An Anatomy of the Business Cycle Data

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Motivation

- **Main goal:** **Detect important regularities of business cycles data; understand what theories can help account for them**
- **How?** Use VAR to attribute the bulk of the business cycle in the US macroeconomic data to a single forcing variable; inspect its empirical properties
- Yet another paper to recover a particular structural shock? **No!**
  - Document that a single force can capture most of the business cycle and recover its observable properties
  - But remain agnostic about what the shock and its propagation mechanism, that is, do not a prior impose any particular theory
  - Vary identification $\rightarrow$ anatomy of comovement patterns
  - Filter useful for evaluating existing models and/or guiding development of new models

Method in a Nutshell

- Estimate VAR on $\mathbf{X}_t = \{Y_t, U_t, H_t, I_t, C_t, W_t, \pi_t, R_t, \ldots\}$

$$A(L)\mathbf{X}_t = \mathbf{u}_t$$

- Recover a "*shock*" as a linear combination of the residuals $\mathbf{u}$
- But no SR/LR/Sign restrictions
- Instead define "Business-Cycle Factor" as "shock" that maximizes volatility of Y at BC frequencies (6-32 quarters)

- May or may not have a theoretical counterpart
  $\Longrightarrow$ Not a *structural shock* in the common sense

- More generally:
  - Look at any shock that targets any (group of) variable(s) at any band of frequencies
  - Study comovement (IRF), variance decomposition, compare to other shocks

  $\Longrightarrow$ An Anatomy of the Business Cycle

Rationale/Goals

- **Rationale 1: Anatomy of Co-Movement**
  - BC shock = one-dimension summary of the business cycle
  - Inspecting each shock, and varying the targets in the identification of the shock, we learn something about the nature of the comovement across variables as well as across frequencies
- **Rationale 2: Parsimony/Mechanism**
  - Models with a single dominant shock ("technology"?)
  - Models with many shocks but a common propagation mechanism ("aggregate demand"?)
  - Models with shock that specialized $\Longrightarrow$ Evaluation based on cross shocks implications.
- Either way, a filter that may help discriminate between different theories

Key Findings

- Bulk of business-cycle volatility in (Y, U, I, H) attributed to a single transitory shock
  - Good news for theorists aspiring to understand the business cycle as the symptom of a single dominant propagation mechanism
- Disconnect between BC movements in (Y, U, I, H) and productivity at any horizon
  - Bad news for RBC paradigm
- Disconnect from inflation, evidence against NKPC
  - Bad news for NK paradigm
- Evidence at odds even with rich DSGE models such as Smets-Wouters
- A mystery?

Related Literature

1 VAR approach + identification of structural shocks (see Ramey, 2016, for a survey)

- SR/LR restrictions: Sims (1980), CEE (1999), Galí (1992, 1999), Blanchard and Quah (1989), Beaudry and Portier (2006). . .
- Sign restrictions: Uhlig (2005), Fry (2011), Baumeister and Hamilton (2014), Arias, Rubio-Ramírez and Zha (2015). . .

2 FAVAR approach $\Longrightarrow$ recovers (and models) factors that drive the business cycle

- Sims and Sargent (1977), Stock and Watson (2005), Reichlin et al. (2006, 2009), Bernanke et al. (2005)

- This paper lies in the middle
  - Use a **VAR** to recover the BC **shock**.
  - Akin to the pioneering work by Uhlig (2003) on financial data (similar to PCA).

Road Map

- Methodology;
- Results on US data;
- Robustness;
- Link to theory: How to use the filter?
- Conclude.

Methodology in a Nutshell

1. Estimate a VAR
2. Switch to the frequency domain and obtain spectral density
3. Apply filter (selection of frequencies)
4. Go back to time domain
5. Extract the "Principal Component" for the filtered (set of) variable(s) of interest
6. Build the BC shock

Methodology: Fixing Notations

- Estimate a VAR/VECM

$$A(L)\mathbf{Y}_t = \mathbf{u}_t \Longleftrightarrow \mathbf{Y}_t = B(L)\mathbf{u}_t$$

with $E(\mathbf{u}_t\mathbf{u}_t') = \Sigma$ and $A(0) = B(0) = I$

- Obtain orthogonal representation of shocks ($\mathbb{E}(\varepsilon\varepsilon') = I$)

$$\mathbf{u}_t = S\varepsilon_t \Longrightarrow SS' = \Sigma$$

- Wold Representation:

$$\mathbf{Y}_t = C(L)\varepsilon_t \text{ with } C(L) = B(L)S$$

Methodology: Spectral Density and Filtering

- Spectral density of kth variable in $\mathbf{Y}_t$

$$\widetilde{F}_k(\omega) = \frac{1}{2\pi} C_k(e^{-i\omega})\overline{C_k(e^{-i\omega})}$$

where $C_k(z)$ is the k-th row of the polynomial matrix $C(z)$.

- Filtered spectral density $F_k(\omega)$

$$F_k(\omega) = f(\omega)^2\, \widetilde{F}_k(\omega)$$

where $f(\omega)$, $\omega \in [-\pi; \pi]$ is given by

$$f(\omega) = \begin{cases} 1 & \text{if } \underline{\omega} \leqslant |\omega| \leqslant \overline{\omega} \\ 0 & \text{otherwise.} \end{cases}$$

Methodology: Decomposition by ε-innovations

- Spectral density, decomposition by shock

$$\widehat{F}_k(\omega) = \frac{f(\omega)^2}{2\pi}\overline{C_k(e^{-i\omega})}C_k(e^{-i\omega})$$

- Use inverse Fourier transform to get
    - Filtered volatility of variable k: σ_k^2
    - Covariance Matrix across shocks for variable k: $\widehat{\Sigma}_k^2$

- Variance decomposition for variable k: $\Theta_k = \widehat{\Sigma}_k^2/\sigma_k^2$
- $\Theta_{k,ij} \equiv$ Contribution of the $\mathrm{cov}(Y_k(\varepsilon_i), Y_k(\varepsilon_j))$ to $\mathrm{Var}(Y_k)$ at frequencies $\omega \in (\underline{\omega}, \overline{\omega})$.

Methodology: Extracting the BC Shock

- **Problem:** find the combination, q, of orthogonal shocks that maximizes the volatility of variable k

$$\max_q \; q' \, \Theta_k q$$
$$\text{s.t. } q' q = 1$$

- Akin to a principal component analysis problem: q is the eigenvector associated to the maximal eigenvalue of Θ_k

- IRF of variable k at horizon τ is then simply given by

$$IRF_{k,\tau} = C_{k,\tau} q$$

Identification

Very easy to extend to

- A group of variables;
- Any linear transformation of variables;
- Co-movement instead of volatility;
- A sequence of mutually orthogonal shocks, or linearly constrained shocks.

Baseline VAR

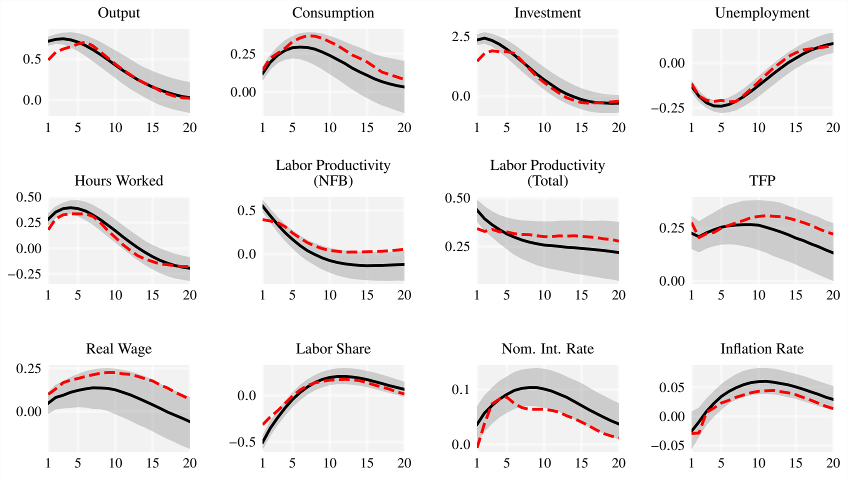
- Quarterly U.S data: 1960Q1-2007:Q4
- GDP, Consumption, Investment, Unemployment, GDP inflation, FFR, Labor Share, Fernald's TFP, NFB productivity and hours worked.
- Bayesian VAR, 2 Lags
- 50000 replications using the Gibbs' sampler (keep 1000 draws).

Baseline VAR: Prototype BC Shock

- **Business Cycle Shock**: Shock that contributes the most to output volatility between 6-32 Quarters.

- Close to the definition of the BC used by Christiano and Fitzgerald, or Baxter and King.
- Main difference: use an ideal filter (on the VAR).
- Can be straightforwardly modified to accommodate other filters (e.g. H-P filter)

Business Cycle Shock: GDP Shock



VAR; VECM; Shaded area (VAR): 68% HPDI.

Business Cycle Shock: GDP Shock

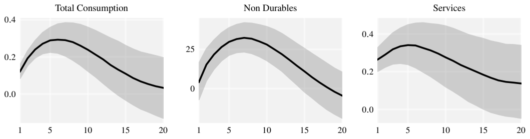
	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
VAR(2)												
SR	**78.24**	36.65	**70.64**	**55.40**	**48.87**	**44.61**	36.32	15.65	**8.19**	42.96	**16.21**	**12.49**
LR	17.88	16.49	18.57	13.96	11.05	8.57	16.69	15.16	8.62	7.16	15.34	13.46
VECM (Theo. Rest.)												
SR	58.56	48.19	55.22	53.97	50.54	38.48	29.72	20.73	17.11	36.30	44.29	27.41
LR	4.80	4.80	4.80	9.92	6.50	4.80	4.80	4.80	4.80	4.22	8.39	7.88

Note: SR: Short-Run (6-32 Quarters), LR: Long-Run (80-∞ Quarters), s^w: Labor share, $(Y/h)^{\mathrm{N}}$: Labor productivity in the Non-Farm Business Sector, $(Y/h)^{\mathrm{T}}$: Labor productivity in the whole economy, TFP: total factor productivity.

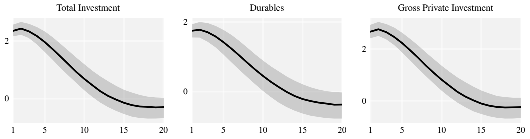
- Strong covariation with other real quantities
- Disconnect from inflation and interest rates
- Disconnect from low frequencies

Business Cycle Shock: GDP Shock

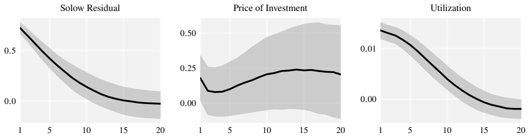
(a) Consumption



(b) Investment



(c) Productivity



Shaded area: 68% HPDI.

Business Cycle Shock: GDP Shock

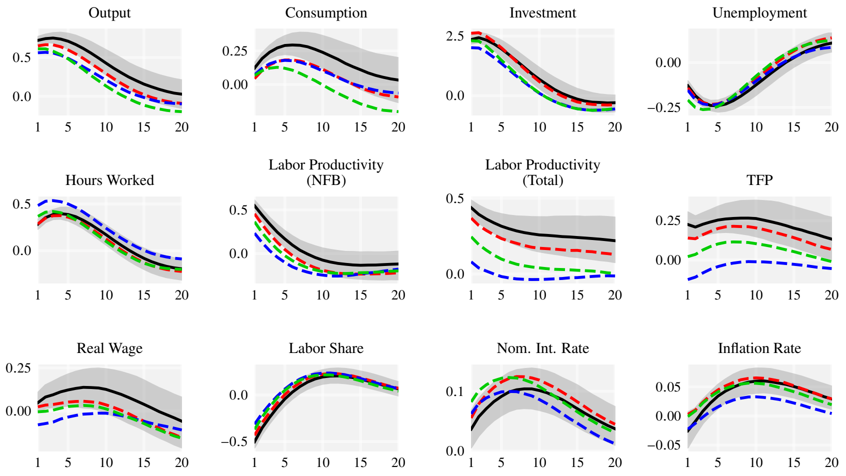
	SR	P^{I}	z	C^{ND}	C^{SERV}	C^{D}	$GPDI$
Short Run	68.95	3.68	60.15	20.28	25.61	62.58	67.06
Long Run	15.29	9.87	12.82	15.61	17.11	16.04	19.53

Note: SR: Solow Residual, TFP: Total Factor Productivity, P^{I}: Relative Price of Investment, z: Utilization rate, C^{ND}: Consumption of Non-Durables, C^{SERV}: Consumption of Services, C^{D}: Consumption of Durables, $GPDI$: Gross Private Domestic Investment.

Are we Capturing the Business Cycle?

- Is the factor indeed specific to the Business Cycle?
- Do we get anything different at lower frequencies?
- Compare alternative identifications: Long-run: $\geqslant 80$ quarters

Business Cycle Shock: Targeting Other Aggregates



Y; I; h; u; Shaded area: 68% HPDI.

Business Cycle Shock: Targeting Other Aggregates

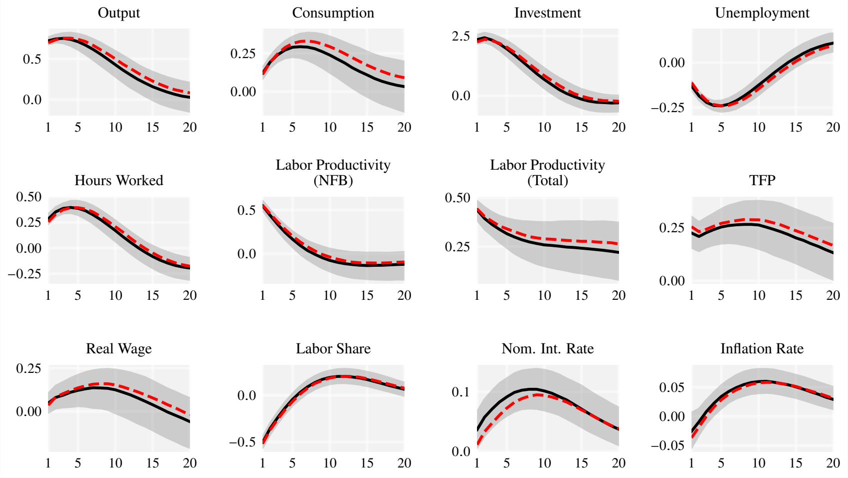
Contribution of Shocks at Business Cycle Frequencies (6–32 Quarters)

	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
Y	**78.24**	36.65	**70.64**	**55.40**	**48.87**	44.61	36.32	15.65	8.19	42.96	**16.21**	**12.49**
I	**67.79**	23.69	**81.22**	**56.94**	**48.22**	36.28	25.95	11.53	5.55	37.39	**22.37**	**11.20**
u	**59.93**	20.67	**65.02**	**68.15**	**55.99**	25.04	12.15	6.02	5.11	29.96	**27.03**	**10.70**
h	**50.95**	21.39	**52.51**	**53.21**	**70.91**	18.52	4.37	5.83	4.63	26.91	**18.67**	**7.75**
C	42.48	62.28	25.93	23.09	23.51	28.89	23.02	9.01	11.31	18.74	5.27	16.84

Note: SR: Short-Run (6-32 Quarters), LR: Long-Run (80-∞ Quarters), s^w: Labor share, $(Y/h)^{\mathrm{N}}$: Labor productivity in the Non-Farm Business Sector, $(Y/h)^{\mathrm{T}}$: Labor productivity in the whole economy, TFP: total factor productivity.

- Conditioning on traditional real BC variables: Very similar pattern!
- Disconnect with Inflation and Interest Rates
- Disconnect with Technology

Maximizing Contribution to Volatility vs Comovement



Y Shock; - - - - Shock that maximizes contribution to comovements; Shaded area: 68% HPDI.

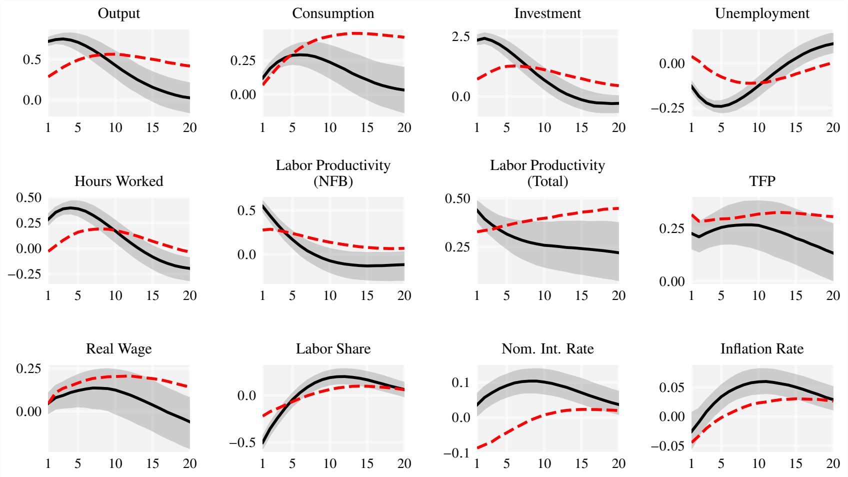
Maximizing Contribution to Volatility vs Comovement

Contribution of Shocks at Business Cycle Frequencies (6–32 Quarters)

	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
Maximizing Contribution to Output Volatility (6–32 Quarters)												
SR	78.24	36.65	70.64	55.40	48.87	44.61	36.32	15.65	8.19	42.96	16.21	12.49
LR	17.88	16.49	18.57	13.96	11.05	8.57	16.69	15.16	8.62	7.16	15.34	13.46
Maximizing the Contribution to the comovements between (C, I, u, h) and Y (6–32 Quarters)												
SR	77.81	39.24	69.02	53.96	47.84	46.14	38.04	16.98	9.08	45.46	14.54	14.40
LR	24.27	22.25	24.95	15.83	11.94	11.76	22.52	20.28	11.77	9.38	12.64	13.17

Note: SR: Short-Run (6-32 Quarters), LR: Long-Run (80-∞ Quarters), s^w: Labor share, $(Y/h)^{\mathrm{N}}$: Labor productivity in the Non-Farm Business Sector, $(Y/h)^{\mathrm{T}}$: Labor productivity in the whole economy, TFP: total factor productivity.

Short-Run vs Long-Run Identification



Short-run Identification; Long-run Identification. Shaded area: 68% HPDI.

Short-Run vs Long-Run Identification

	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
Short Run Identification (6–32 Quarters)												
SR	78.24	36.65	70.64	55.40	48.87	44.61	36.32	15.65	8.19	42.96	16.21	12.49
LR	17.88	16.49	18.57	13.96	11.05	8.57	16.69	15.16	8.62	7.16	15.34	13.46
Long Run Identification (80–∞ Quarters)												
SR	22.26	24.49	16.67	14.26	12.30	17.29	24.53	16.67	10.02	11.95	16.63	11.16
LR	99.15	99.03	96.51	27.85	25.06	71.81	98.08	93.71	68.71	59.77	23.40	23.08

Note: SR: Short-Run (6-32 Quarters), LR: Long-Run (80-∞ Quarters), s^w: Labor share, $(Y/h)^{\mathrm{N}}$: Labor productivity in the Non-Farm Business Sector, $(Y/h)^{\mathrm{T}}$: Labor productivity in the whole economy, TFP: total factor productivity.

- LR shock explains all of the volatility in Y in the LR but very little at BC frequencies
- The short and the long term are driven by distinct forces.

Disconnect from Technology

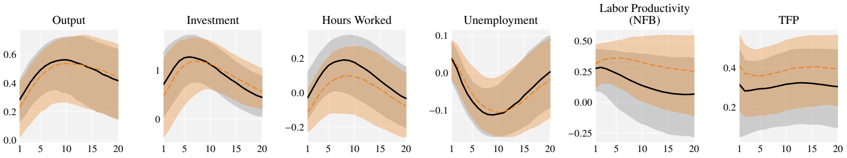
- The BC seems to be disconnected from productivity.
- May be due to identification strategy: Common to use LR restrictions

- Use Blanchard and Quah (1989) / Galí (1999) identification to recover a technological shock
- Append TFP (adjusted for utilization) to the VAR
- Maximize the contribution to the volatility of labor productivity / TFP at frequency 0
- How much of the business cycle does this shock account for?

Disconnect from Technology

(a) Short-Run Identification

(b) Long-Run Indentification



——— Y_t; - - - - TFP_t; Shaded area: 68% HPDI.

Disconnect from Technology

Variance Contribution: Short-Run identification (6-32 Quarters)

	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
Output												
SR	78.24	36.65	70.64	55.40	48.87	44.61	36.32	15.65	8.19	42.96	16.21	12.49
LR	17.88	16.49	18.57	13.96	11.05	8.57	16.69	15.16	8.62	7.16	15.34	13.46
∞	17.83	16.73	18.48	3.83	8.00	7.10	16.80	15.17	7.20	6.34	10.41	4.19
Labor Productivity												
SR	44.71	28.86	33.51	23.93	12.02	72.46	62.84	40.38	19.93	35.04	6.12	13.07
LR	18.76	17.36	21.90	13.57	11.57	15.85	20.66	22.27	14.63	18.85	11.00	18.50
∞	18.70	17.48	21.51	3.92	4.96	14.67	20.42	21.39	12.06	20.19	10.41	15.77
TFP												
SR	10.31	6.98	6.72	2.98	3.65	34.29	48.93	85.27	24.17	4.59	3.22	6.47
LR	16.57	16.04	20.23	13.57	23.47	15.53	20.67	24.55	14.16	16.44	12.33	27.15
∞	16.56	16.14	19.88	10.50	14.23	11.53	20.03	22.88	9.86	15.97	9.41	29.49

Note: SR: Short-Run (6-32 Quarters), LR: Long-Run (80-∞ Quarters), ∞: Frequency 0.

Disconnect from Technology

Variance Contribution: Long-Run identification (80-∞ Quarters)

	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
Output												
SR	22.26	24.49	16.67	14.26	12.30	17.29	24.53	16.67	10.02	11.95	16.63	11.16
LR	99.15	99.03	96.51	27.85	25.06	71.81	98.08	93.71	68.71	59.77	23.40	23.08
∞	99.87	99.83	98.45	29.74	27.76	86.40	99.16	97.59	84.95	75.88	23.56	17.34
Labor Productivity												
SR	12.54	14.16	13.87	13.47	9.33	17.05	10.27	9.68	12.85	6.54	22.79	23.39
LR	46.37	47.02	46.27	54.94	41.71	67.06	47.42	49.82	65.67	49.89	59.59	49.36
∞	46.05	46.40	46.11	51.01	29.79	67.32	47.33	49.80	67.53	52.92	56.74	29.43
TFP												
SR	18.74	23.24	14.58	13.33	10.63	21.33	26.86	23.59	15.33	8.29	19.67	14.71
LR	93.72	93.53	93.64	33.86	30.88	78.41	95.46	95.75	75.17	63.09	32.13	29.89
∞	94.78	94.61	95.40	31.79	28.69	90.55	96.43	98.65	89.10	78.78	27.96	22.91

Note: SR: Short-Run (6-32 Quarters), LR: Long-Run (80-∞ Quarters), ∞: Frequency 0.

Disconnect from Technology

Variance Contribution: Galí identification (∞ Quarters)

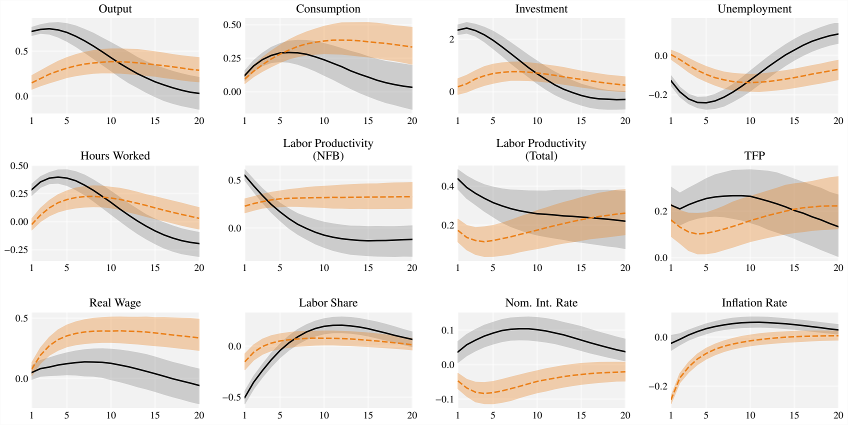
	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
Output												
SR	22.84	24.33	17.13	14.32	12.53	17.72	25.87	17.18	9.95	12.30	16.22	10.11
LR	99.38	99.21	96.96	24.75	22.80	70.49	98.48	94.07	66.85	58.86	20.41	21.13
∞	100.00	99.90	98.88	24.62	26.40	85.05	99.53	97.92	83.34	75.21	20.71	16.25
Labor Productivity												
SR	16.43	28.73	11.34	14.31	11.81	16.42	17.21	12.31	12.58	7.03	24.61	18.21
LR	84.12	84.47	81.21	34.50	23.13	90.61	84.42	85.95	87.70	71.03	32.45	20.54
∞	85.05	85.67	83.51	48.17	23.68	100.00	85.77	90.03	99.08	87.89	41.62	21.82
TFP												
SR	21.04	25.59	15.39	13.80	11.40	19.92	27.92	22.69	12.25	10.22	18.55	11.72
LR	96.69	96.46	96.39	25.59	20.48	76.76	98.07	97.48	73.53	62.53	21.29	21.47
∞	97.92	97.68	98.40	26.34	21.59	90.03	99.17	100.00	88.63	79.55	21.56	17.64

Note: SR: Short-Run (6-32 Quarters), LR: Long-Run (80-∞ Quarters), ∞: Frequency 0.

Disconnect From Nominal Aspects

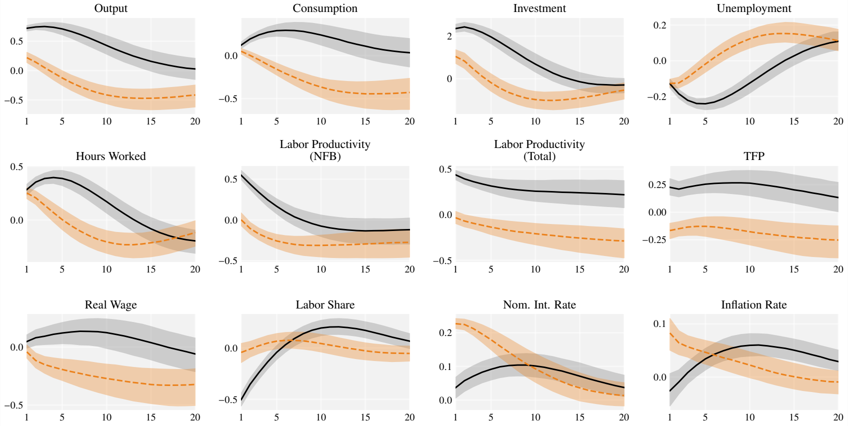
- Identify inflation and interest rates shocks
- Connection to real variables?

Disconnect From Nominal Aspects: Output versus Inflation Shock



Output Shock; Inflation Shock. Shaded area: 68% HPDI.

Disconnect From Nominal Aspects: Output versus Interest Rate Shock



Output Shock; Inflation Shock. Shaded area: 68% HPDI.

Disconnect From Nominal Aspects

Variance Contribution: BC Frequencies (6-32 Quarters)

	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
VAR(2)												
Y	**78.24**	36.65	**70.64**	**55.40**	**48.87**	44.61	36.32	15.65	8.19	42.96	**16.21**	**12.49**
π	**8.93**	19.06	**5.84**	**8.86**	**10.01**	10.74	3.92	3.47	18.65	4.70	11.71	**80.78**
R	**20.83**	22.62	**21.61**	**27.22**	**23.95**	11.22	3.82	4.29	5.63	5.36	**80.67**	14.77
VECM (Theo. Rest.)												
Y_t	**58.56**	48.19	**55.22**	**53.97**	**50.54**	38.48	29.72	20.73	17.11	36.30	**44.29**	**27.41**
pi_t	**25.68**	32.37	**23.18**	**26.62**	**29.61**	19.88	8.23	13.18	26.75	16.30	26.75	**75.52**
R_t	**44.27**	39.58	**46.40**	**48.72**	**46.35**	28.62	14.87	16.01	11.66	21.18	**78.67**	28.37

- Whether we target real quantities or inflation $\Longrightarrow$ a disconnect between the two

Where is the NKPC?

Variance Contribution of the Labor Share Shock: SR Identification

	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
s^w	39.83	19.52	34.62	30.39	25.60	36.57	27.67	7.59	17.69	**79.04**	8.45	**5.95**

Note: s^w: Labor share, $(Y/h)^{\mathrm{N}}$: Labor productivity in the Non-Farm Business Sector, $(Y/h)^{\mathrm{T}}$: Labor productivity in the whole economy, TFP: total factor productivity.

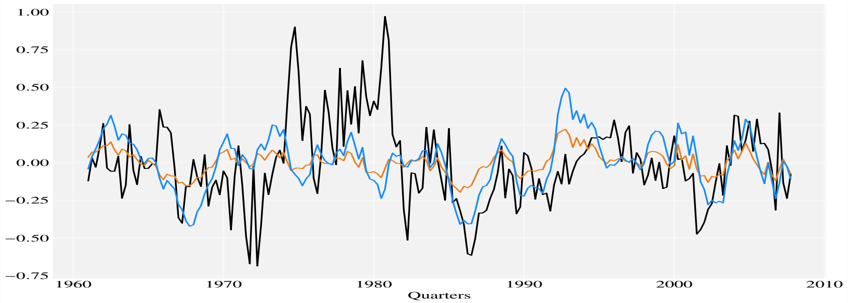
Where is the NKPC?

Variance Contribution of the Labor Share Shock: SR Identification

	Y	C	I	u	h	$(Y/h)^{\mathrm{N}}$	$(Y/h)^{\mathrm{T}}$	TFP	W	s^w	R	π
s^w	39.83	19.52	34.62	30.39	25.60	36.57	27.67	7.59	17.69	**79.04**	8.45	**5.95**

Note: s^w: Labor share, $(Y/h)^{\mathrm{N}}$: Labor productivity in the Non-Farm Business Sector, $(Y/h)^{\mathrm{T}}$: Labor productivity in the whole economy, TFP: total factor productivity.

Where is the NKPC?



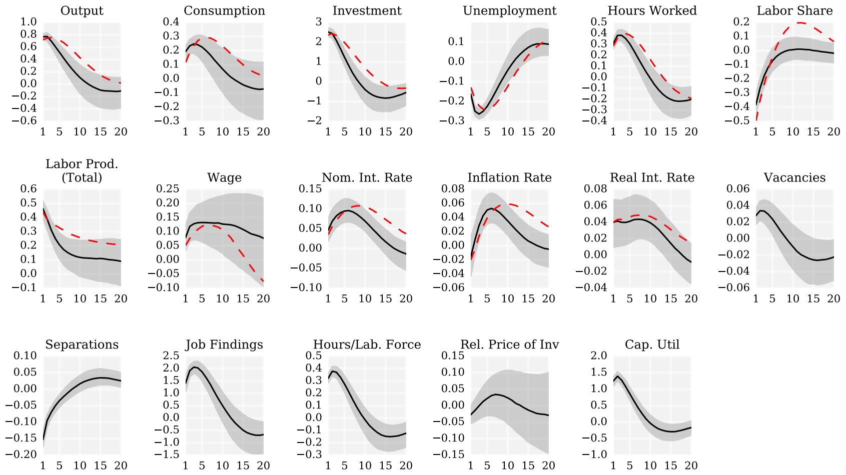
Inflation Shock, NKPC-Labor Share Shock, Hybrid NKPC-Labor Share Shock.

- NKPC is a good theory if inflation $\Longleftrightarrow$ black line (80% of π) tracks the other 2
- Correlation with basic NKPC (red) $=$ 0.11; with Hybrid NKPC (blue): 0.14 !

Extending the VAR

- Results may be specific to the information set we used
- Extend the VAR to include additional information on
    - Labor markets: Vacancies, Separations, Job Findings, Hours/Labor force
    - Technology: TFP, Relative price of investment
    - Capital utilization
- Based on Christiano, Trabandt, Walentin's (2015) data.
- Very similar results

Extending the VAR



Extended VAR; Baseline; Shaded area: 68% HPDI.

Extending the VAR

Variance Contribution: Output Shock

	Y_t	C_t	I_t	u_t	h_t	s_t^w	p_t^{TOT}	W_t	
SR	67.13	31.66	56.06	52.19	44.33	22.79	33.91	7.02	
LR	3.48	3.35	3.68	5.74	5.05	4.08	3.37	3.23	
	R_t	π_t	r_t^r	v_t	s_t	f_t	h_t/LF_t	P_t^{I}	z_t
SR	20.31	12.28	7.47	27.16	32.58	44.43	50.67	5.57	53.35
LR	5.80	5.65	5.01	4.32	4.28	6.50	3.75	3.41	7.20

Note: s_t^w: Labor share, p_t^{TOT}: Labor productivity in the whole economy, v_t: Vacancies, s_t: Job Separation Rate, f_t: Job Finding Rate, h_t/LF_t: Hours/Labor Force, P_t^{I}: Relative Price of Investment, z_t: Capacity Utilization Rate.

Extending the VAR

- Disconnect between Y, C, h, I, u, z and
  - Nominal aspects (R, π, r)
  - Technology $(Y/h, P^i)$

- These results extend to shocks to
  - Fiscal Shocks
  - Financial shocks
  - Uncertainty shocks

Tentative Lessons for Theory

- Clear evidence of strong co-movement in quantities
- Perhaps a *single dominant* mechanism driving most of this comovement
- **But unclear that this mechanism is as in the NK framework**
  - Inflation lags quantities, but no obvious Philips Curve
  - Most of inflation movements due to a persistent "residual"
  - Very different picture from Gali-Gertler, Sbordone, ...
- **But also very different from RBC**
- Some kind of "*demand fluctuations*" unlike NK?

Bigger Models?

- So far: interpretations based small models
- What if we consider medium-scale DSGE models featuring
  - lots of shocks
  - Bells and Whistles?
- Mapping from findings to theory becomes more tricky,
- But method remains a useful filter for measuring the performance of the theory
- **Next:** Do medium scale DSGE models really account for the BC?

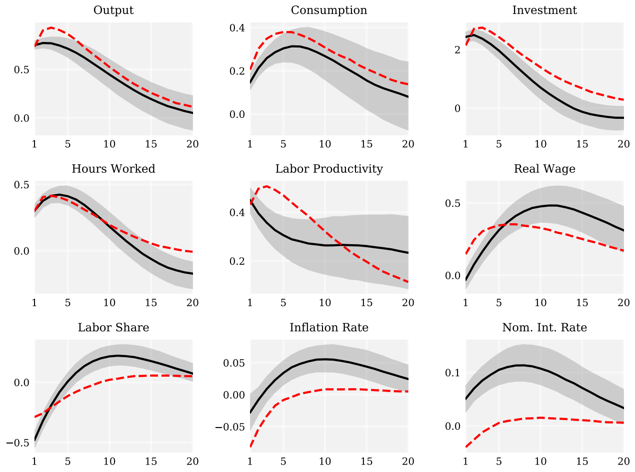
Does Smets Wouters (2007) Recover the “right” Business Cycle?

- Just to refresh your mind
- Smets Wouters (2007) = Standard NK model featuring
  - Calvo contracts on prices and wages, both with backward indexation;
  - A Taylor rule with both NIR smoothing, reaction to output growth;
  - All possible bells and whistles (Habit persistence, Investment Adj. Costs, utilization,...)
  - 7 shocks (Technology, Investment, Discount, Monetary policy, Fiscal, price and wage markup shocks)
- We re-estimate it on our data
- Restrict our VAR by eliminating unemployment

Does Smets Wouters (2007) Recover the "right" Business Cycle?

- Simulate artificial data form the model
- Estimate the same VAR as in the data
- Identify the BC shock
- Compare to the data

Model vs Data: Output Shock



Data (SW VAR); Model (SW VAR); Shaded area (VAR): 68% HPDI.

Model vs Data

Variance Contribution: Output Shock

	Y	C	I	h	Y/h	W	s^w	R	π
Short-Run									
Data	84.23	39.30	73.17	51.98	35.55	29.59	39.57	17.83	11.63
Model	67.02	32.19	58.51	41.27	52.87	21.30	18.54	8.89	11.40
Long-Run									
Data	4.89	4.56	5.45	5.46	5.01	5.10	4.58	10.08	5.70
Model	25.56	14.63	28.25	15.75	23.11	18.75	7.36	11.61	10.23

Note: s^w: Labor share.

Model vs Data

Variance Contributions: Alternative Shocks

	Y	C	I	h	Y/h	W	s^w	R	π
Output Shock									
Data	84.23	39.30	73.17	51.98	35.55	29.59	39.57	17.83	11.63
Model	67.02	32.19	58.51	41.27	52.87	21.30	18.54	8.89	11.40
Investment Shock									
Data	72.70	25.23	84.74	51.75	24.43	27.77	35.45	25.18	10.30
Model	50.04	11.71	75.71	36.24	32.21	12.07	13.49	6.13	5.41
Hours Worked Shock									
Data	54.04	21.76	54.54	76.28	4.08	20.10	24.02	23.14	6.76
Model	38.95	15.70	40.60	66.13	6.61	7.93	6.62	14.49	8.17
Consumption Shock									
Data	40.80	70.26	24.04	21.60	20.92	12.30	14.58	3.66	15.80
Model	36.42	64.18	16.60	23.72	27.52	13.27	13.43	14.42	18.85
Labor Productivity Shock									
Data	35.03	21.72	25.45	5.98	88.38	20.23	23.48	5.07	7.09
Model	44.34	21.48	32.83	8.65	82.02	22.82	27.23	6.97	6.72

Model vs Data

Variance Contributions: Alternative Shocks

	Y	C	I	h	Y/h	W	s^w	R	π
Wage Shock									
Data	3.52	2.53	3.40	8.31	10.52	65.60	32.41	2.44	3.75
Model	16.11	9.33	10.45	7.07	20.51	78.01	27.45	7.05	9.27
Labor Share Shock									
Data	37.70	17.24	31.08	20.92	27.90	37.22	76.90	8.02	4.83
Model	17.03	15.22	14.26	9.43	25.24	24.76	87.01	7.34	9.53
Inflation Shock									
Data	8.41	20.31	5.54	8.71	4.14	4.61	4.11	12.66	82.50
Model	29.14	32.80	17.63	27.06	15.67	17.00	10.12	42.82	89.69
Interest Rate Shock									
Data	18.02	12.86	22.36	22.76	3.17	5.59	7.06	81.82	15.61
Model	25.99	27.09	16.81	26.81	14.35	12.61	8.45	79.60	40.06

Model vs Data

- The model lacks the common driver of business cycle property: shocks in the model are specialized.
  - The investment shock accounts for less of the volatility of Y and h than of I
  - The employment shock for less of the volatility in Y and I than in h.
- The inflation shock in the model plays a much more active role with regard to both the business cycle and the other variables.
- The model does not actually have much of a use for a NK Phillips curve relationship. As in the data, the labor share shock contributes little to the volatility of inflation.

Tentative Conclusion

- New method for characterizing business cycle data relying on the existence of a main BC shock
- (Hopefully) Useful filter to identify and recover the Business Cycle shock
- Fairly robust to the real identifying shock
- No clear evidence in favor of NKPC
- Standard shocks fail to explain the BC

- From a more theoretical point of view
    - Basic RBC fails to explain the data
    - Basic Keynesian story does not square well with the data
    - Even rich DSGE models fail to capture salient patterns