Aggregate Demand and Aggregate Supply Effects of CoViD-19: A Real-time Analysis

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The expressed views do not necessarily reflect those of the Board of Governors of the Federal Reserve System, or its staff.

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Definitions

- Following Keynesian tradition (e.g., Blanchard, 1989):
  - Aggregate demand (AD) shocks: move inflation and real activity in the same direction
  - Aggregate supply (AS) shocks: move inflation and real activity in the opposite direction

Motivation

- Distinguishing AD from AS shocks is a long-standing goal of macroeconomics (earlier studies include, e.g., Burns and Mitchell, 1946):
    - Fiscal and monetary policy responses usually very different
    - Affect performance of various asset classes differently (Bekaert, Engstrom, Ermolov, 2021)

AD/AS Shocks during CoViD-19

- For many recessions the dominant force is immediately clear:
  - Oil crises in the 1970s $\Rightarrow$ supply shocks
  - Volcker experiment $\Rightarrow$ demand shock
- AD-AS decomposition is particularly interesting during CoViD-19: massive lockdowns are large negative demand shocks, but also many supply shocks at the same time...

Supply Shocks during CoViD-19: Labor force

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Coronavirus Relief Often Pays Workers More Than Work

When combined with state benefits, weekly government payouts create incentives that employers say complicate efforts to reopen businesses

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1. China's Comac Aims to Rival Boeing and Airbus in the World's Biggest Market

2. How Mortgages Work in the U.S.

3. iPhone 12 Mini: The Mini Review

Supply Shocks during CoViD-19: Domestic production

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BUSINESS

Grocers Hunt for Meat as Coronavirus Hobbles Beef and Pork Plants

Surging consumer demand also tightens supplies; supermarkets brace for shortages

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Supply Shocks during CoViD-19: International Supply Chains

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ECONOMY | THE OUTLOOK

Firms Want to Adjust Supply Chains Post-Pandemic, but Changes Take Time

Covid-19 has exposed the risk of farflung production; alternatives like making things at home could raise costs

RECOMMENDED VIDEOS

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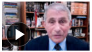
2. iPhone 12 Mini: The Mini Review

3. Fauci Says the U.S. Will Remain in the WHO



Contribution

- Novel, **easily implementable** approach to identify demand and supply shocks
- Identification through non-Gaussian features of the data:
  - minimal theoretical assumptions
  - strongly supported by data (e.g., Evans and Wachtel, 1993, for inflation, and Hamilton, 1989, for GDP growth)
- Relies on survey forecast revisions:
  - aggregate measure available in real time
  - no need to model conditional mean
  - good empirical fit (e.g., Ang, Bekaert, and Wei, 2007)

Demand and Supply Shocks

- Consider GDP growth and inflation shocks:
  - $g_{t+1} = E_t[g_{t+1}] + \epsilon^g_{t+1}$
  - $\pi_{t+1} = E_t[\pi_{t+1}] + \epsilon^\pi_{t+1}$
- Model them as functions of AD (u^d_t) and AS (u^s_t) shocks:

$$\epsilon^g_{t+1} = \underbrace{\sigma^d_g}_{>0} u^d_{t+1} + \underbrace{\sigma^s_g}_{>0} u^s_{t+1},$$

$$\epsilon^\pi_{t+1} = \underbrace{\sigma^d_\pi}_{>0} u^d_{t+1} - \underbrace{\sigma^s_\pi}_{>0} u^s_{t+1},$$

$$Cov(u^d_{t+1}, u^s_{t+1}) = 0, Var(u^d_{t+1}) = Var(u^s_{t+1}) = 1.$$

Identification 1/3

- Sample covariance matrix:

$$Cov(\epsilon_t^g, \epsilon_t^\pi) = \begin{bmatrix} (\sigma_g^s)^2 + (\sigma_g^d)^2 & -\sigma_\pi^s \sigma_g^s + \sigma_\pi^d \sigma_g^d \\ -\sigma_\pi^s \sigma_g^s + \sigma_\pi^d \sigma_g^d & (\sigma_\pi^s)^2 + (\sigma_\pi^d)^2 \end{bmatrix}$$

- 3 unique moments, but need 4 coefficients to extract AD and AS shocks

- "Demand" and "supply" shocks are not identified in Gaussian framework $\Rightarrow$ use unconditional higher order moments (in spirit of Lanne, Meitz, and Saikkonen, 2017)

Identification 2/3

- For example, identification via matching co-skewness moments:

$$E[u_t^g (u_t^\pi)^2] = \sigma_g^d (\sigma_\pi^d)^2 E[(u_t^d)^3] + \sigma_g^s (\sigma_\pi^s)^2 E[(u_t^s)^3],$$
$$E[(u_t^g)^2 u_t^\pi] = (\sigma_g^d)^2 \sigma_\pi^d E[(u_t^d)^3] - (\sigma_g^s)^2 \sigma_\pi^s E[(u_t^s)^3].$$

- Imagine $E[(u_t^s)^3] \approx 0$ and $E[(u_t^d)^3] < 0$:

$$E[u_t^g (u_t^\pi)^2] = \sigma_g^d (\sigma_\pi^d)^2 E[(u_t^d)^3] \cancel{+ \sigma_g^s (\sigma_\pi^s)^2 E[(u_t^s)^3]},$$
$$E[(u_t^g)^2 u_t^\pi] = (\sigma_g^d)^2 \sigma_\pi^d E[(u_t^d)^3] \cancel{- (\sigma_g^s)^2 \sigma_\pi^s E[(u_t^s)^3]}.$$

  - If in data $E[u_t^g (u_t^\pi)^2] < E[(u_t^g)^2 u_t^\pi] \Rightarrow \sigma_\pi^d > \sigma_g^d$
  - Co-skewness moments admit identification of σ_π^d and σ_g^d

Identification 3/3

- **12** unconditional moments to match:
  - **3** second order moments: $Std(u_t^g)$, $Std(u_t^\pi)$, $Corr(u_t^g, u_t^\pi)$
  - **4** third order moments: $Skw(u_t^g)$, $Skw(u_t^\pi)$, $E[(u_t^\pi)^2 u_t^g]$, $E[u_t^\pi (u_t^g)^2]$
  - **5** fourth order moments: $Kurt(u_t^g)$, $Kurt(u_t^\pi)$, $E[(u_t^\pi)^2 (u_t^g)^2]$, $E[(u_t^\pi)^3 u_t^g]$, $E[u_t^\pi (u_t^g)^3]$
- **9** parameters to estimate:
  - **4** AD/AS loadings: σ_g^d, σ_g^s, σ_π^d, σ_π^s
  - **2** unconditional skewnesses: $E[(u_t^d)^3]$, $E[(u_t^s)^3]$
  - **3** unconditional excess (co-)kurtoses: $E[(u_t^d)^4] - 3$, $E[(u_t^s)^4] - 3$, $E[(u_t^d)^2 (u_t^s)^2] - 1$

Extracting Demand and Supply Shocks

- Given AD/AS loadings can invert AD/AS shocks from GDP growth and inflation shocks:

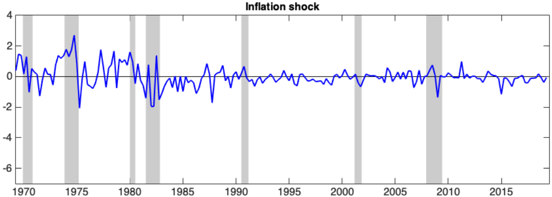
$$u_t^d = \frac{\sigma_\pi^s \epsilon_t^g + \sigma_g^s \epsilon_t^\pi}{\sigma_\pi^d \sigma_g^s + \sigma_\pi^s \sigma_g^d}$$

$$u_t^s = \frac{\sigma_\pi^d \epsilon_t^g - \sigma_g^d \epsilon_t^\pi}{\sigma_\pi^d \sigma_g^s + \sigma_\pi^s \sigma_g^d}$$

GDP Growth and Inflation Shocks

- Extracting US real-time GDP growth and inflation shocks from quarterly mean Survey of Professional Forecasters revisions:

$$u_t^g = E_t[g_t] - E_{t-1}[g_t],$$
$$u_t^\pi = E_t[\pi_t] - E_{t-1}[\pi_t]$$



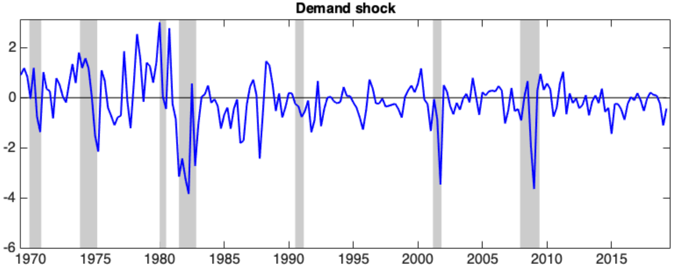
AD/AS Inversion: Matching Moments

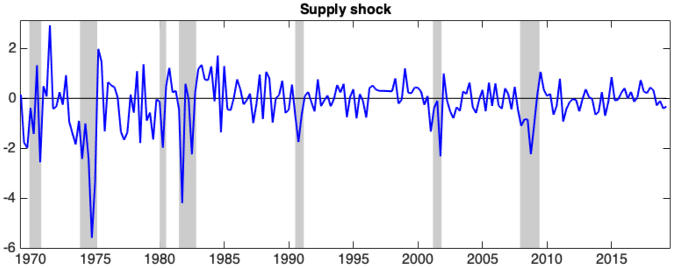
	Volatility		Correlation		
	u_t^π	u_t^g	$u_t^\pi u_t^g$		
Data	0.6361	1.1885	-0.1344		
Standard error	(0.0913)	(0.1448)	(0.1555)		
Fitted value	[0.7083]	[1.3295]	[-0.2776]		
	Skewness		**Coskewness**		
	u_t^π	u_t^g	$(u_t^\pi)^2 u_t^g$	$u_t^\pi (u_t^g)^2$	
Data	0.2005	-1.2343	-0.7873	0.4309	
Standard error	(0.3712)	(0.3890)	(0.2674)	(0.4884)	
Fitted value	[0.3663]	[-1.4465]	[-0.9808]	[0.4874]	
	Excess kurtosis		**Excess cokurtosis**		
	u_t^π	u_t^g	$(u_t^\pi)^2 (u_t^g)^2$	$(u_t^\pi)^3 u_t^g$	$u_t^\pi (u_t^g)^3$
Data	1.7280	4.7138	1.9239	-0.5464	-1.6186
Standard error	(0.9813)	(1.3877)	(0.8979)	(1.1467)	(1.5647)
Fitted value	[1.7502]	[4.3216]	[2.6462]	[-1.7761]	[-3.2401]
	Test for joint significance of 3^{rd} and 4^{th} order moments				
J-stat	25.3618				
p-value	0.26%				
	Overidentification test				
J-stat	2.9781				
p-value	38.74%				

AD/AS Inversion: Parameter Estimates

Panel A: Inflation/GDP Growth Shocks Loadings		
	u_t^{π}	u_t^{g}
u_t^s	-0.4829	1.1802
	(0.0566)	(0.1129)
u_t^d	0.5141	0.6035
	(0.0685)	(0.1064)
Panel B: Higher-order Moments of Supply and Demand Shocks		
	Skewness	Excess kurtosis
u_t^s	-1.9563	6.8535
	(0.3873)	(1.5692)
u_t^d	-0.6896	1.0062
	(0.5413)	(1.6825)
Co-excess kurtosis	-0.0095	
	(0.2843)	

AD/AS Shocks


Demand shock
2
0
-2
-4
-6
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015


Supply shock
2
0
-2
-4
-6
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015

Check 1: Impulse Responses

- Identification relies only on sign restriction and unconditional higher order moments
- Literature mostly uses additional economic restrictions: e.g., demand shocks should not have long-run GDP effects (Blanchard and Quah, 1989)
- Is our identification consistent with such restrictions?
- VAR model is: $Y_t = A_0 + A_1 Y_{t-1} + S \begin{bmatrix} u_t^s \\ u_t^d \end{bmatrix} + \epsilon_t$, where:
    - Y_t - vector of revised real GDP growth and inflation
    - $[u_t^s, u_t^d]'$ - pre-estimated demand and supply shocks
    - ϵ_t - residual noise vector

Check 1: Impulse Responses

	Contemporaneous (quarter 0) responses	
Shock	Real GDP level	Price level
Demand	0.19%***	0.33%***
	(0.22%)	(0.00%)
Supply	0.32%***	-0.18%***
	(0.00%)	(99.98%)
	Cumulative (20 quarters) responses	
Shock	Real GDP level	Price level
Demand	0.00%	1.17%***
	(52.25%)	(0.00%)
Supply	0.66%***	-0.45%
	(0.00%)	(93.95%)

block-bootstrapped probabilities that impulse response < 0 in parentheses

Check 2: Recession Classifications

- AD component: sum of demand shocks during recession $\times \sigma_g^d$
- AS component: sum of supply shocks during recession $\times \sigma_g^s$

NBER Recession	GDP shock: demand component	GDP shock: supply component
1969Q4-1970Q4	-0.34%	-2.11%
1973Q4-1975Q1	-0.08%	-2.33%
1980Q1-1980Q2	0.72%	-0.51%
1981Q3-1982Q4	-3.63%	0.12%
1990Q4-1991Q1	-0.20%	-0.32%
2001Q1-2001Q4	-1.55%	-0.37%
2008Q1-2009Q2	-1.92%	-0.18%

- First 5 recessions consistent with Gali (1992)
- Great Recession debatable: demand (e.g., Mian and Sufi, 2014) vs supply (e.g., Ireland, 2011, or Mulligan, 2012)

Real Time GDP Growth and Inflation Shocks

	Real GDP growth shock	Inflation shock
2020: Q1	-6.6%	-2.7%
2020: Q2	-34.3%	-4.6%
Max(1968Q4-2019Q2)	3.6%	2.7%
Min(1968Q4-2019Q2)	-6.6%	-2.1%
2008Q4	-3.5%	-1.4%

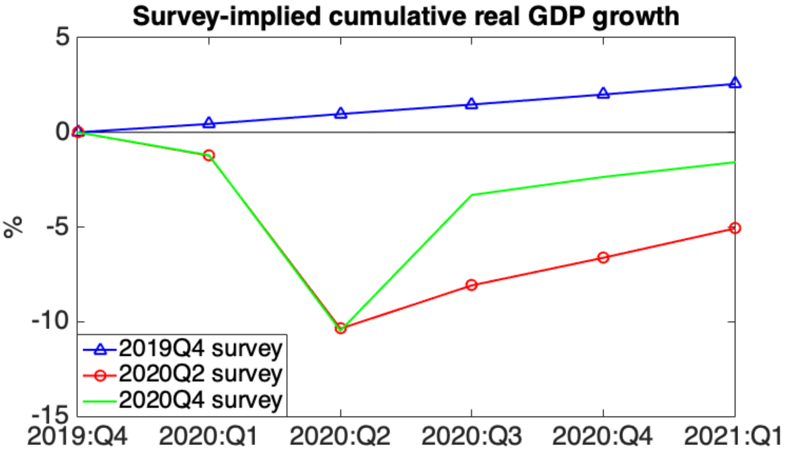
Real Time Demand and Supply Shocks

	Demand shock	Supply shock
2020: Q1	-7.1	-1.9
2020: Q2	-24.5	-16.5
Max(1968Q4-2019Q2)	3.0	2.9
Min(1968Q4-2019Q2)	-3.8	-5.6
2008Q4	-3.7	-1.1

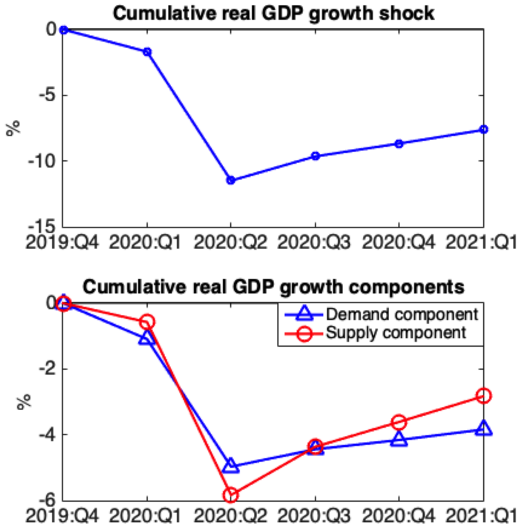
Real Time GDP Growth Demand and Supply Components

	Real GDP growth demand component	Real GDP growth supply component
2020: Q1	-4.3%	-2.3%
	(0.8%)	(0.2%)
2020: Q2	-14.8%	-19.5%
	(2.6%)	(1.9%)
Max(1968Q4-2019Q2)	1.8%	3.5%
Min(1968Q4-2019Q2)	-2.3%	-6.6%
2008Q4	-2.2%	-1.3%
	(0.4%)	(0.1%)

Real GDP Growth



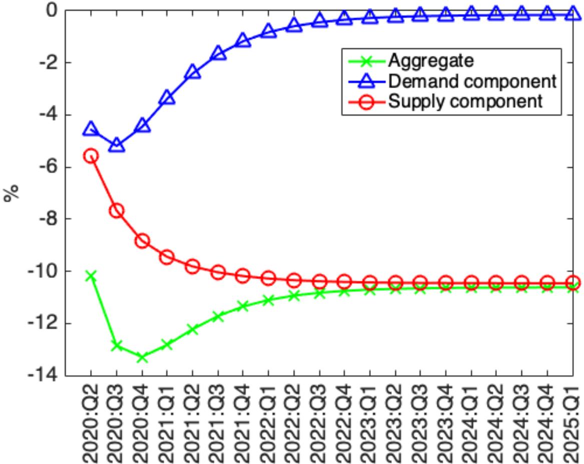
2020Q2 Survey Forecast Revisions Implied Real GDP Growth Shock



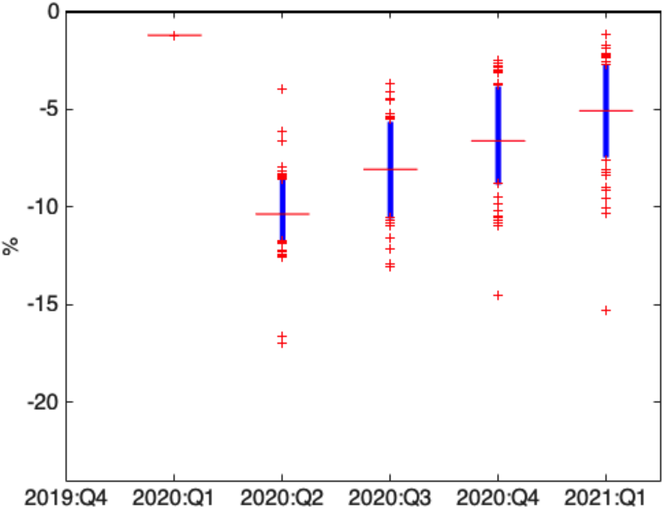
VAR Impulse Response to 2020:Q2 Demand and Supply Shocks

- Survey forecasts reflect real time expectations of market participants
- What would be impulse response to shock of such composition based on historical data?
- VAR model $Y_t = A_0 + A_1 Y_{t-1} + S \begin{bmatrix} u_t^s \\ u_t^d \end{bmatrix} + \epsilon_t$, where:
  - Y_t - vector of final revised real GDP growth and inflation
  - $[u_t^s, u_t^d]'$ - pre-estimated demand and supply shocks
  - ϵ_t - residual noise vector

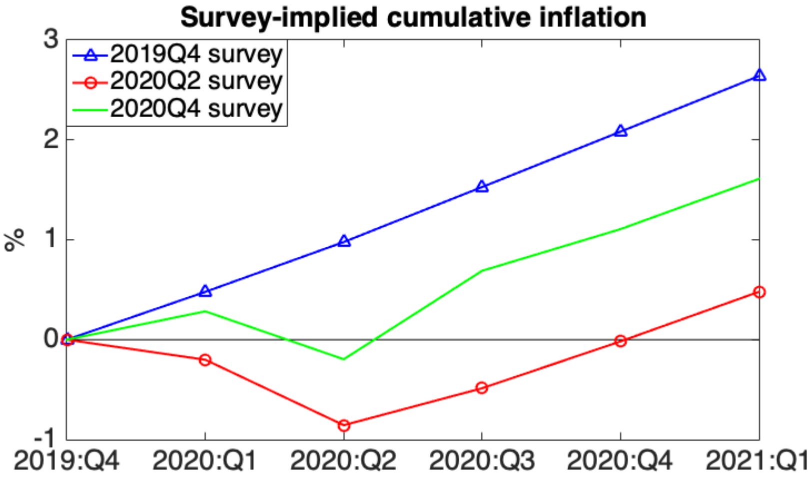
VAR Cumulative Real GDP Growth Response to 2020:Q2 Demand and Supply Shocks



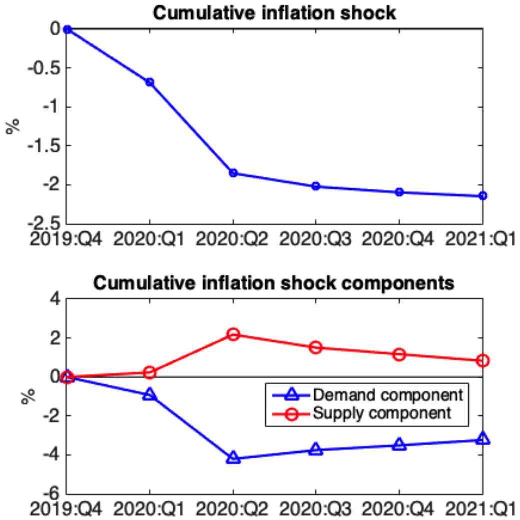
Cumulative Real GDP Growth: Individual Forecasts - 2020:Q2



Inflation


Survey-implied cumulative inflation
2019Q4 survey
2020Q2 survey
2020Q4 survey
%
3
2
1
0
-1
2019:Q4
2020:Q1
2020:Q2
2020:Q3
2020:Q4
2021:Q1

2020Q2 Forecast Revisions Implied Inflation Shock



Conclusions

- Novel way to identify AD/AS shocks:
  - Minimal theoretical restrictions (just a sign restriction)
  - Utilizing survey forecast revisions
  - Identification through non-Gaussian features
- CoViD-19 dynamics:
  - 2020Q1 GDP growth shock - very large by historical standards: mostly demand-driven
  - 2020Q2 shock - extraordinary by historical standards: $\frac{2}{3}$ supply- and $\frac{1}{3}$ demand-driven
- Many applications: contact us with any questions during implementation!