# Demand-Driven Business Cycles
# without Sticky Prices/Phillips Curves

George-Marios Angeletos

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1st paper: Motivating Evidence

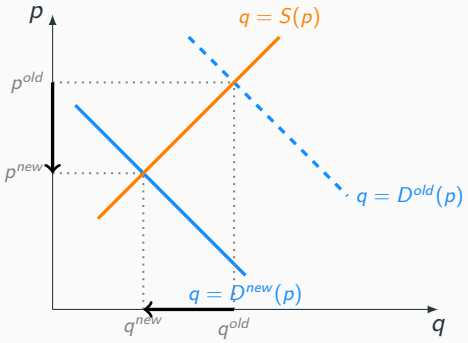
with F. Collard and H. Dellas (AER 2020), "Business Cycle Anatomy"

2nd paper: A Theory

with C. Lian (REStud forth), "Confidence and the Propagation of Demand Shocks"

# Demand and Supply: Micro vs Macro

- how do demand shocks matter? and what do they really mean?



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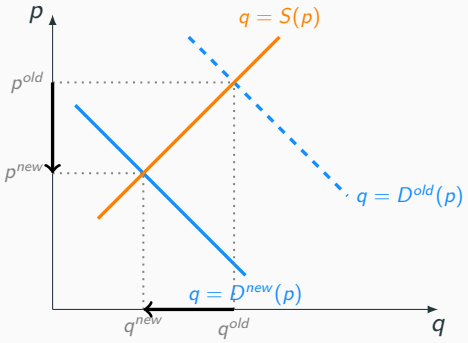


- tempting: just replace $(p, q)$ with $(P, Q)$
- problem: in micro, $p$ is a relative price of one good vs an index of all goods
  $\Rightarrow$ the corresponding macro/GE concept is $P = 1$ always!

# Demand Shocks in Macro

Two resolutions: Keynesian vs Neoclassical

1. $P$ is the nominal price level, or inflation $\pi$
   - requires nominal confusion or nominal rigidity
   - maps "supply curve" to a Phillips curve
   - requires failure of MP to replicate flexible-price outcomes
   - equates "demand shocks" to monetary contractions/expansions
   - requires positive comovment between real economic activity and $\pi$

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2. $P$ is $r$, the real interest rate (price of today's goods relative to tomorrow's goods)
   - maps "demand shocks" to discount-rate shocks (relative demand for today's goods)
   - difficulty: in basic RBC, demand shocks to not generate realistic business cycles (Barro-King)
     $\Rightarrow$ in NK, demand shocks work only when they are equated to $M$ shocks $\Rightarrow$ back to [1]

# Business Cycle Anatomy

George-Marios Angeletos[1] Fabrice Collard[2] Harris Dellas[3]

[1]MIT and NBER [2]TSE [3]University of Bern

# Motivation and Contribution

*"One is led by the facts to conclude that, with respect to the qualitative behavior of co-movements among series, business cycles are all alike. To theoretically inclined economists, this conclusion should be attractive and challenging, for it suggests the possibility of a unified explanation of business cycles." (Lucas 1977)*

- A theorist's ambition: account for bulk of the business cycle with a single-shock model
  i.e., multiple triggers but a dominant propagation mechanism
- This paper's contribution: provide an empirical template of it

# What We Do

- Estimate a VAR (or VECM) on a few key variables
- Recover shock that has max contribution to volatility of $U$ over BC frequencies
- Repeat exercise by targeting other variables (e.g., $I$, TFP, $\pi$) or other frequencies (e.g, LR)

$\Longrightarrow$ "**Business Cycle Anatomy**" = large collection of one-dimensional cuts of the data

= rich set of restrictions on models of any size and type

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$\Longrightarrow$ "**Business Cycle Anatomy**" = large collection of one-dimensional cuts of the data
= rich set of restrictions on models of any size and type

$\Longrightarrow$ Key findings:

- a single shock can account for bulk of BC fluctuations in key quantities
- shocks that target $u$, $Y$, $h$, $I$, and $C$ over BC frequencies produce similar IRFs
- supports hypothesis of single dominant propagation mechanism
- disconnect from both technology and inflation

$\Longrightarrow$ Support for non-inflationary, non-specialized, demand shocks

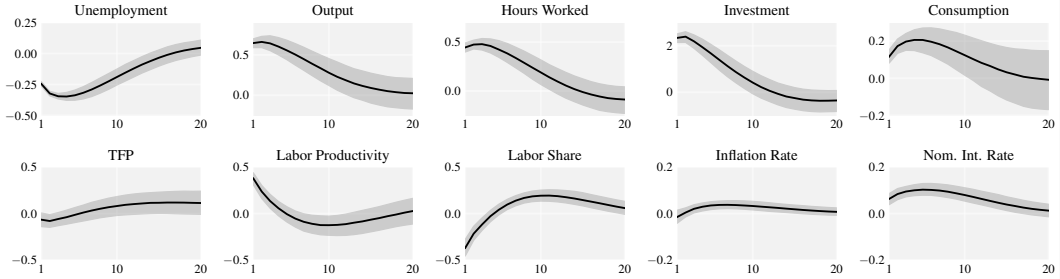
# Baseline VAR

- Quarterly U.S data: 1955Q1-2017Q4
  - Macro Quantities: Unemployment, GDP, Hours, Invest. (inclusive of durables), Cons.
  - Productivity: util-adjust TFP, NFB labor productivity;
  - Nominal: Inflation (GDP Delator), Federal Fund Rate, Labor Share
- VAR with 2 Lags (robust to 4 or 6 lags and VECM)
- What next? Construct the "shock to variable X"

  Linear combination of the VAR residuals that has the maximal contribution to the volatility of a variable X at the business-cycle frequencies, 6-32 quarters.

# Main Business Cycle Shock: Targeting Unemployment

## Impulse Response Functions

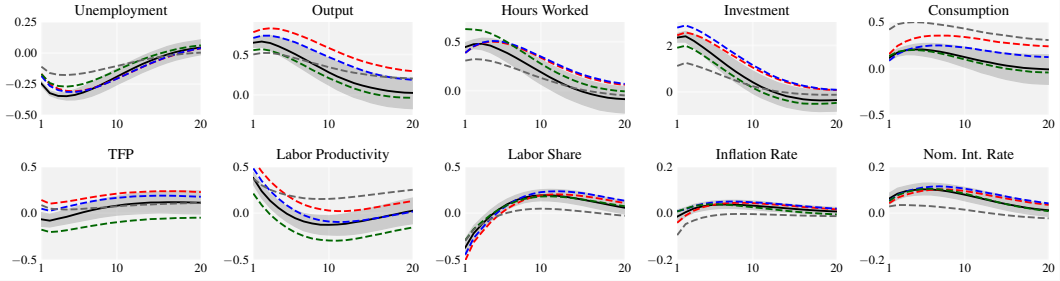



## Variance Contributions, Business-Cycle Frequencies

| $u$ | $Y$ | $h$ | $I$ | $C$ | TFP | $Y/h$ | $Wh/Y$ | $\pi$ | $R$ |
|---|---|---|---|---|---|---|---|---|---|
| 73.71 | 58.51 | 47.72 | 62.09 | 20.38 | 5.86 | 23.91 | 27.02 | 6.96 | 22.27 |

# Main Business Cycle Shock: Alternative Targets

Interchangeable facets of the same shock!



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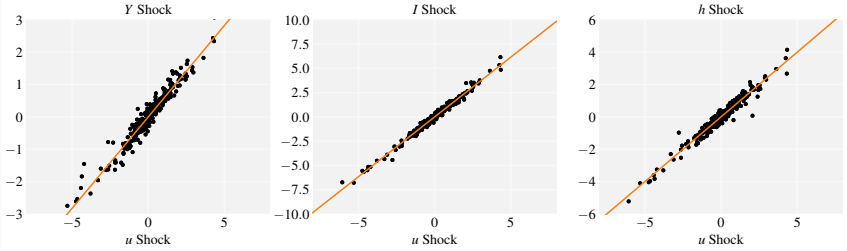
|---|---|---|---|---|---|---|---|---|---|---|
| $u$ | 73.71 | 58.51 | 47.72 | 62.09 | 20.38 | 5.86 | 23.91 | 27.02 | 6.96 | 22.27 |
| $Y$ | 56.24 | 80.13 | 44.73 | 67.13 | 33.03 | 4.24 | 41.31 | 40.20 | 10.47 | 16.89 |
| $h$ | 49.84 | 47.54 | 70.45 | 47.99 | 21.78 | 11.62 | 22.61 | 19.47 | 7.23 | 22.38 |
| $I$ | 59.03 | 66.60 | 45.20 | 80.29 | 19.01 | 3.81 | 33.74 | 36.44 | 7.69 | 21.51 |
| $C$ | 19.19 | 31.59 | 20.15 | 17.10 | 68.30 | 1.57 | 12.93 | 10.31 | 9.93 | 4.50 |



# PCA on Business Cycle Frequencies

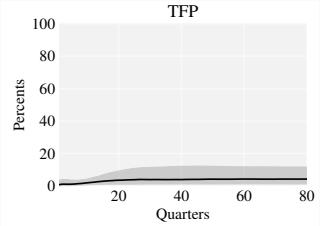
First Principal Component, Business Cycle Frequencies

| | $u$ | $Y$ | $h$ | $I$ | $C$ | TFP | $Y/h$ | $wh/Y$ | $\pi$ | $R$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw Data | 75.33 | 92.26 | 81.24 | 99.80 | 60.19 | 6.10 | 17.73 | 3.02 | 2.33 | 12.27 |
| VAR-Based | 63.31 | 87.33 | 62.47 | 99.72 | 26.67 | 1.22 | 29.19 | 14.16 | 0.68 | 8.10 |

- Similar message about variance contributions: MBC $\approx$ 1st PC
- But our approach adds info about (i) IRFs and (ii) footprint on other frequencies

# Disconnect from TFP and news thereof

MBC shock $\rightarrow$ FEV contribution to TFP at different horizons




| | $u$ | $Y$ | $h$ | $I$ | $C$ |
|---|---|---|---|---|---|
| LR TFP shock $\rightarrow$ Short Run | 9.63 | 24.78 | 11.01 | 17.56 | 15.58 |

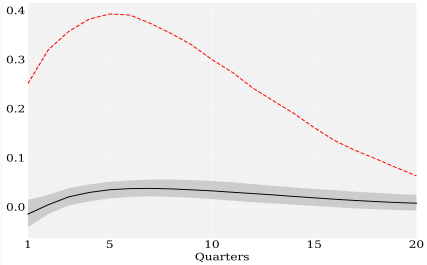
- echoes and reinforces Blanchard & Quad (1989), Galí (1999), Basu et al (2005)
- speaks against not only traditional technology shocks
  but also uncertainty, financial and other shocks operating via current TFP (e.g., Bloom et al, 2017) and news about future TFP (e.g., Beaudry & Portier, 2004, Lorenzoni, 2010)

# MBC as a Demand Shock along a Phillips curve?

Challenge #1: tiny signal-to-noise ratio

| Target | $u$ | $\pi$ | $Wh/Y$ |
|---|---|---|---|
| Unemployment | 73.71 | 6.96 | 27.02 |
| Inflation | 4.24 | 83.03 | 1.96 |
| Labor Share | 26.01 | 4.03 | 85.59 |

Challenge #2: magnitude



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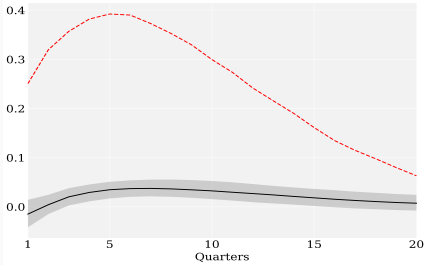



Challenge #3: semi-structural exercises (in paper)

- remove AS shock via TFP shock: same picture
- estimate two-shock, AD-AS model to fit both MBC and inflation shock in the data
  $\Rightarrow$ Phillips curve slope $\approx 0$, demand shock explains nearly all of $u$ and none of $\pi$

# MBC Shock: Robustness

**Robust to**

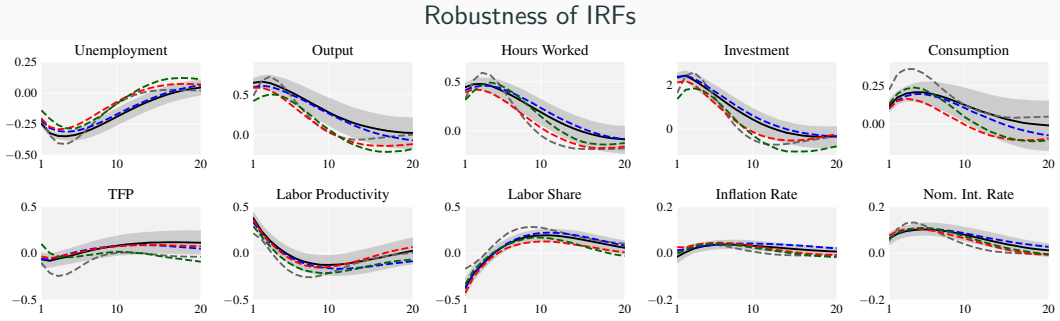
- More lags, VECM
- Varying the sample: Post vs Pre-Volcker era, w/o Great Recession/ZLB ...
- Adding variables: Stock Prices, $P^{\mathrm{I}}/P^{\mathrm{C}}$, financial variables ...
- ...
- Shifting to time domain rather than frequency domain

# MBC Shock: Robustness

Short-Run Variance Contributions

| | $u$ | $Y$ | $h$ | $I$ | $C$ | TFP | $Y/h$ | $Wh/Y$ | $\pi$ | $R$ |
|---|---|---|---|---|---|---|---|---|---|---|
| [1] Benchmark | 73.71 | 58.51 | 47.72 | 62.09 | 20.38 | 5.86 | 23.91 | 27.02 | 6.96 | 22.27 |
| [2] 4 lags | 74.49 | 58.23 | 49.16 | 62.42 | 21.20 | 6.28 | 23.10 | 27.87 | 6.91 | 24.75 |
| [3] VECM(1) | 62.43 | 50.27 | 48.81 | 53.39 | 34.88 | 18.13 | 23.80 | 24.11 | 10.46 | 33.37 |
| [4] VECM(2) | 64.85 | 54.99 | 48.82 | 53.78 | 44.93 | 12.17 | 19.51 | 29.71 | 11.29 | 19.51 |
| [5] 1948-2017 | 78.98 | 65.32 | 49.61 | 63.76 | 19.52 | 6.14 | 26.53 | 29.62 | 5.16 | 16.94 |
| [6] 1960-2007 | 68.15 | 59.93 | 55.99 | 65.02 | 20.67 | 6.02 | 25.04 | 29.96 | 10.70 | 27.03 |
| [7] pre-Volcker | 74.23 | 56.75 | 43.21 | 61.50 | 23.43 | 6.82 | 30.69 | 28.43 | 17.45 | 27.60 |
| [8] post-Volcker | 73.39 | 50.37 | 50.65 | 58.44 | 20.23 | 7.94 | 18.46 | 23.01 | 4.65 | 15.05 |
| [9] Extended | 59.33 | 50.61 | 45.50 | 52.91 | 21.83 | 4.81 | 26.69 | 27.82 | 12.12 | 28.99 |
| [10] Financial | 68.57 | 57.56 | 46.84 | 59.95 | 25.94 | 7.04 | 27.20 | 26.86 | 8.42 | 26.59 |
| [11] Chained-Type C&I | 81.41 | 59.04 | 45.96 | 61.52 | 17.36 | 4.03 | 20.35 | 20.19 | 5.82 | 23.17 |

# MBC Shock: Robustness



# Bottom Line (so far)

- One shock explains bulk of BC volatility in key quantities
  - with $u, h, Y, I, C$ moving in tandem
- Interchangeability: same IRFs regardless of target
  - support for parsimonious theories
  - unlike many state-of-the-art DSGE (more on this shortly)
- $\approx 0$ comovement with TFP at all frequencies, and $\approx 0$ footprint on the Long Run
  - echoes and reinforces Blanchard & Quad (1989), Galí (1999)
  - rules out financial, uncertainty or other shocks that map to SR fluctuations in TFP
  - rules out news about future TFP or LR outlook
- Disconnect from inflation
  - rules out "textbook" Keynesian model
  - NKPC is as good in explaining $\pi$ as C-CAPM is in explaining asset prices

# Pushing the Lessons Further: DSGE and Beyond

Two candidate classes of models:

1. state-of-the-art DSGE with extremely flat Phillips curves and accommodative MP
   - Christiano, Eichenbaum & Evans (2005), Smets & Wouters (2007), Justiniano, Primiceri & Tambalotti (2010), Christiano, Motto, & Rostagno (2014), and thousands more
2. demand shocks outside the realm of sticky prices/Phillips curves
   - older literature on multiple equilibria and coordination failures: Azariadis (1981); Benhabib & Farmer (1994); Diamond (1982); Guesnerie & Woodford (1993)
   - newer literature on belief or other real frictions: Angeletos, Collard, & Dellas (2018); Angeletos & La'O (2010, 2013); Angeletos & Lian (2021); Bai, Ros-Rull, and Storesletten (2017); Basu et al (2021); Beaudry & Portier (2014, 2018); Beaudry, Galizia, & Portier (2018); Benhabib, Wang, & Wen (2015); Eusepi & Preston (2015); Hall & DiTella (2020); Huo & Rios-Rull (2021); Huo & Takayama (2015); Jaimovich and Rebelo (2009); Ilut & Saijo (2018)

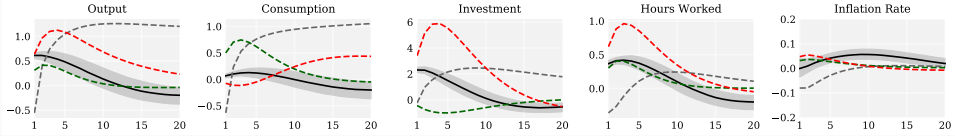
# Pushing the Lessons Further: DSGE and Beyond

Two representative examples:

1. JPT (Justiniano, Primiceri & Tambalotti, JME 2010)
   - similar to CEE/SW (but estimation more suitable for our purposes)
   - also similar to CMR (replace "investment shock" with "risk shock")
   - very sticky prices, very sticky wages, sufficiently accommodative MP
   - standard bells and whistles (Habit, Invt Adj Costs, Utilization)
   - multiple shocks (but *I* shock is most important)
2. ACD (Angeletos, Collard & Dellas, Ecma 2018)
   - RBC with variation in HOB, or "sentiments" (Angeletos & La'O, Ecma 2013)
   - extrinsic waves of optimism and pessimism about SR economic outlook
   - animal spirits/coordination failure along unique equilibrium

# JPT and ACD: Theoretical Shocks vs MBC in Data

JPT: $A$, $I$, and $C$ shocks



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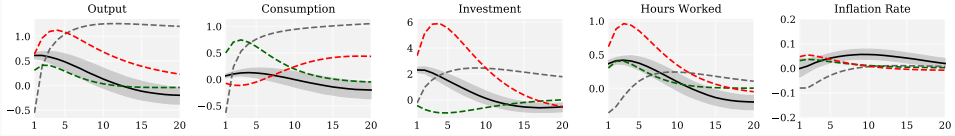
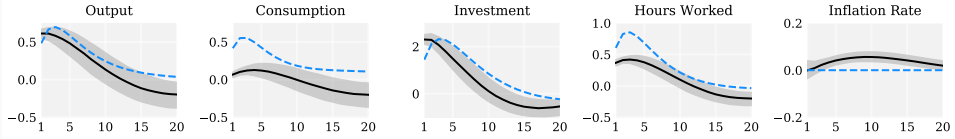



Technology Shock — Investment Shock — Consumption Shock — MBC Shock in Data

ACD: Confidence Shock




Confidence Shock, — MBC Shock in Data

- Only our "exotic" theoretical shock directly captures MBC shock in the data
- But could it be that combination of 7 "familiar" shocks does the job?

# Bottomline

- Bread-and-butter theoretical mechanisms fail to capture MBC in the data
- State-of-the art DSGE models (JPT, SW, CMR, ...) also fail
  - despite of their use of multiple shocks and other bells and whistles
  - because they have too much "specialized" shocks
  - not enough comovement
- Hints at a missing propagation mechanism in flexible-price core of dominant NK paradigm
  - AD shocks may drive $y_{\text{natural}}$ and generate comovement without strict reliance of nominal rigidity and accommodative MP

# Confidence and the Propagation of Demand Shocks

George-Marios Angeletos[1] Chen Lian[2]

[1]MIT and NBER [2]University of California, Berkeley

# Popular Narrative: Keynesian Multiplier

- Household deleveraging or other AD shocks
  - $\Longrightarrow$ Consumers spend less
  - $\Longrightarrow$ Firms produce and hire less
  - $\Longrightarrow$ Consumers lose confidence and spend even less
  - $\Longrightarrow$ Firms produce and hire even less
  - $\Longrightarrow \ldots$
  - $\Longrightarrow$ The Great Recession!

# Does It Make Sense?

Basic RBC: **no** ("Barro-King puzzle")

- In GE, interest rates adjust, offsetting AD shock
- $N$, $Y$, and $I$ move in opposite direction than $C$

Basic NK: **yes, but:**

- Only when MP does not replicate flexible price outcomes
- Translates any AD shock to a monetary expansion/contraction
- Inflation and output must co-move
- Also, hard to get $C$ and $I$ to comove

# This Paper: Demand-driven fluctuations with flexible prices

Element 1: variable utilization + adjustment cost for $K$ (or $I$)

$\Rightarrow$ intertemporal substitution in production

$\Rightarrow$ AS responds to AD along flexible-price outcomes

Element 2: confusion between idiosyncratic & agg. income fluctuations

$\Rightarrow$ confidence multiplier

(feedback loop b/w $y$, consumer sentiment, & investor sentiment)

1+2 $\Rightarrow$:

$u$, $y$, $h$, $c$, $i$ comove without TFP & $\pi$

# Roadmap

1. Start with FIRE (full-info, rational expectations) and no investment margin
   variable utilization $\Rightarrow$ **AS responds to AD**

2. Add info friction (or bounded rationality) $\Rightarrow$ **confidence multiplier**

3. Comovement and other implications
   - Gov spending (crowding in, front-loading vs back-loading)
   - Comovement between savers and borrowers
   - Comovement between consumption and investment
   - TFP/AS shocks vs AD shocks

# Preferences and AD Curve

- Preferences (representative agent & complete info)

$$\mathcal{U}(c_t, n_t) + \beta_t \mathcal{U}(c_{t+1}, n_{t+1}) + \beta_t \beta_{t+1} \mathcal{U}(c_{t+2}, n_{t+2}) + \cdots,$$

$$\mathcal{U}(c, n) = \frac{c^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \frac{n^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}$$

$$\log \beta_t = (1-\rho_\beta) \log \beta + \rho_\beta \log \beta_{t-1} - \underbrace{\log \eta_t}_{\text{AD shock}}$$

- Positive $\eta_t$ shock = urge to consume = real AD shock

- AD (log-linearized, complete info):

$$y_t = -\sigma (r_t + \beta_t) + \mathbb{E}_t [y_{t+1}]$$

# Technology and AS Curve

- Technology

$$y_t = (n_t)^{\alpha} (u_t k_t)^{1-\alpha}$$
$$k_{t+1} = (1 - \delta(u_t) + \Psi(\iota_t)) k_t,$$

- Tentatively: shut down $\iota_t$ margin (infinite adjustment cost: $\Psi(0) = 0$ and $\Psi'(0) \to \infty$)

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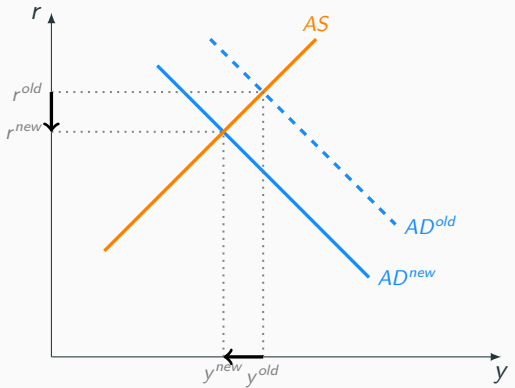
- Tentatively: shut down $\iota_t$ margin (infinite adjustment cost: $\Psi(0) = 0$ and $\Psi'(0) \to \infty$)

- AS (log-linearized):

$$n_t = \tilde{\theta}(u_t + k_t)$$
$$y_t = (1 - \tilde{\alpha})(u_t + k_t),$$
$$u_t = \frac{\beta}{\tilde{\alpha} + \beta\phi} r_t + \beta \mathbb{E}_t [u_{t+1}],$$
$$k_{t+1} = k_t - \kappa u_t,$$

- intuition: as $r$ falls, substitute less goods today for more goods tomorrow

# Equilibrium without Info Frictions




- Resembles NK, but: $r$ vs $P$ in vertical axis, and $y^{\text{natural}}$ vs $y^{\text{gap}}$ on horizontal axis
- Flexible-price core of NK: vertical AS, $y^{\text{natural}}$ invariant to AD
- Here: Intertemporal "Econ 101"

# Equilibrium without Info Frictions

**Prop. Demand-driven fluctuations without nominal rigidity**

$$\frac{\partial y_t}{\partial \eta_t} = \gamma \equiv \frac{\varsigma\sigma\beta}{\sigma+\varsigma}\frac{1}{1-\rho_\beta\beta} > 0$$

where $\sigma$ and $\varsigma \equiv \frac{1-\tilde{\alpha}}{\tilde{\alpha}+\beta\phi}$ parameterize the elasticities of AD and AS, respectively.

- $\varsigma$ and hence $\gamma$ increase with flexibility of $u$ (decrease with $\phi \equiv \frac{\delta''(u^*)u^*}{\delta'(u^*)}$)

# Full Model with Information Frictions

Supply side

- Complete info, same as above

Demand side

- Islands & idiosyncratic shocks
- Knowledge of own discount rate, own income & own interest rates
- Incomplete info about, or inattention to, aggregate conditions
- (Rational) confusion of idiosyncratic & agg. income fluctuations

# AD Curve

**Prop. The AD Curve**

$$y_t = -\sigma\left(r_t + \beta_t\right) + \mathbb{E}_t\left[y_{t+1}\right] + \mathcal{B}_t + \mathcal{G}_t$$

- $\mathcal{B}_t$ captures avg misperception of permanent income

$$\mathcal{B}_t \equiv \frac{1-\beta}{\beta}\sum_{k=0}^{+\infty}\beta^k \int \left(E_t^h\left[y_{h,t+k}\right] - \mathbb{E}_t\left[y_{h,t+k}\right]\right) dh,$$

  where $y_{h,t} = y_t + \xi_{h,t}$ is local/idiosyncratic income at $t$.

- $\mathcal{G}_t$ captures avg misperception of future interest rates

$$\mathcal{G}_t \equiv -\sigma\sum_{k=1}^{+\infty}\beta^k \int \left(E_t^h\left[r_{t+k}\right] - \mathbb{E}_t\left[r_{t+k}\right]\right) dh$$

# Our Hulten's Theorem

To understand $\mathcal{B}_t$, let's study first the true aggregate permanent income

**Prop. Our Hulten's Theorem**

Aggregate permanent income is **invariant to AD shock** $\eta_t$. It is pinned down by technology/capital alone:

$$\sum_{k=0}^{+\infty} \beta^k \int \mathbb{E}_t \left[ y_{t+k} \right] = \tfrac{1-\tilde{\alpha}}{1-\beta} k_t$$

- Standard Hulten's theorem: static. Here: dynamic
- Key assumption: efficient production (both within and across periods)
- Note: current aggregate output/income *does* move
  - intertemporal substitution without altering present discounted value

# $\mathcal{B}_t$ : Misperception of Permanent Income

Our Hulten's theorem implies that $\mathcal{B}_t$ is procyclical

Mechanism: current aggregate income $y_t$ drops

$\Rightarrow$ local income $y_{h,t} = y_t + \xi_{h,t}$ drops

$\Rightarrow$ rationally confused as drop in idiosyncratic income $\xi_{h,t}$

$\Rightarrow$ drop in perceived permanent income

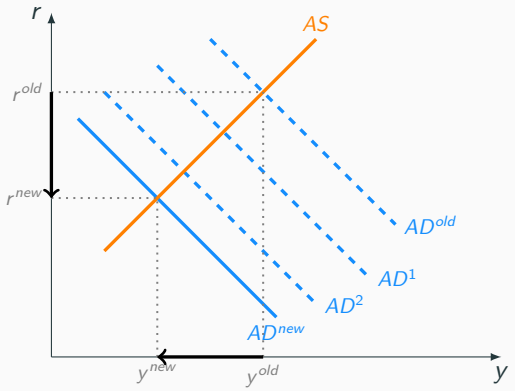
**Prop. Pro-cyclical misperception of permanent income**

$$\frac{\partial \mathcal{B}_t}{\partial \eta_t} = \frac{1-\beta}{\beta(1-\beta\rho_\xi)}(1-\lambda)\frac{\partial y_t}{\partial \eta_t} > 0$$

where $1-\lambda$ measures degree of confusion of idiosyncratic & agg income fluctuations

# Confidence Multiplier

$AD$ drops $\Rightarrow$ $y$ drops $\Rightarrow$ perceived permanent income drops even though actual doesn't $\Rightarrow$ $AD$ drops further $\Rightarrow$ $y$ drops further $\Rightarrow$ ...



# Confidence Multiplier

Focus on the impact of $\mathcal{B}_t$ (as if $\mathcal{G}_t = 0$)

**Prop. Equilibrium Impact of Confidence Multiplier**

$$\frac{\partial y_t}{\partial \eta_t} = \gamma \cdot m^{\text{conf}}(\lambda, \rho_\xi),$$

where the "confidence multiplier" is given by

$$m^{\text{conf}}(\lambda, \rho_\xi) \equiv \frac{\varsigma + \sigma}{\varsigma + \sigma - \varsigma \frac{1-\beta}{1-\beta\rho_\xi}(1-\lambda)} > 1;$$

increases with the degree of confusion, $1 - \lambda$; increases with the persistence of idiosyncratic income, $\rho_\xi$; is invariant to the persistence of AD shoc $\rho_\beta$; and increases with the MPC.

# $\mathcal{G}_t$: Discounting GE Adjustment in Interest Rate

Consider now the role of $\mathcal{G}_t$

- Neoclassical GE: interest rates $r_{t+k}$ drop
  - discourages consumption
  - goes against the direct impact of the AD shock
- Here: cannot fully perceive $r_{t+k}$ drop
  - arrests the Neoclassical GE effect
  - i.e., amplifies the impact of the AD shock
- Bottom line: this mechanism reinforces confidence multiplier

# Full Equilibrium

**Prop. Two Multipliers**

The equilibrium response of aggregate output is given by

$$\frac{\partial y_t}{\partial \eta_t} = \gamma \cdot m^{\text{conf}}(\lambda, \rho_\xi) \cdot m^{\text{GE}}(\lambda, \rho_\beta),$$

where both $m^{\text{conf}}$ and $m^{\text{GE}}$ increase with degree of confusion

# Taking Stock

Element 1: variable utilization $\Rightarrow$ **AS responds to AD**

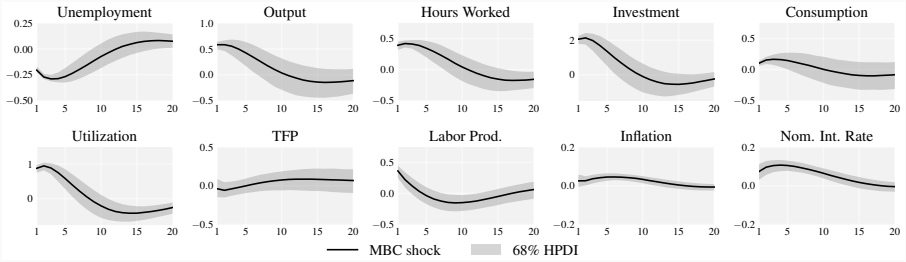
Element 2: info friction $\Rightarrow$ **amplification**

Additional results (in paper):

- Signal extraction, endogeneity/uniqueness of $\lambda$
- Bounded rationality interpretations
- Comovement (savers & borrowers; investment & consumption)
- $G$ can crowd in $C$ (plus: favors front-loading fiscal stimuli)
- AS shocks dampened while AD shocks amplified

# Circling Back to Motivating Facts

- Main Business Cycle Shock (Angeletos, Collard & Dellas, 2020)




- Not only: $u$, $y$, $h$, $c$, $i$ comove without TFP & $\pi$
- But also: **evidence of intertemporal substitution in utilization/production**
- Plus: Utilization accounts for pro-cyclicality in labor prod
- And: non-accommodative MP and procyclical real $r$

# Conclusion

- Evidence calls for theories that make room for Keynesian narrative, and let AD drive business cycles, without strict reliance on sticky prices and Phillips curves
- This echoes the older literature on coordination failures and multiple equilibria
- Newer literature shifts focus on belief, financial, and other frictions on the demand side
- More to be done on both the empirical and theoretical front!