it} \]

- Public:
  \[ z_t = \bar{a}_t + \varepsilon_t \]
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Stage 1: employment and production with dispersed info
- Each household sends a worker to each island
- Aggregate and idiosyncratic shocks are realized
- Information in each island is revealed
- Local labor markets operate and production choice takes place

Stage 2: consumption and saving with common info
- Workers return home
- Aggregate state becomes commonly known
- Consumption and saving choices take place in centralized markets
Key equilibrium condition (with $\eta \to \infty$, i.e. no monopoly power within an island):

$$V'(n_{it}) = \mathbb{E}_{it} \left[ U'(Q_t) \left( \frac{q_{it}}{Q_t} \right)^{-\frac{1}{\rho}} (\theta A_{it} n_{it}^{\theta-1}) \right]$$
Equilibrium levels of output:

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

\[
\log Q_t = \text{const} + \int \log q_{it} \, di
\]

where

\[
f_{it} := \log \left[ \theta \frac{\theta}{1 - \theta + \epsilon + \gamma \theta} A_{it}^{\frac{1 + \epsilon}{\frac{1}{\rho} + \frac{1 - \theta + \epsilon}{\theta}}} \right]
\]

\[
\alpha := \frac{1}{\frac{1}{\rho} + \frac{1 - \theta + \epsilon}{\theta}} < 1
\]

- \( \alpha \) measures “strategic complementarity”
- \( \alpha \) monotonically decreasing in \( \rho \), cross-island e. of subst.
**Proposition:** There exist economies in which

- Agents are arbitrarily well informed about fundamentals
- TFP innovations account for nearly zero of SR variation in $Q_t$
- Employment falls with a positive TFP shock

**Intuition:**

- With strong complementarities agents care more about average forecast than about fundamentals per se
- With sufficiently strong complementarity, agents disregard private info even if arbitrarily precise
- Key is not imperfect info, but lack of common knowledge interacting with complementarities
Extension with slow learning

- Relax assumption that aggregate state is revealed at end of $t$
- Agents learn only through exogenous signals
5.1 Impulse responses to productivity and noise shocks

Figure 1 plots the impulse responses of aggregate output and employment to a positive innovation of productivity, for various degrees of $\alpha$ (the size of the innovation here, and in all other impulse responses we report, is equal to one standard deviation). Clearly, if aggregate productivity were common knowledge, then output would follow the same AR(1) process as aggregate productivity itself. This is simply because there is no capital in our model. The same thing happens when information is dispersed but there is no strategic complementarity in output decisions ($\alpha = 0$).

This is simply because when $\alpha = 0$ islands are effectively isolated from one another; but as each island knows perfectly its own productivity, the entire economy responds to the aggregate shock as if the aggregate shock had been common knowledge. In contrast, when information is dispersed but islands are interconnected ($\alpha \neq 0$), employment and output in one island depends crucially on expectations of employment and output in other islands. As a result, even though each island remains perfectly informed about their local fundamentals, each island responds less to the shock than what it would have done had the shock been common knowledge, precisely because each island expects output in other islands to respond less.

Note then that the key for the response of each island is not per se whether the island can disentangle an aggregate shock from an idiosyncratic shock. Even if a particular island was perfectly
It is worth noting that there are few variants of the baseline RBC model that can also accommodate a negative response of employment to technology shocks, through very different mechanisms than ours. See Collard and Dellas (2005a), Francis and Ramey (2003a), Rotemberg (2003), Wen (2001), and the discussion in Section 4.2 of Galí and Rabanal (2004). Most interestingly for our purposes, as Collard and Dellas (2005a) emphasize, the RBC paradigm faces a tension between, on the one hand, accounting for the negative response of employment to technology shocks and, on the other hand, maintaining the proposition that business cycles are driven by technology shocks. In our framework, this tension is still present, but it is only complementary to our own view about the business cycle: the central position of our approach is that it is the uncertainty agents face about one another's beliefs and responses, not the underlying technology shocks, that explain the bulk of short-run fluctuations.

At the same time, note that it is the dispersion of information, not the uncertainty about the technology shock, that causes employment to fall. If agents had been imperfectly informed about the productivity shock but information had been common, then they could fail to increase their employment as much as they would have done with perfect information, but they would not have reduced their employment—for how could they respond to the shock by reducing employment if they were not aware of the shock in the first place? Thus, employment falls in our model precisely...
Variance Decomposition

Figure 3: Variance decomposition.

Complementarity, productivity shocks explain only a small fraction of the high-frequency variation in output—short-run fluctuations are driven mostly by noise. As for employment, the contribution of noise is quite dramatic.

Finally, Figure 4 plots the dynamics of the average forecast of aggregate output and the true level of aggregate output in response to a productivity or noise shock. The average forecast error is the distance between the two aforementioned variables. A salient feature of this figure is that forecast errors are smallest when the degree of strategic complementarity is highest. This is crucial. We earlier showed that a higher degree of strategic complementarity, \( \alpha \), leads to both more inertia in the response of output and employment to productivity shock, and to a bigger impact of noise. In this sense, the deviation from the common-knowledge benchmark is highest when \( \alpha \) is highest. However, one should not expect that these large deviations will show up in large forecast errors. To the contrary, a higher \( \alpha \) implies that actual economic activity is more driven by forecasts of economic activity, so that at the end a higher \( \alpha \) guarantees that the forecast errors are smaller. It follows that, as we vary \( \alpha \), the magnitude of the deviations of actual outcomes from their common-knowledge counterparts is inversely related to the magnitude of the associated forecast errors. Indeed, both the inertia and the impact of noise become nearly self-fulfilling as \( \alpha \) gets closer to 1.

Combined, these results illustrate the distinct mark that dispersed information can have on macroeconomic outcomes once combined with strategic complementarity. Not only can the effects we have documented be significant, but they are also consistent with small errors in the agents' forecasts of either the underlying economic fundamentals or the level of economic activity.
5.3 Demand shocks, new-Keynesian models, and structural VARs

Many economists have found the idea that short-run fluctuations are driven primarily by technology shocks implausible either on a priori grounds or on the basis of certain structural VARs. Blanchard and Quah (1989) were the first to attempt to provide some evidence that short-run fluctuations are driven by “demand” rather than “supply” shocks, albeit with the caveat that one cannot know what the shocks they identify really capture. Subsequent contributions by Galí (1999), Basu, Fernald and Kimball (2006), Galí and Rabanal (2004), and others have tried to improve in that dimension. One way or another, though, this basic view that business cycles are not driven by technology shocks appears to underly the entire New-Keynesian literature.

Our findings here are consistent with this view. In our environment, technology shocks may explain only a small fraction of the high-frequency volatility in macroeconomic outcomes. However, the residual fluctuations have nothing to do with monetary shocks. Rather, they are the product of the noise in the agents’ information. Importantly, to the extent that information is dispersed and trade linkages are important, this noise might be quite small and nevertheless explain a big fraction of the high-frequency volatility in macroeconomic outcomes.

Furthermore, the noise-driven fluctuations we have documented here, albeit being purely neoclassical in their nature, they could well be interpreted as some kind of “demand” or “monetary” shocks in the following sense. This is because they share many of the features often associated with...