

Semiconductors and the Economic Outlook* Planning Through A Pandemic

Electronic Specialty Gas Conference 2020

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**Based on Consensus Economics, Inc. CONSENSUS FORECASTS®*

Outline: Dealing With Uncertainty

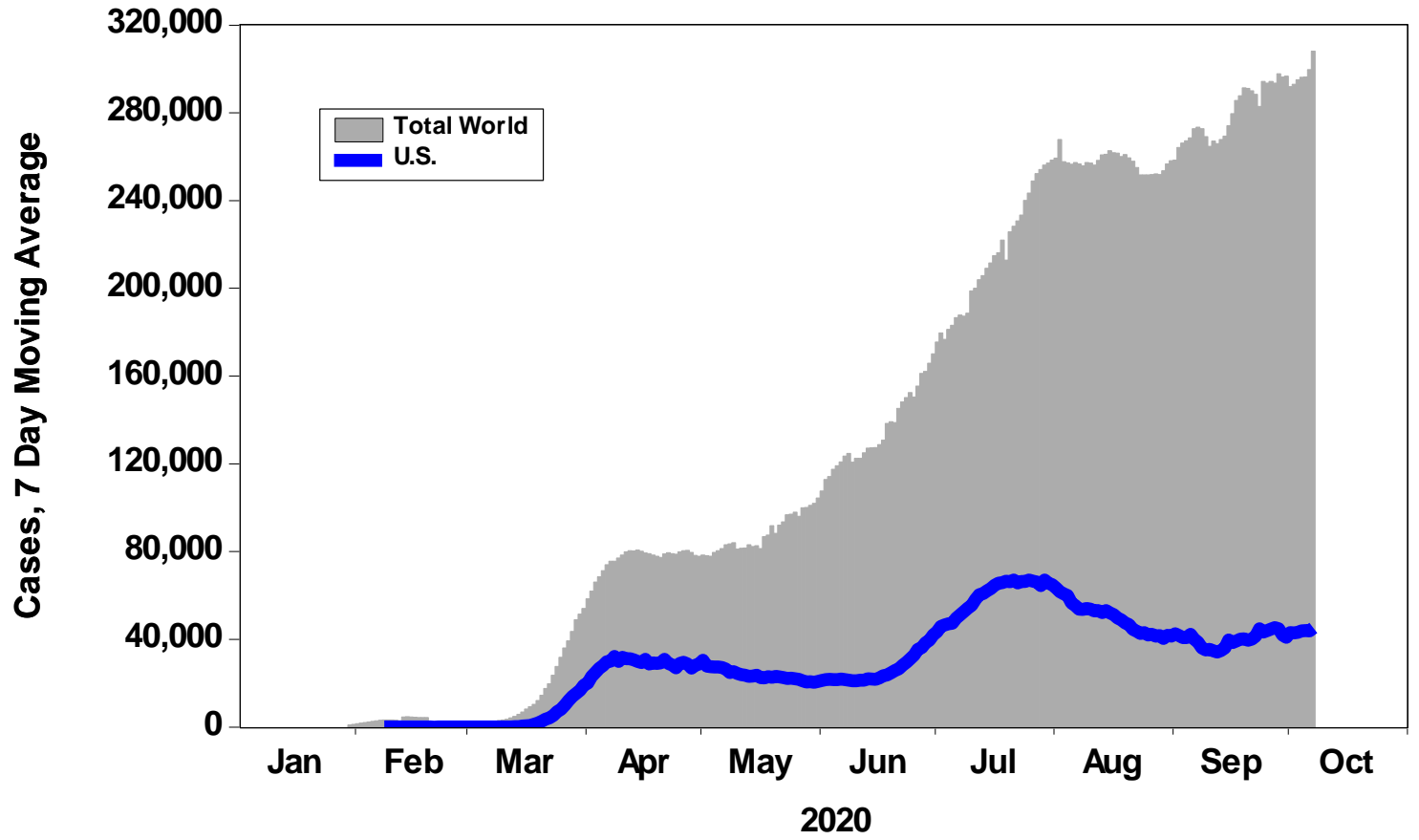
- Pandemic and the economic policy responses introduce multiple uncertainty levels, producing a severe external shock
- Normal forecasting techniques break down in external shock-recessions
- Planning & operating through a shock-recession:
 - Consensus-based forecasts* lag events for a while, but tend to be the best over the long run
 - Scenarios to assess different futures
 - Real-time tracking of higher frequency data

*Consensus: I calculate a consensus global real GDP forecast using world bank history and consensus forecasts for 85 countries reported by Consensus Economics® in their four regional monthly Consensus Forecasts. Consensus Economics® surveys more than 700 forecasters monthly to produce their Consensus Forecasts. www.consensuseconomics.com

The Covid-19 Pandemic Produces a Severe Shock

More than 36 million cases, still rising ~1%/day

New Cases By Day Through October 7

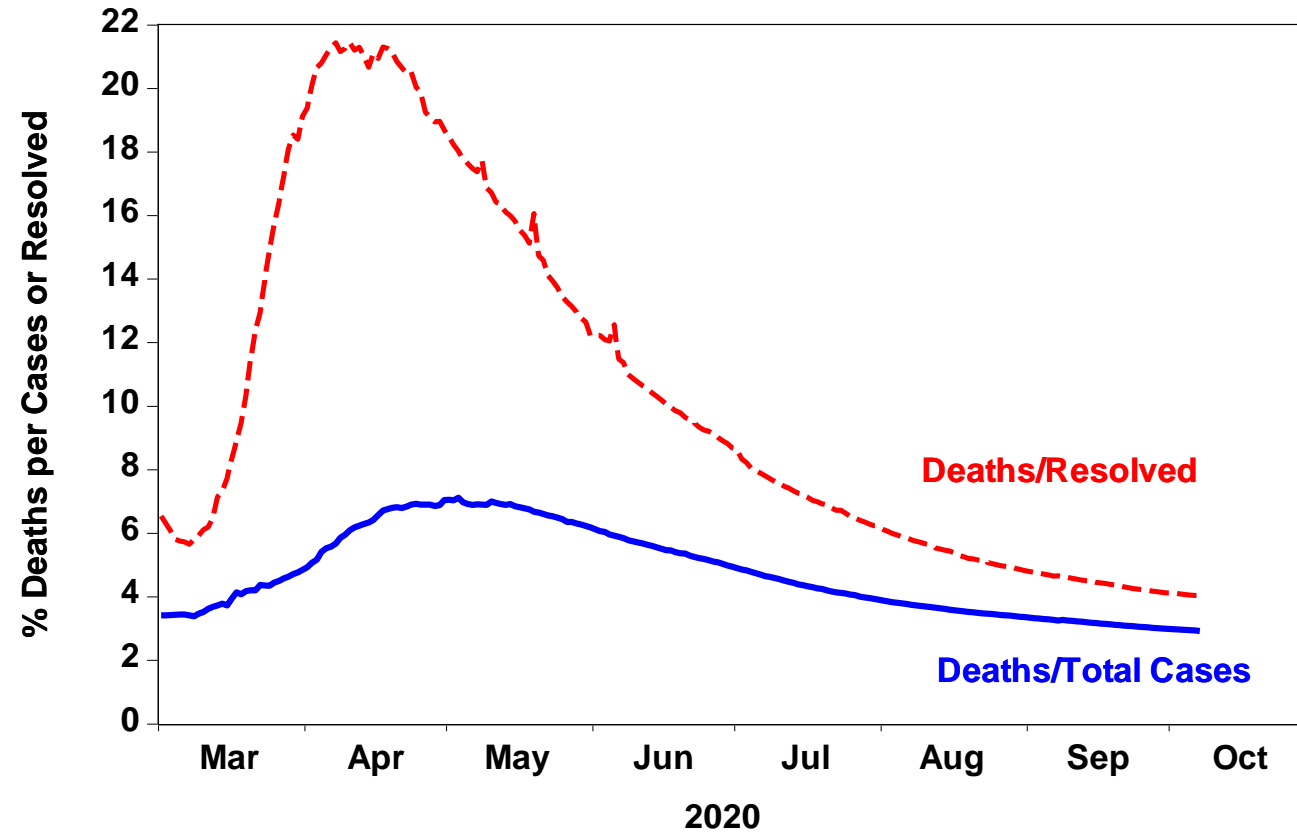


Sources: Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) 10/7/2020; WHO Covid-19 Dashboard

The Covid-19 Pandemic Produces a Severe Shock

More than 1 million deaths (~3% of cases)

Mortality Range Estimates

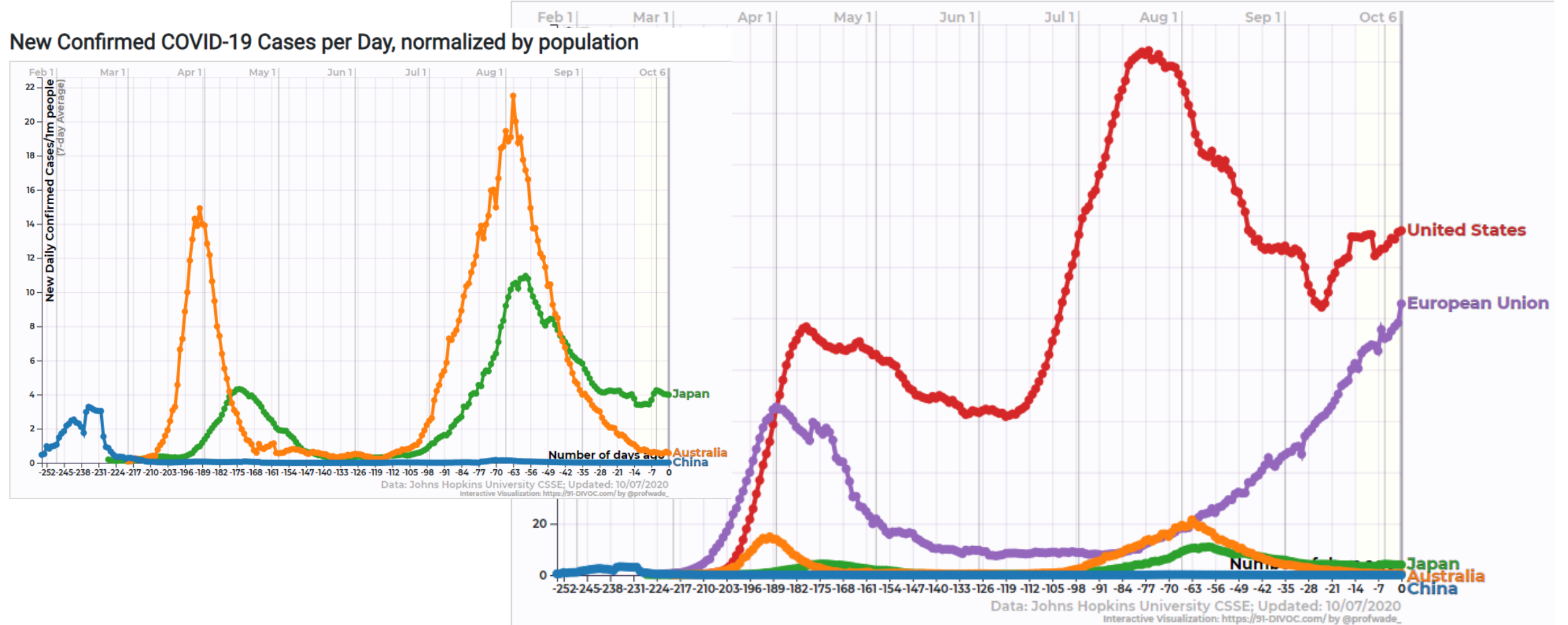


Resolved: all cases that have ended in recovery plus cases ended in death – does not include active cases
Src: Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) 10/7/2020
WHO Covid-19 Dashboard 10/7/20

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Pandemic Impact Coming in Waves

New Confirmed COVID-19 Cases per Day, normalized by population

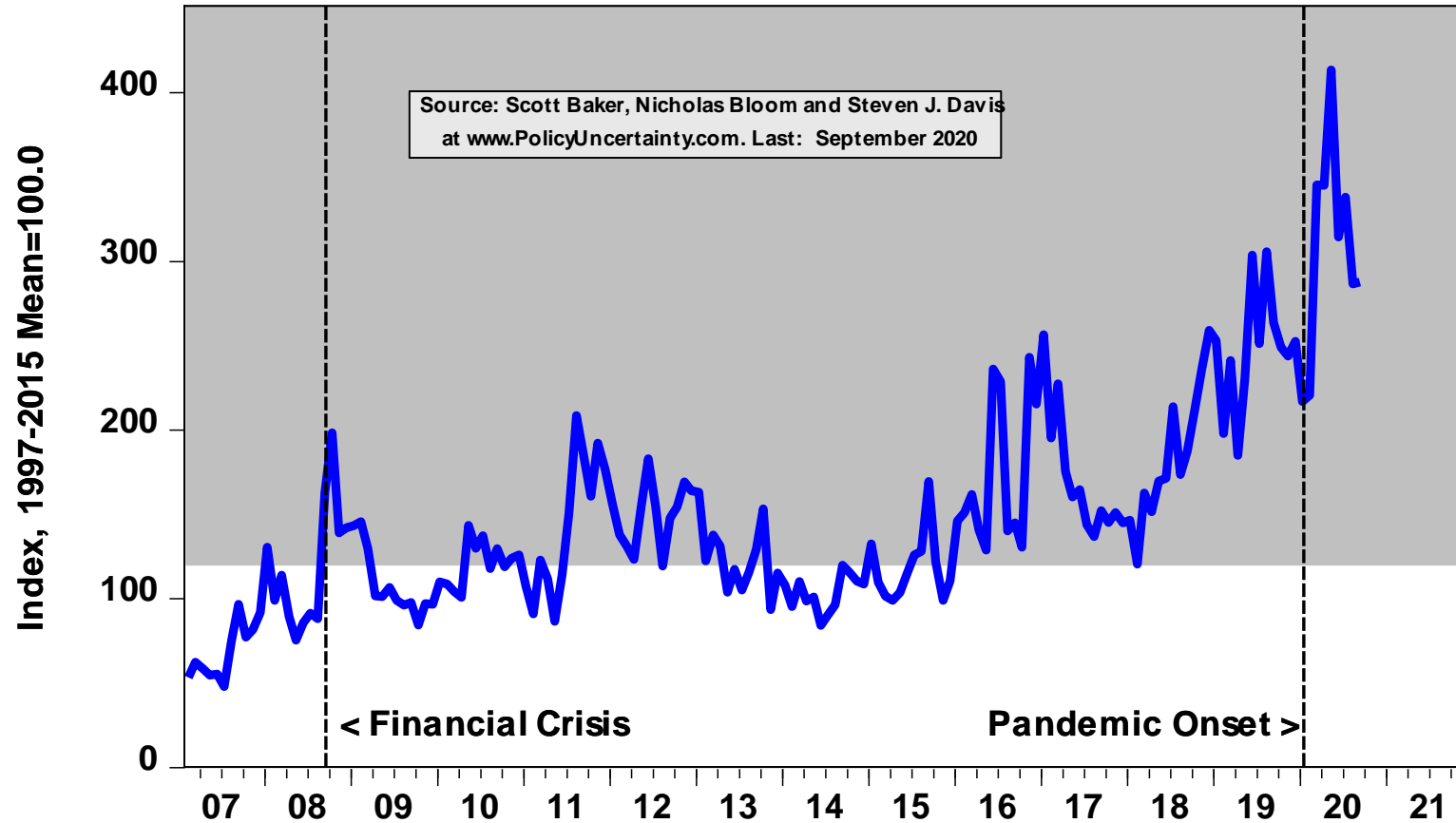


Pandemic Control Actions Produce Uncertainty at a High Level

Actions:	Timing	Effectiveness	Economic Impact
Social Distance (Masks, personal hygiene precautions, remote work/education etc.)	Varies	Varies	Varies by country
Curtail Economic Activity to force social distancing	Varies	Varies	Severe
Develop Effective Treatment Protocol	Months since inception	Varies, improvement from first wave	Dependent on Effectiveness
Develop Vaccine	End 2020 at the earliest	Unknown	Dependent on Effectiveness

Responses to the Pandemic Disrupt Economic Policy

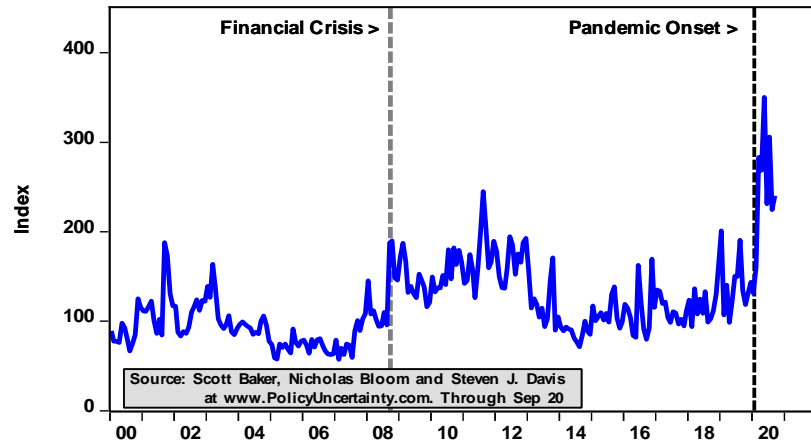
Global Economic Policy Uncertainty



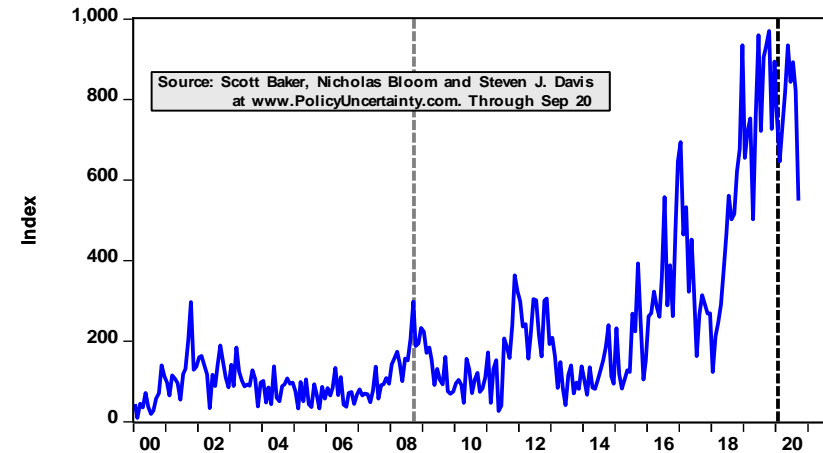
Responses to the Pandemic Disrupt Economic Policy

But usually less of an impact with second waves, i.e. US, Europe, Japan

Economic Policy Uncertainty: U.S.



Economic Policy Uncertainty: China



Economic Policy Uncertainty: Europe

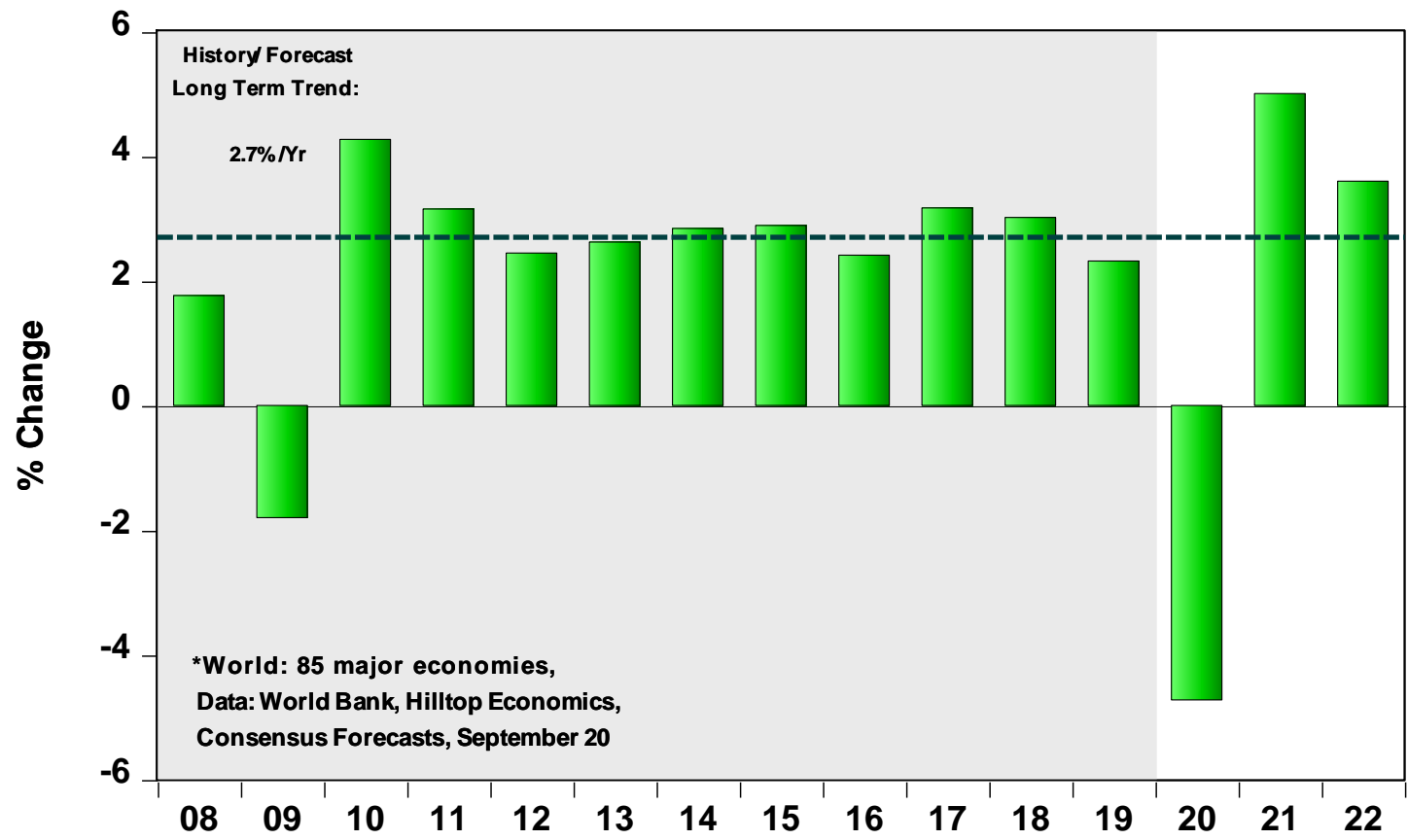


Economic Policy Uncertainty: Japan



The Consensus "V" Outlook for Final Demand

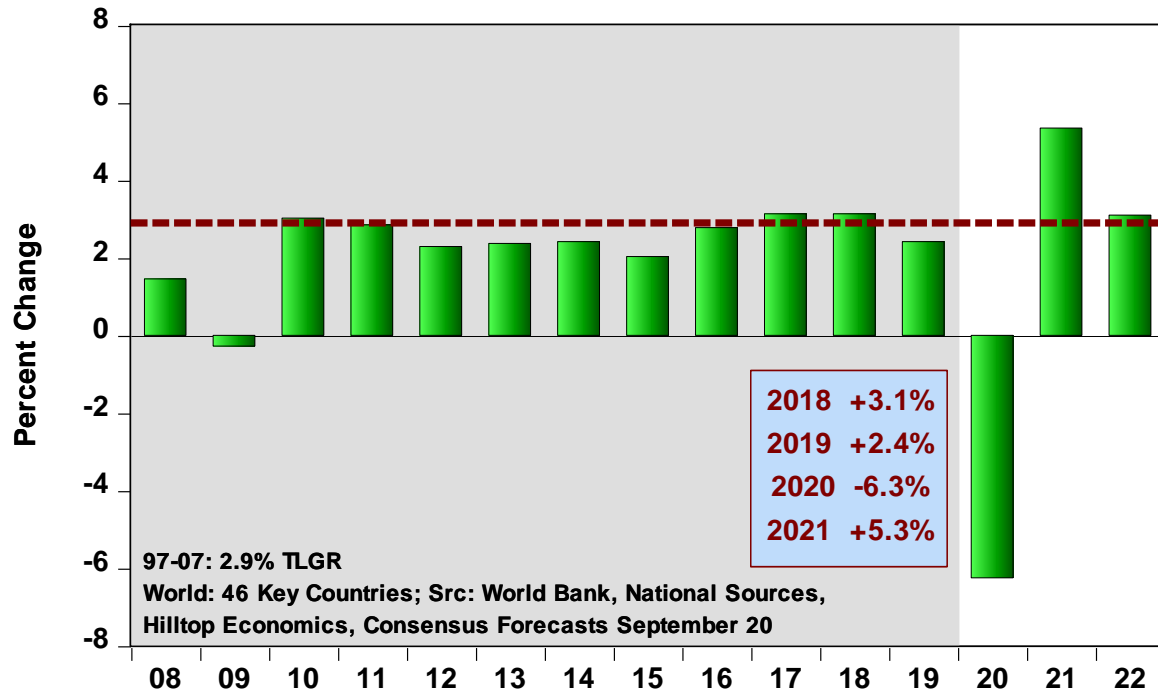
World* Real GDP Growth
2019: 2.3% 2020: -4.7% 2021: 5.0% 2022: 3.6%



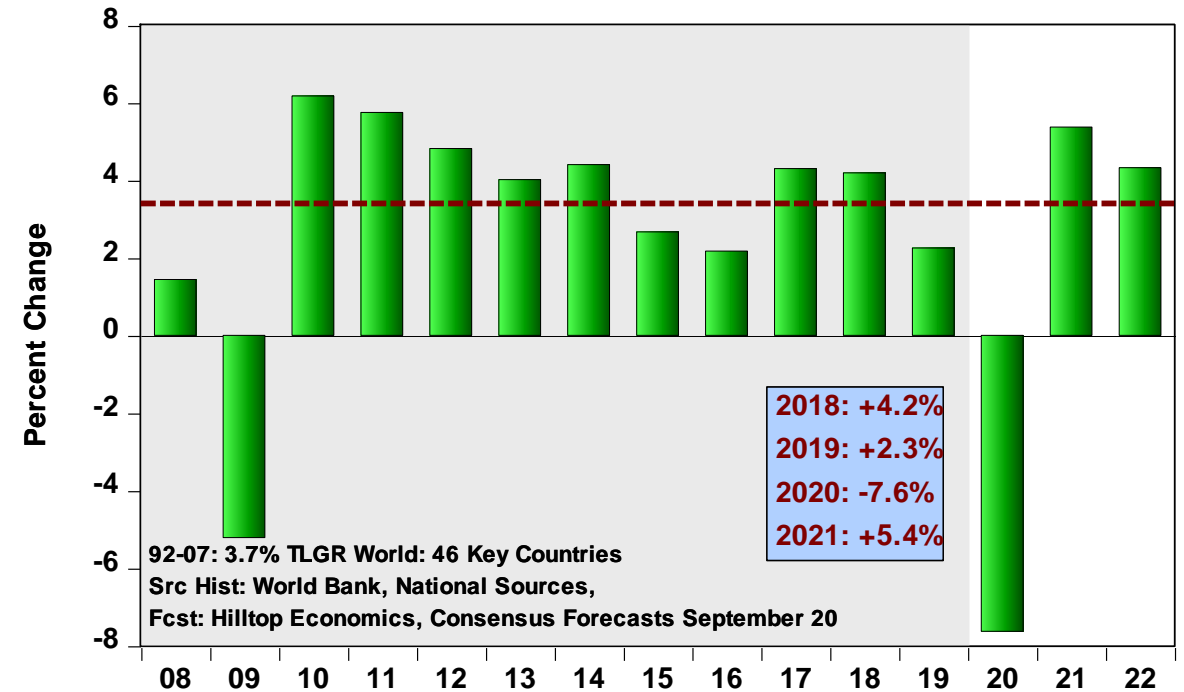
Unusually Wide Swing in Consumer Spending

Investment Cycle More Typical, But Much Weaker Recovery Expected

World* Real Consumption

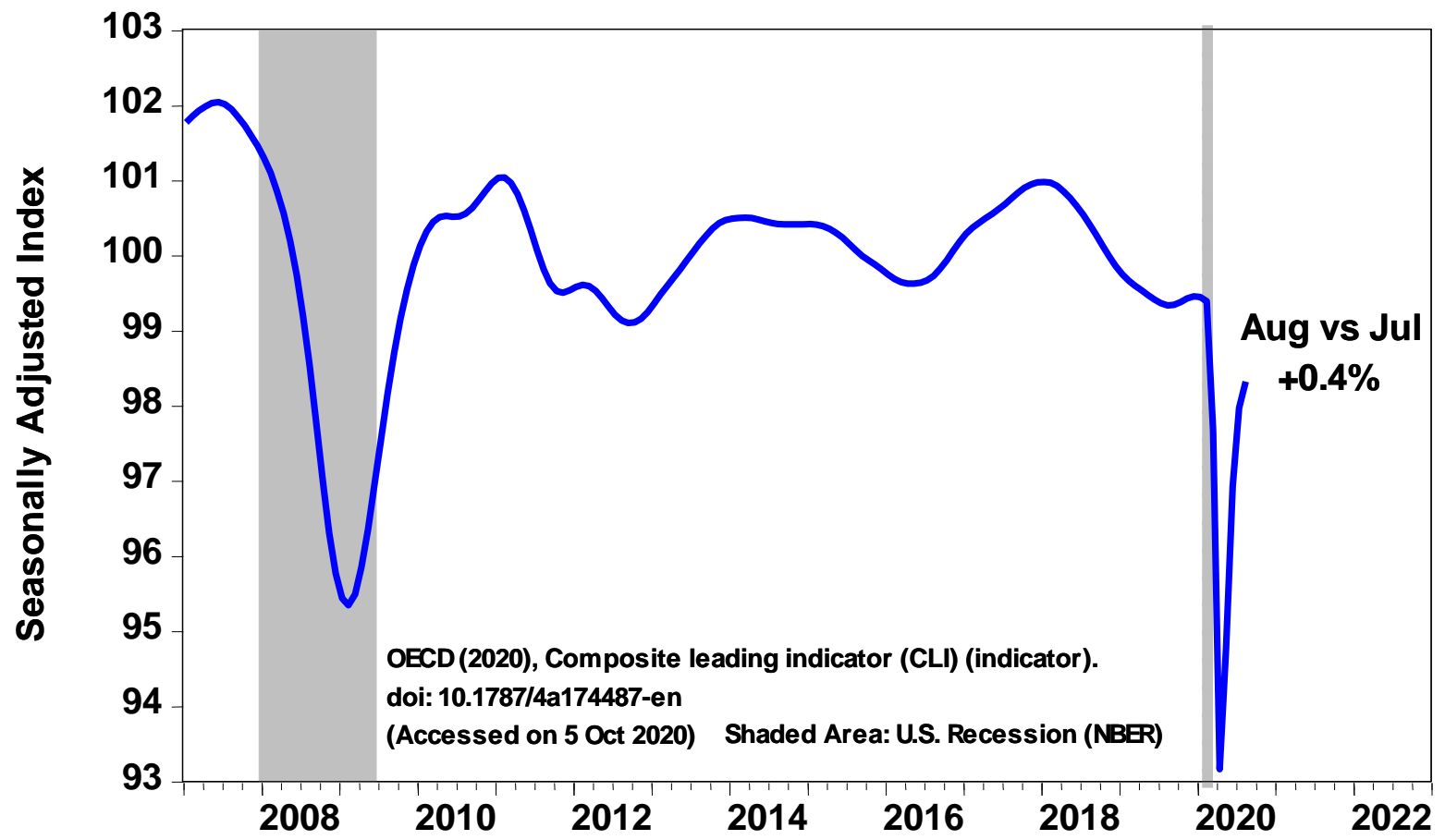


World* Real Investment



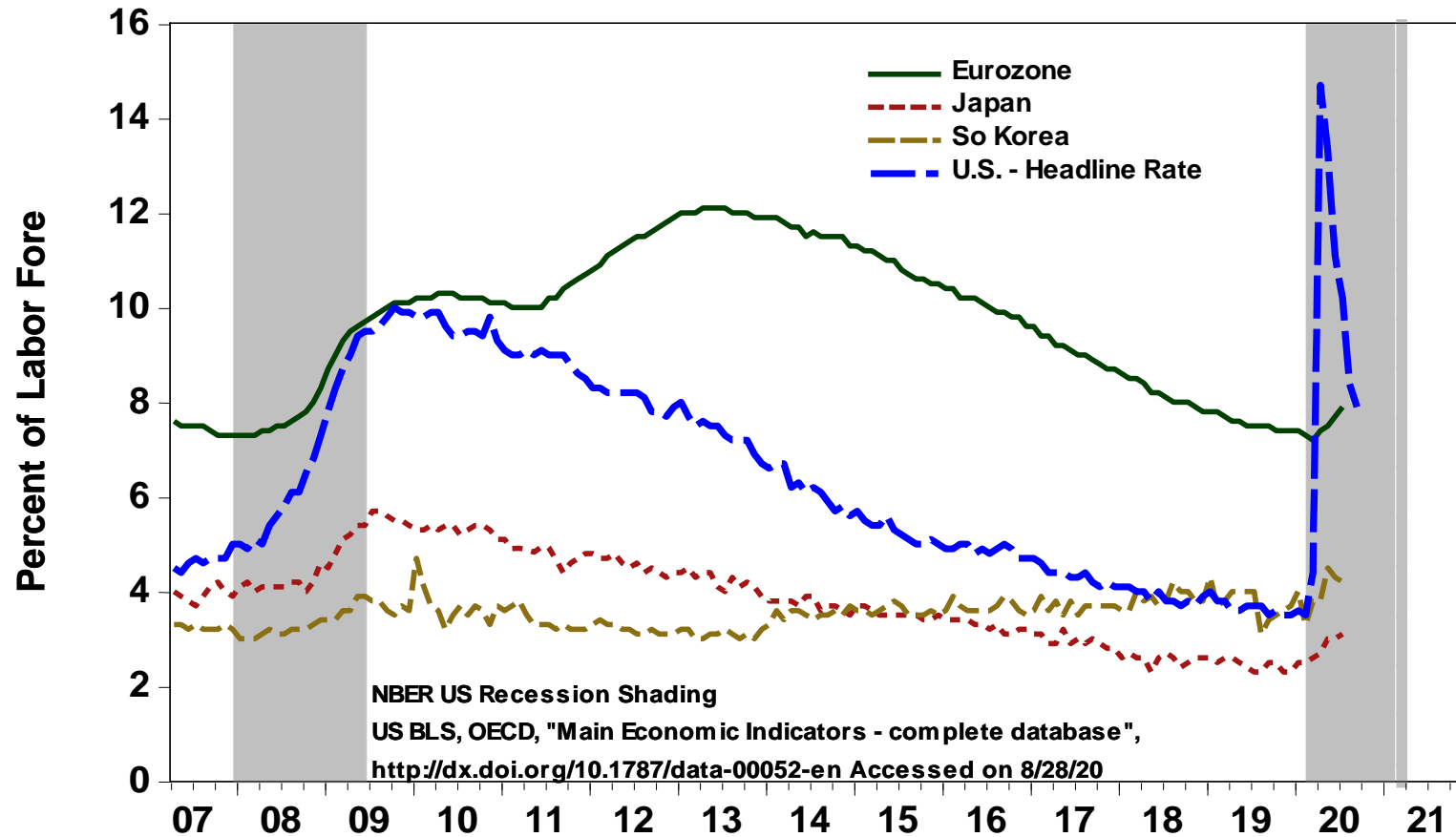
A Deep Recession, But LEI Rose in May through July

OECD Leading Economic Indicator



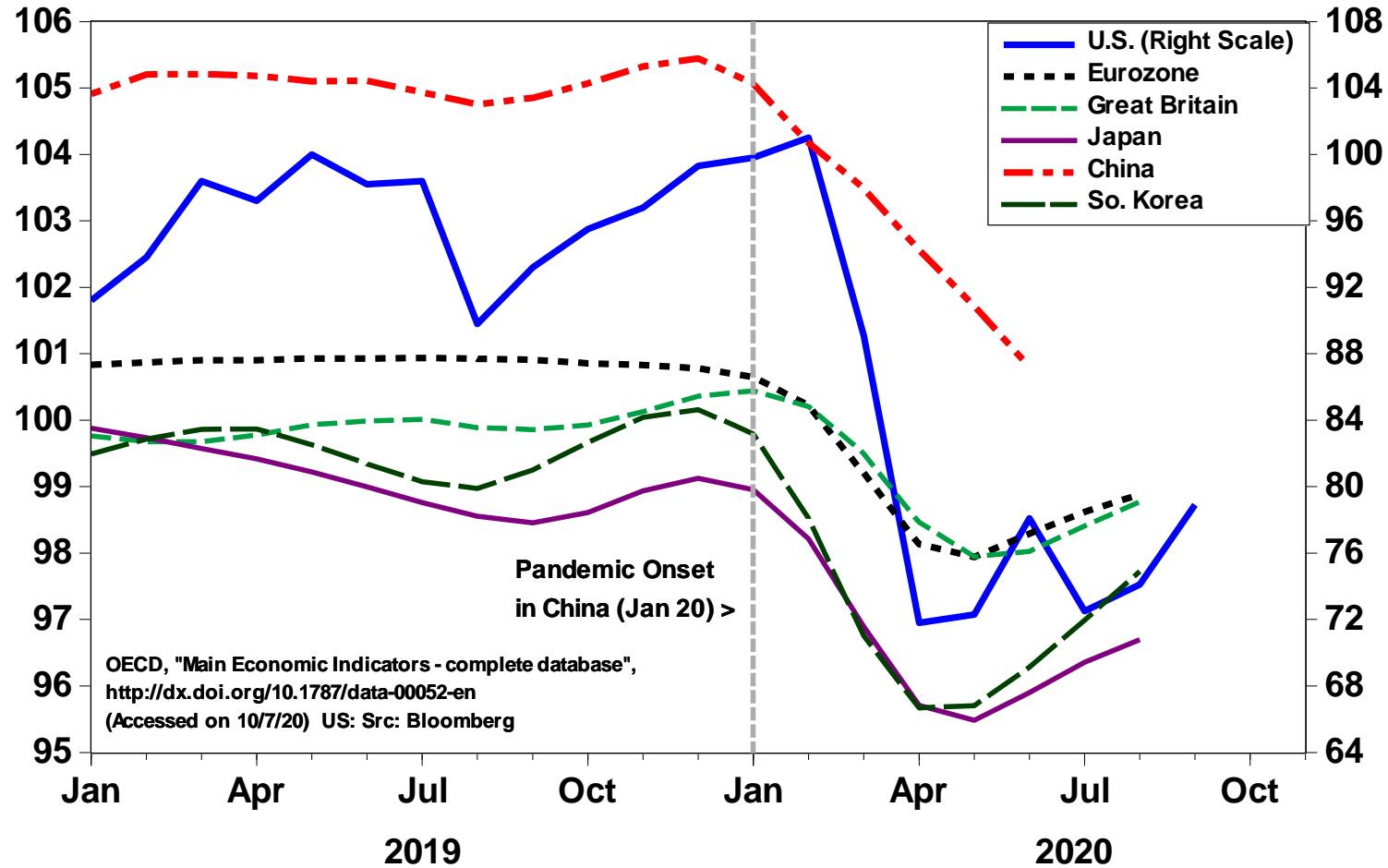
U.S. Unemployment Peaked in April, Rising Elsewhere - But Less of a Problem

Unemployment Rates (Harmonized)



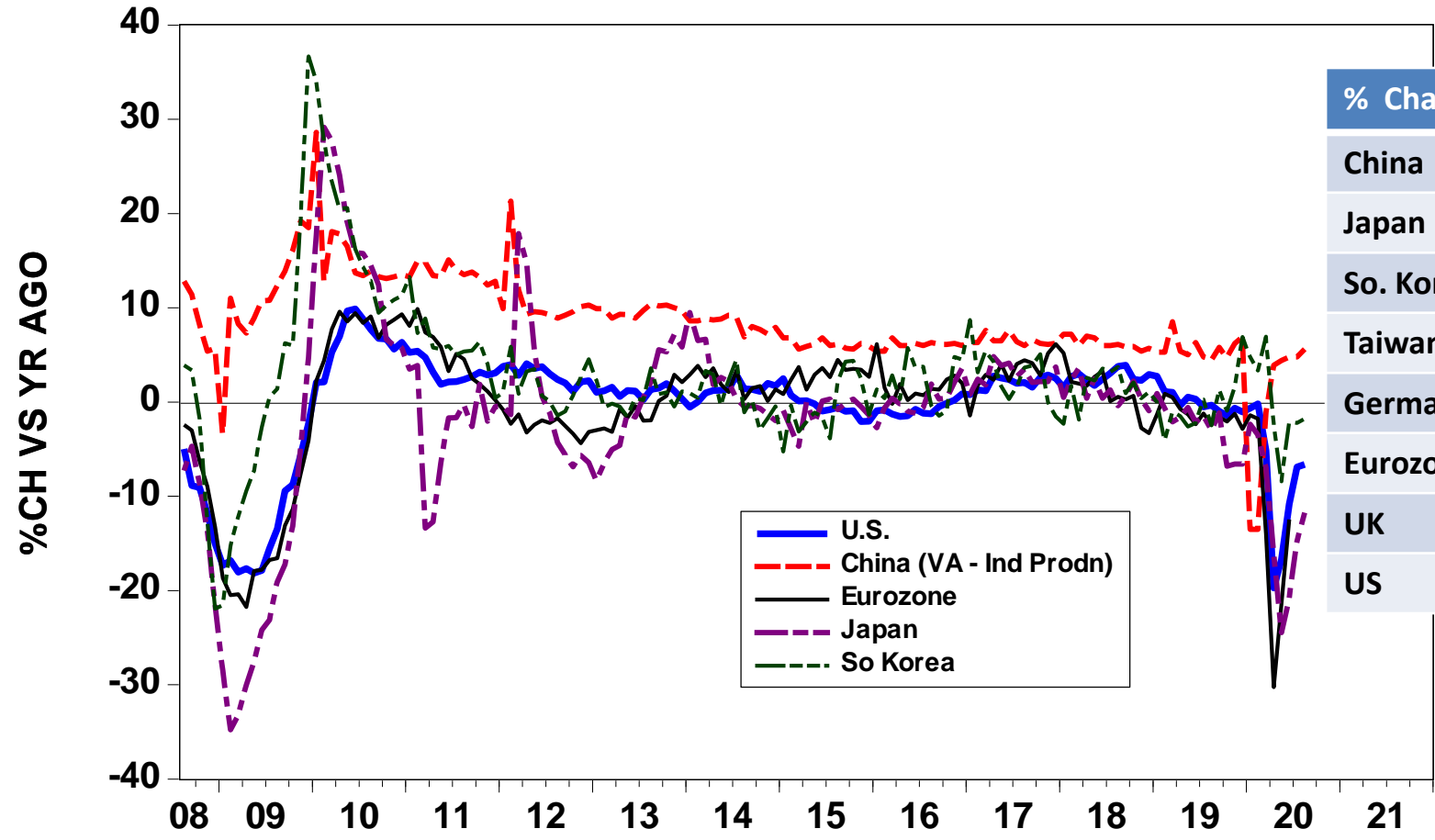
Weak Confidence, Improving Except in China

Consumer Confidence Indexes



Output Growth Is Still Negative In Many Key Economies

Global Industrial Production Manufacturing Momentum

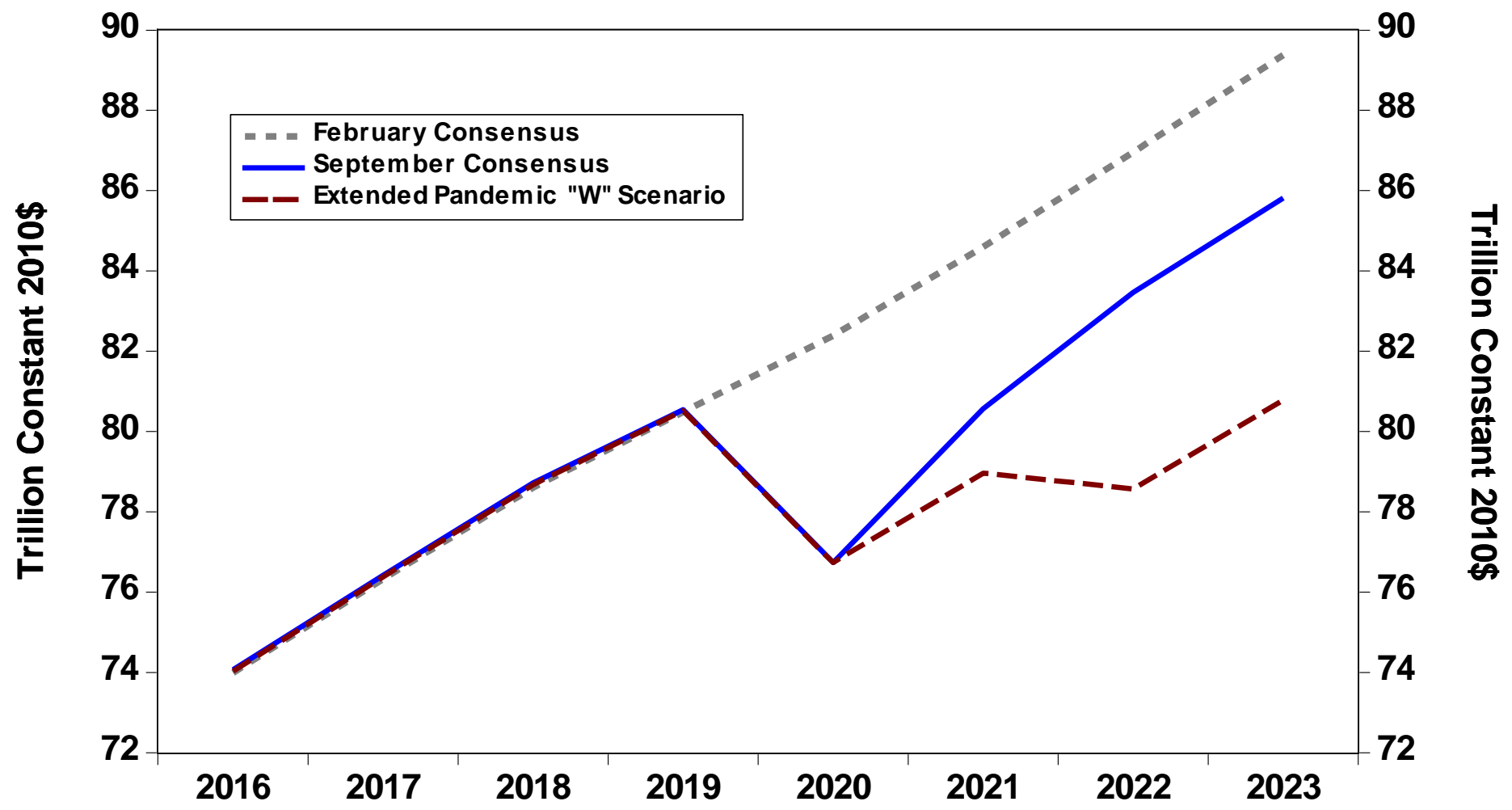


% Change	2019	2020	2021
China	6.1	2.3	7.4
Japan	(2.7)	(11.5)	4.9
So. Korea	(0.1)	(0.9)	3.4
Taiwan	(0.4)	4.3	5.1
Germany	(3.2)	(9.2)	7.3
Eurozone	(1.3)	(10.0)	7.2
UK	(1.7)	(11.1)	7.0
US	0.9	(8.1)	4.5

Economic Scenario Overviews

- **September Consensus Forecast: a “V”-shaped global recession**
 - Severe Covid-19 impact, but successfully managed
 - V-shaped global recession extremely disruptive in the short run but economies rebound in 2021
- **Extended Pandemic – A “W” shaped global recession**
 - Severe Covid-19 impact, followed by waves of infection that continue to disrupt spending pattern. Eventually produces permanent structural changes in the global economy.
 - Fiscal and monetary responses are ineffective or counter-productive, and leave economies too weakened to recover quickly.
 - Real GDP bounces up and down until the world learns to live with the Covid-19 virus.

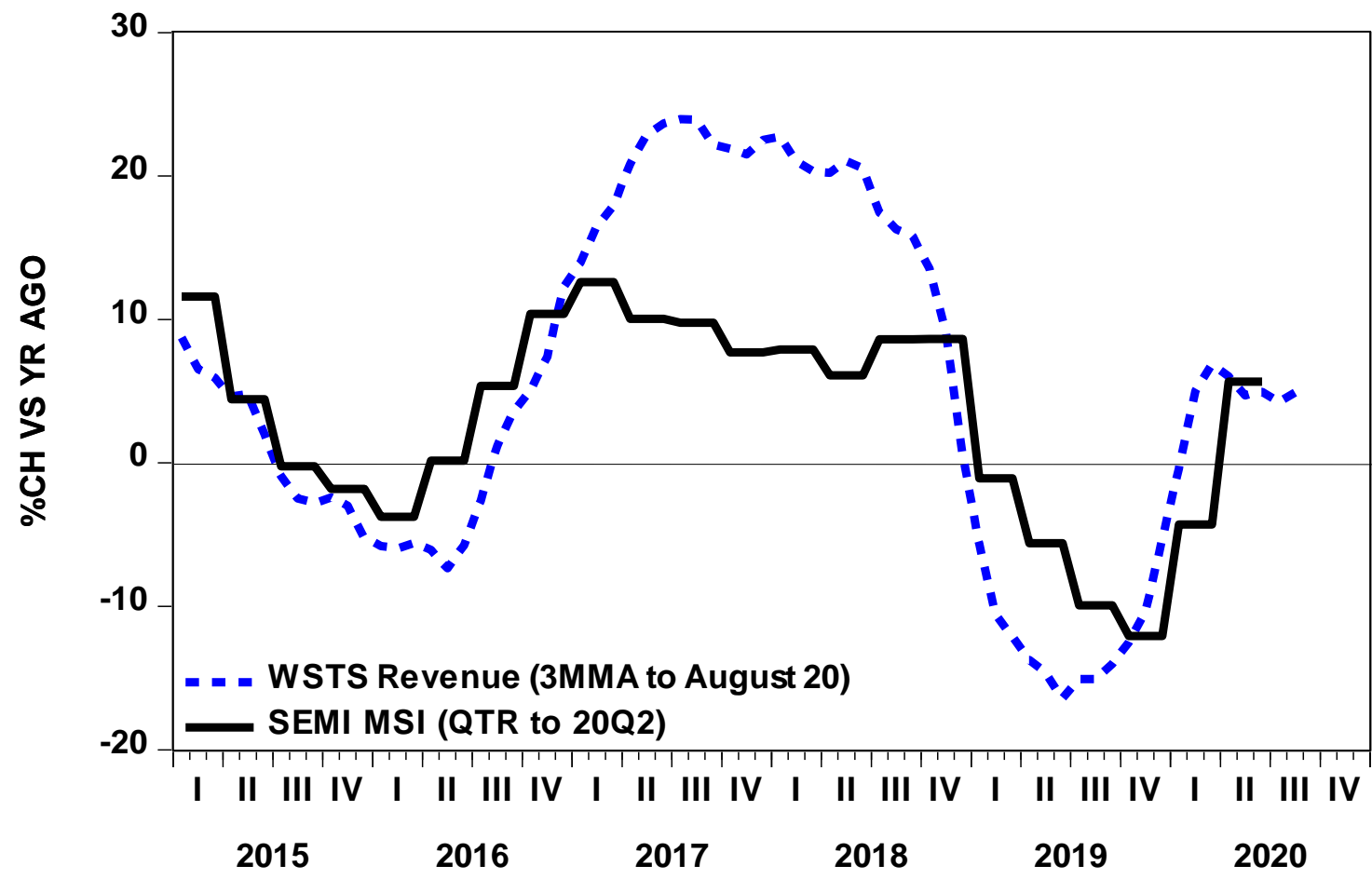
Scenario Real GDP Levels



Semiconductors Growing Since Pandemic Began

(MSI +5.7% in Q2, WSTS Revenue +4.9% through August, 3MMA)

Semiconductor Revenue & MSI Volume Momentum



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Semiconductor Production & Sales (WSTS)

Strong year-over-year growth carrying through to August except in Japan and Europe

Monthly Performance Semiconductors	AVE %CHYA	Percent Change VS Year Ago												
		Prior 5 Yrs	2019M08	2019M09	2019M10	2019M11	2019M12	2020M01	2020M02	2020M03	2020M04	2020M05	2020M06	2020M07
Industrial Production/Volume except WSTS (Revenue)														
WSTS Revenue	6.6%	(14.5%)	(13.8%)	(8.9%)	(7.8%)	1.2%	7.1%	7.4%	6.2%	4.5%	3.4%	6.9%	2.3%	5.5%
WSTS Revenue Americas	7.7%	(27.2%)	(32.3%)	(16.5%)	(13.0%)	0.3%	21.1%	26.8%	18.1%	29.5%	27.5%	30.9%	20.9%	19.3%
WSTS Revenue Asia-Pacific	7.9%	(11.8%)	(7.8%)	(6.5%)	(5.6%)	3.9%	5.0%	4.4%	4.3%	3.0%	1.2%	3.6%	(0.4%)	4.4%
WSTS Revenue China (3MMA)	N/A	(15.4%)	(13.0%)	(10.3%)	(5.8%)	0.5%	5.1%	7.8%	4.5%	4.5%	3.7%	4.3%	1.9%	3.0%
WSTS Revenue A-P Exc China (3MMA)	N/A	(8.4%)	(6.3%)	(6.7%)	(7.8%)	(7.1%)	(4.3%)	0.5%	4.6%	3.3%	1.8%	0.3%	0.9%	2.1%
WSTS Revenue Japan	1.5%	(8.4%)	(5.9%)	(8.4%)	(10.1%)	(5.1%)	0.1%	1.4%	1.9%	(4.4%)	(0.2%)	(3.0%)	1.4%	(2.8%)
WSTS Revenue Europe	3.0%	(6.5%)	(9.1%)	(5.6%)	(8.5%)	(8.2%)	(0.2%)	(2.6%)	(0.6%)	(20.6%)	(22.3%)	(8.9%)	(14.1%)	(7.0%)
U.S. IP (SA)Semiconductor and other electronic component	5.9%	1.8%	2.7%	5.1%	9.3%	11.0%	9.6%	6.9%	8.2%	5.4%	5.4%	6.8%	8.2%	6.7%
China Integrated Circuits Output (100 million units)	14.0%	22.9%	25.9%	38.0%	21.6%	40.0%	29.1%	29.1%	53.3%	55.6%	30.1%	41.7%	28.8%	23.2%
Korea IP (SA) Mfg of Semiconductor	16.7%	13.1%	9.8%	11.9%	32.6%	35.7%	40.7%	46.0%	45.8%	16.3%	26.9%	23.8%	16.7%	19.5%
Taiwan IP 26: Electronic Parts and Components	4.8%	10.3%	3.4%	(1.5%)	8.7%	10.6%	17.7%	32.3%	27.5%	22.9%	23.0%	23.4%	14.8%	17.9%
Taiwan IP 2611: Integrated Circuits	10.6%	21.8%	5.9%	(2.2%)	13.1%	11.2%	30.5%	46.6%	42.5%	33.0%	37.2%	34.3%	22.2%	
Taiwan Foundry wafer (12 inch & above) (1,000 Pcs)	9.1%	10.2%	(1.6%)	(10.4%)	3.1%	14.7%	25.0%	30.5%	31.3%	30.2%	24.5%	29.8%	18.0%	
Taiwan Foundry wafer (8 inch) (1,000 Pcs)	3.4%	(12.4%)	(7.7%)	(12.2%)	(3.9%)	(0.1%)	10.1%	18.2%	15.4%	18.7%	19.1%	19.9%	5.9%	
Taiwan Foundry wafer (6 inch and below) (1,000 Pcs)	2.5%	(19.2%)	(18.2%)	(21.4%)	(14.2%)	(5.0%)	7.4%	24.9%	27.3%	19.8%	14.2%	17.6%	9.3%	
Taiwan IP 2613: Packaging and Testing of Semi-conductors	2.4%	11.3%	11.1%	8.7%	9.9%	16.8%	19.0%	27.1%	15.3%	12.8%	0.3%	3.5%	(0.4%)	
Taiwan DRAM (Dynamic random access memory) (1,000 Pcs)	5.0%	15.0%	22.7%	26.7%	34.3%	18.8%	16.2%	27.0%	14.2%	9.2%	6.9%	(6.7%)	(11.8%)	
Taiwan Flash disk (Set)	13.6%	32.6%	31.1%	7.3%	(22.0%)	10.9%	(15.3%)	13.7%	3.5%	(10.6%)	(34.0%)	(23.1%)	(16.8%)	
Japan IP All Integrated Circuits	5.5%	(17.7%)	(22.3%)	(20.2%)	(21.9%)	(18.0%)	2.7%	7.1%	0.6%	(5.3%)	(25.3%)	(1.7%)	(3.6%)	4.8%
Japan IP Linear ICs 13.6	3.1%	(6.8%)	(8.0%)	0.9%	3.5%	8.4%	5.6%	15.4%	15.1%	6.1%	0.2%	(3.2%)	(13.4%)	(20.4%)
Japan IP MOS ICs (Micro computer) 13.5	(3.1%)	2.2%	6.0%	5.2%	11.7%	0.3%	(1.6%)	(2.2%)	(1.8%)	(6.4%)	(3.2%)			
Japan IP MOS ICs (Logic) 23.1	(12.0%)	(11.4%)	0.5%	(11.8%)	(9.2%)	(8.3%)	(13.5%)	(7.1%)	2.0%	(8.0%)	(7.8%)	(11.6%)	(8.9%)	(10.2%)
Japan IP MOS ICs (Memory) 84.7	12.3%	(43.3%)	(52.8%)	(43.9%)	(49.7%)	(46.0%)	0.5%	7.5%	(1.7%)	(4.2%)	(37.4%)	25.6%	27.9%	65.1%
Japan IP MOS ICs (CCD) 32.7	18.0%	21.0%	16.2%	13.8%	26.8%	35.6%	12.7%	17.2%	(1.4%)	(5.5%)	(1.9%)			
Japan IP Hybrid ICs 43.5	1.5%	(7.2%)	(3.3%)	(10.0%)	(6.3%)	(2.6%)	3.6%	3.6%	1.6%	(12.1%)	(36.2%)	(24.9%)	(15.8%)	(2.5%)
SGP IP Semiconductors (3344)	15.6%	(28.0%)	(13.7%)	7.4%	(21.2%)	2.7%	0.6%	(24.8%)	11.1%	3.4%	6.4%	22.5%	1.2%	56.9%
Number of Rising Indicators		12	12	12	13	19	22	25	25	20	20	19	17	13
Number of Falling Indicators		17	17	17	16	10	7	4	4	9	9	8	10	5
Net (Rising minus Falling)		(5)	(5)	(5)	(3)	9	15	21	21	11	11	11	7	8

Sources: SIA & National statistics databases for China, US, Japan, Taiwan, South Korea, Singapore

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Despite Growth, Still A Lot of Uncertainty Even in 2020 Revenue Forecasts

Semiconductor Revenue Forecasts		Actual July Year-to-Date, +5.7%
Forecaster:	When	2020 % Change
VLSI	September	6.6
Cowan LRA **	August	5.2
ARIMA (Hilltop Econ X-13)**	September	3.6
WSTS	June	3.3
Semico	August	3.3
IC Insights	June	3.0
Omdia	May	2.5
Semiconductor Intelligence	August	1.0
LEI-demand model (Hilltop Econ "V" economy)	September	-1.7
McKinsey (Scenario A1 & A3 midpoints)	June	-3.0
IDC	May	-4.2
Gartner	July	-9.6
IBS	July	-10.4
Consensus Revenue Forecast	September	-0.2%
Standard Deviation		+/- 4.9%

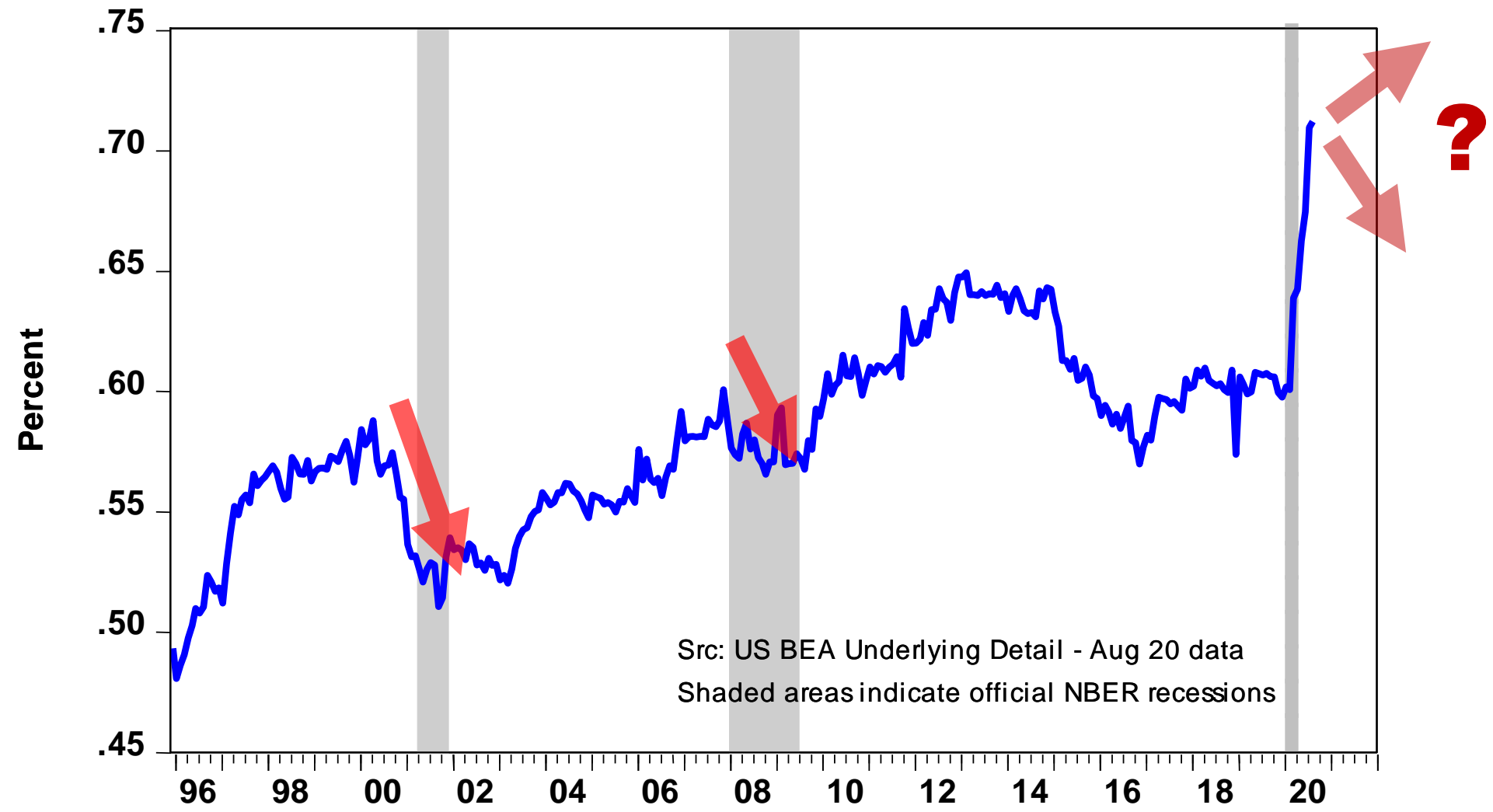
** Time series or trend-only methods
Sources: public news releases or presentations

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Big Change in Spending Behavior in the Pandemic Recession

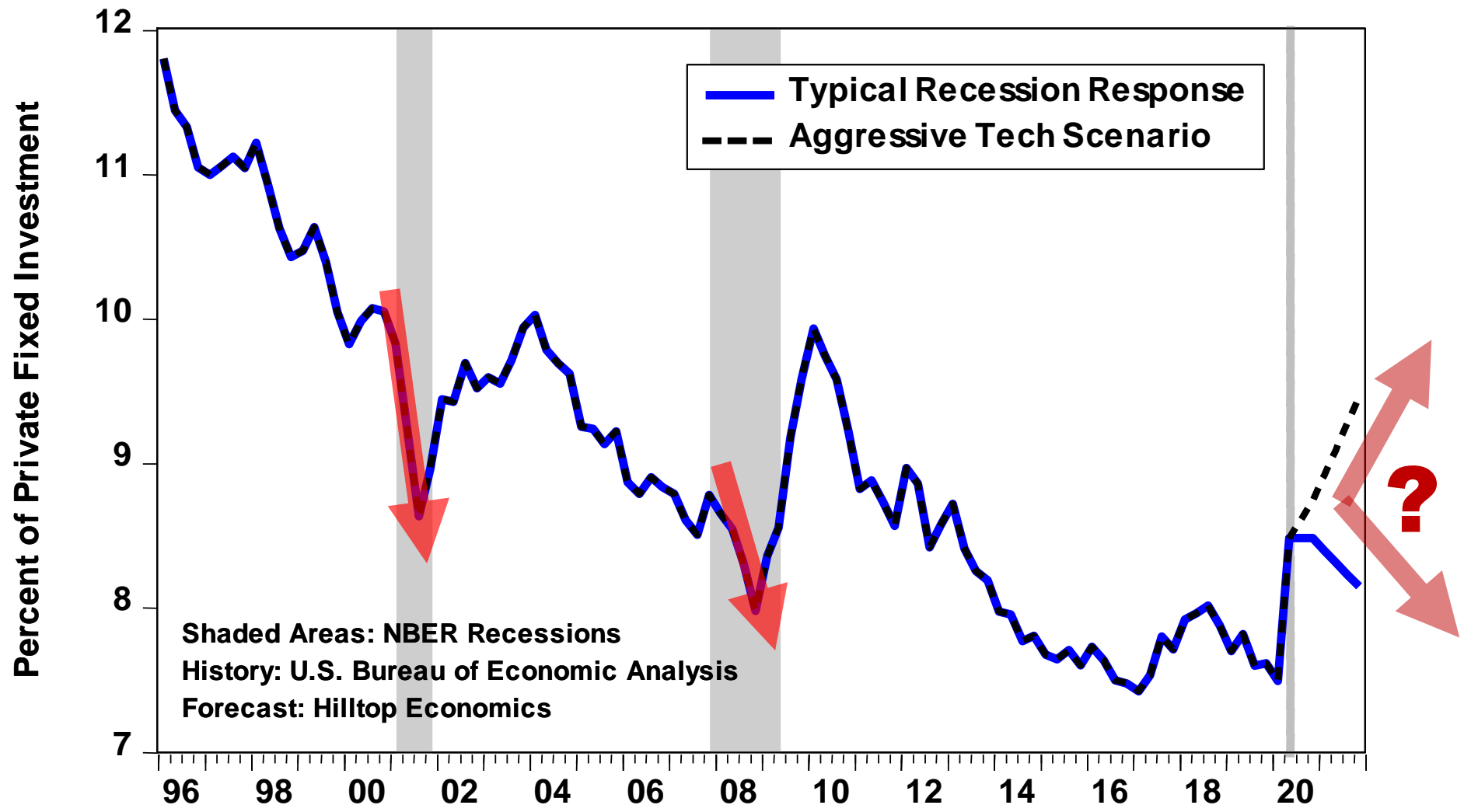
- Normal Behavior in Past Recessions:
 - Consumers cut spending on discretionary items – including technology goods
 - Businesses delay investment in new PCs, equipment, etc. to conserve cash and wait for capacity utilization to recover
- Pandemic Recession Observed Behavior:
 - Lock-downs, work-from-home, remote education all contributed to a spike in spending, especially where incomes have been supported by government assistance programs
 - Severe declines in Real GDP come from declines in services (travel & leisure, discretionary activities including elective medical, personal services, any activity requiring people to associate in close contact)

Share of Consumer Spending Spent On Technology Goods



Src: US BEA Underlying Detail - Aug 20 data
Shaded areas indicate official NBER recessions

Technology Equipment Investment



Shaded Areas: NBER Recessions
History: U.S. Bureau of Economic Analysis
Forecast: Hilltop Economics

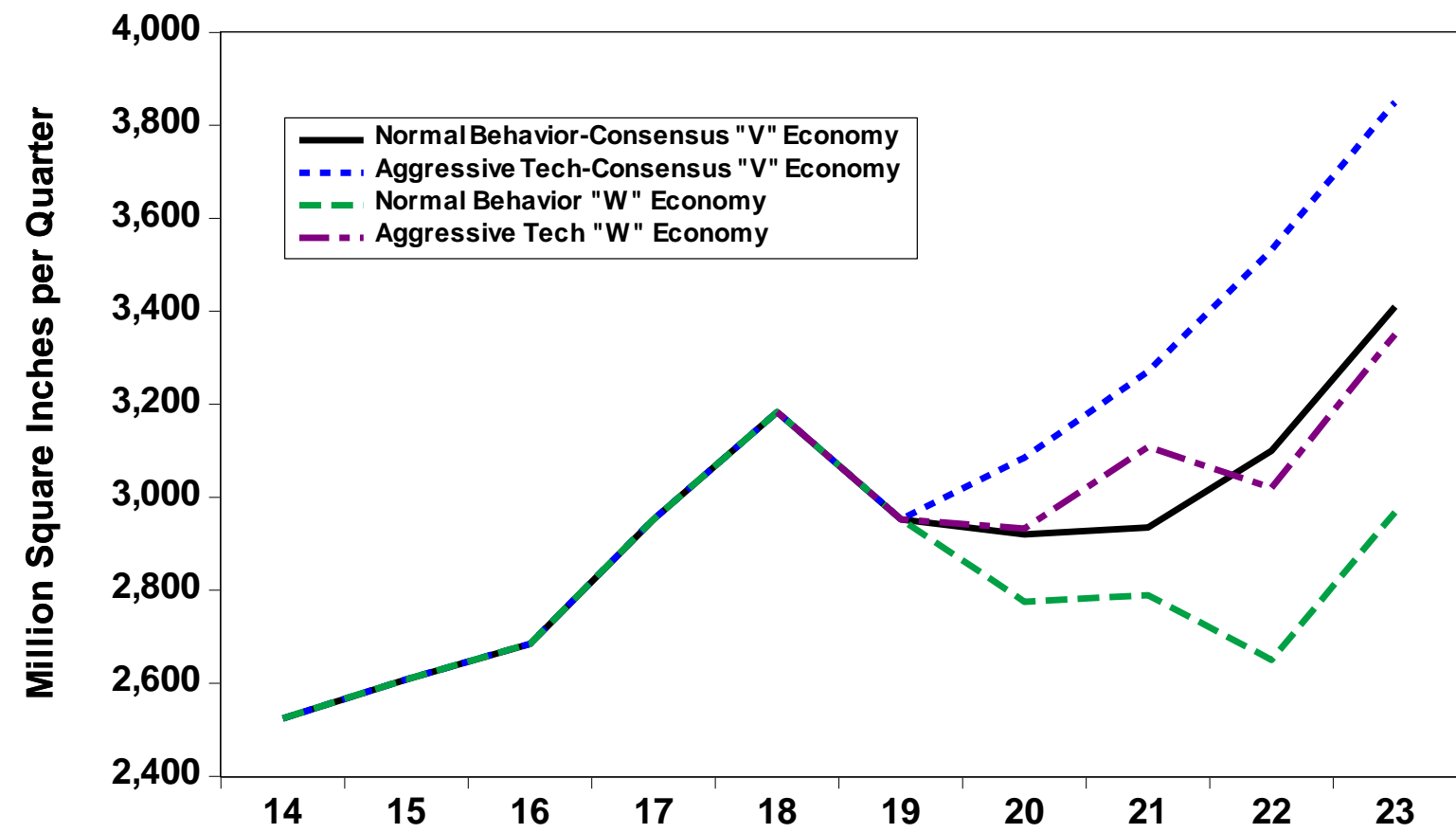
Scenario Overviews

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 - Severe Covid-19 impact, but successfully managed
 - V-shaped global recession extremely disruptive in the short run but economies rebound through 2021
- **Extended Pandemic – A “W” shaped global recession**
 - Severe Covid-19 impact, followed by waves of infection that continue to disrupt spending patterns. Permanent structural changes in the global economy.
 - Fiscal and monetary responses are ineffective, and leave economies too weakened to recover quickly.
- **Aggressive Technology Spending by Businesses & Consumers**
 - Tech-related investment prioritized over other investment categories into recovery.
 - Consumers shift to tech products and tech-based services accelerates into recovery period. 5G rapid penetration helps drive growth.
- **Normal Recession Behavior Prevails after initial shock**
 - Tech-related purchases react in modified traditional way: initial boost, then slides as spending patterns back to “normal” in recession.
 - Consumers react to opening economies by sharply increasing leisure, travel, etc. while cutting demand for goods. Tech good spending slides as replacement demand unneeded.

Scenarios Give Wide Range of Semiconductor MSI Outcomes

Behavioral Assumptions at least as important as the underlying demand situation

Demand-Driven Forecasts

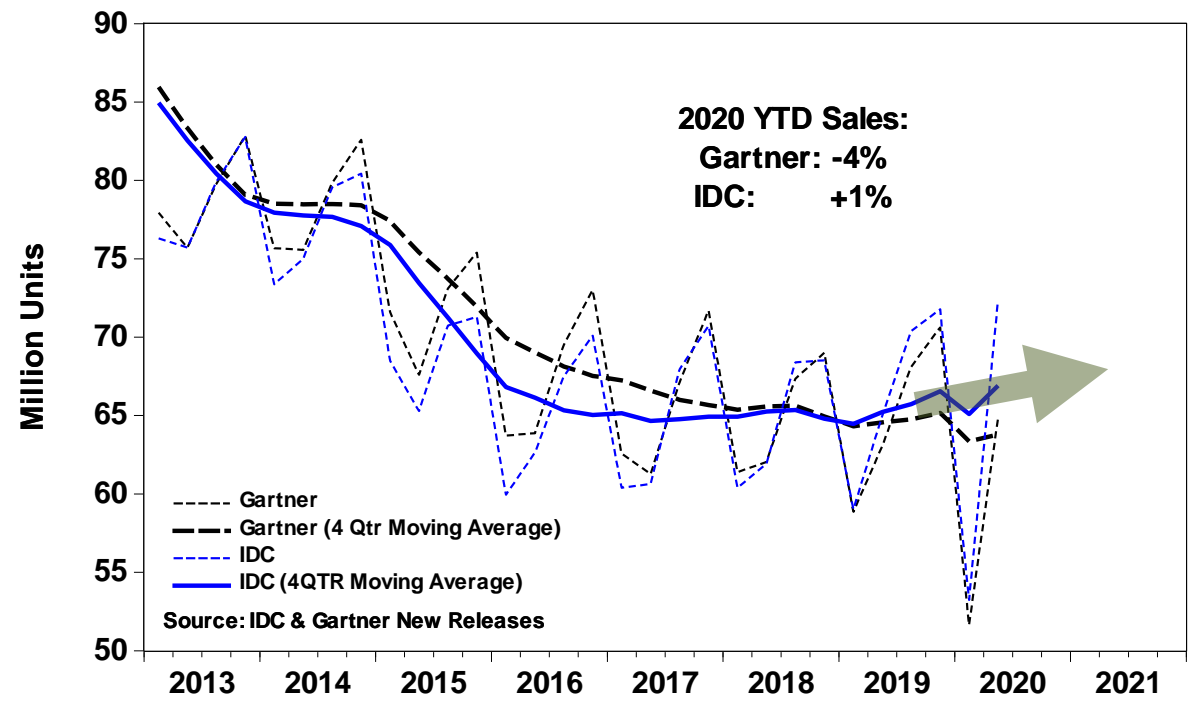




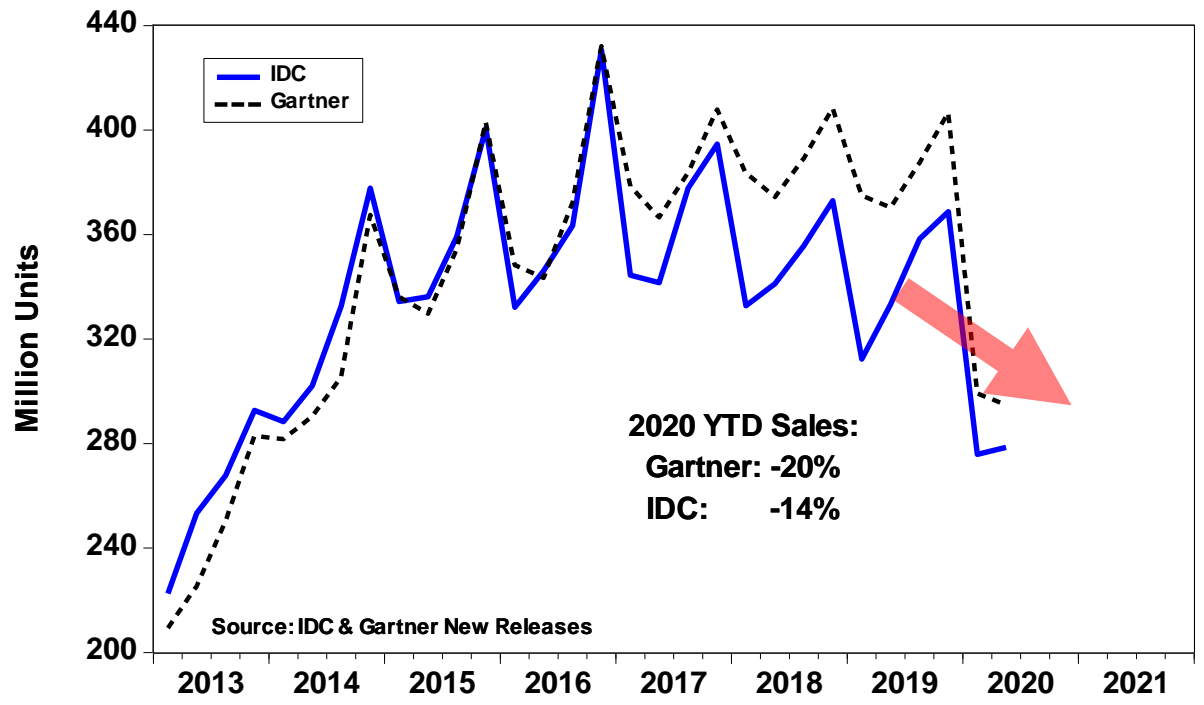
Tracking Downstream Technology Data To Determine Which Scenario Might Hold

PCs Support Aggressive Tech, Smartphones Less So

PC Sales

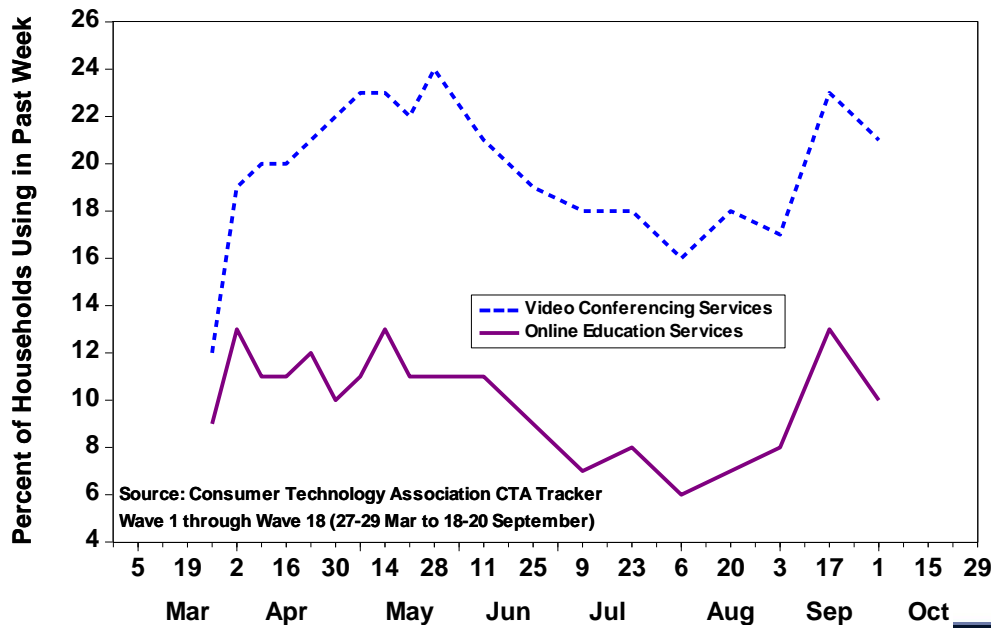


Smartphones



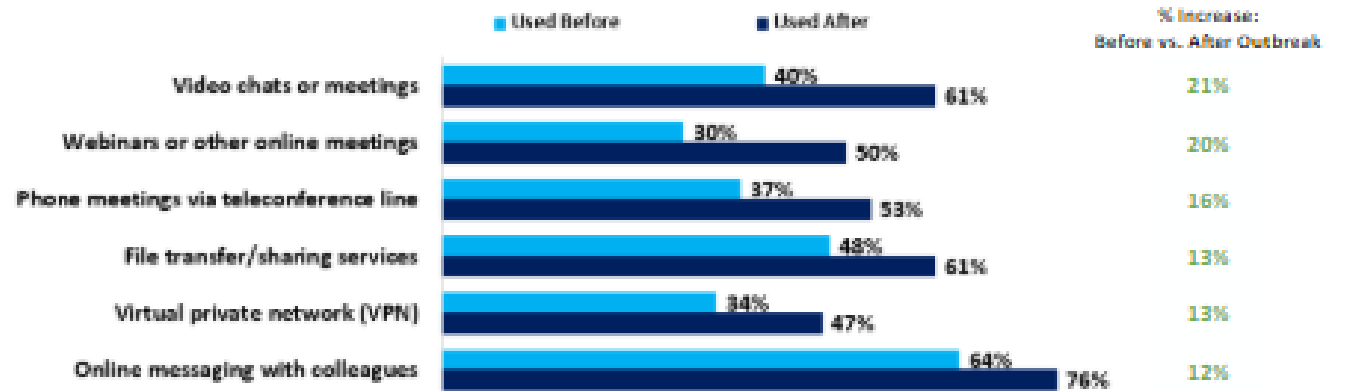
Some Optimism for Aggressive Tech Scenarios

Selected Services Used By CONSUMERS



Staying Connected At Work

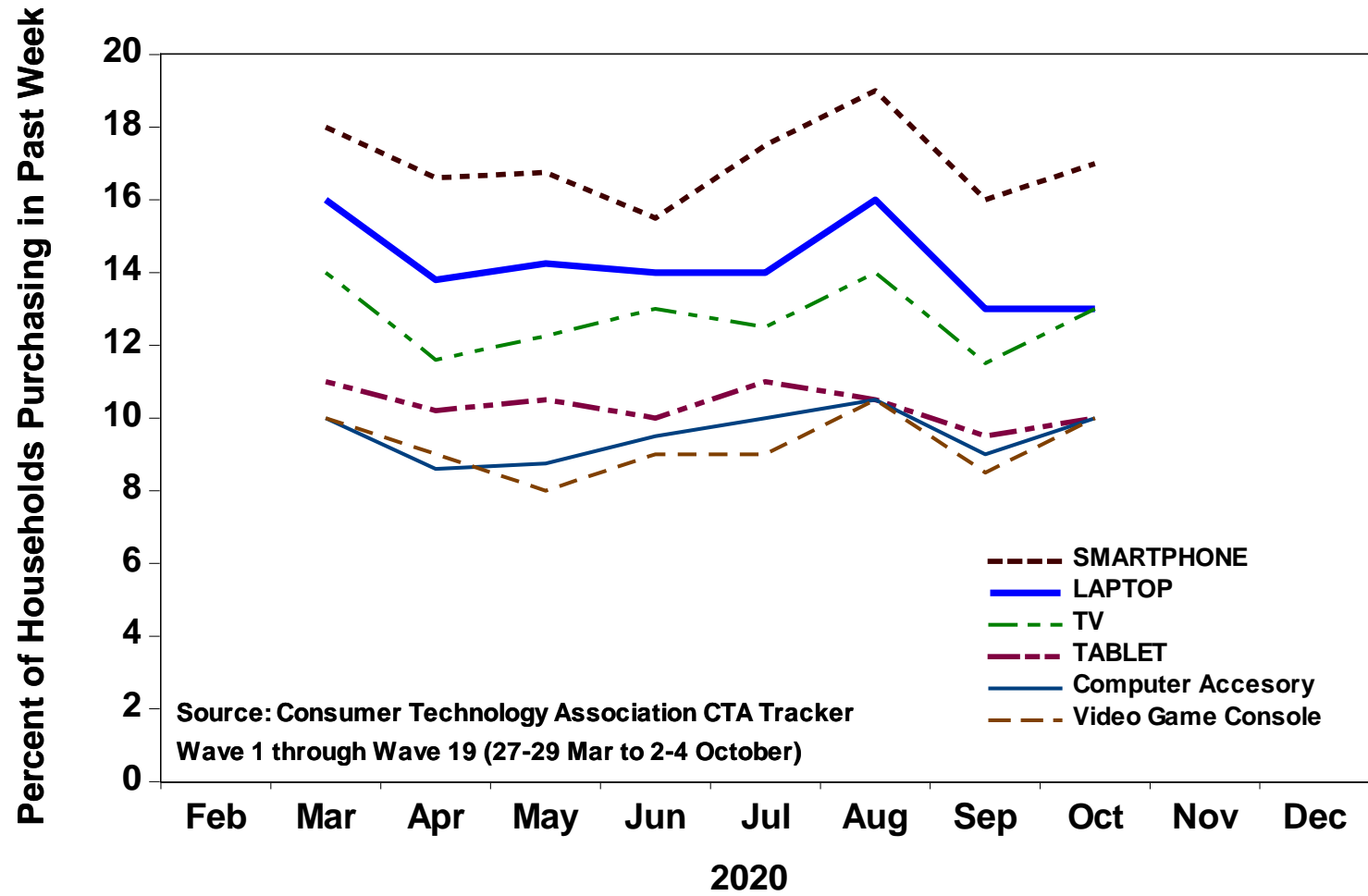
Services Used "Once a Week or More Often" Before and After the Coronavirus Outbreak (Ranked by Largest to Smallest % Increase in Use)



Source: CTA, COVID-19 Impact: Telework & the New Home Office, May 2020

U.S. Bi-Weekly CTA Tracker of Consumer Purchases

(No significant trends up or down, but perhaps a fall-off after August supporting “Normal Behavior”?)



Source: Consumer Technology Association CTA Tracker
Wave 1 through Wave 19 (27-29 Mar to 2-4 October)

Intermediate Demand: Products With Semiconductors

PRODUCTION of Computers strong ex-Japan, peripherals mixed, comm weak, most others in decline

Monthly Performance Products Industrial Production (Volume index) or units	AVE %CHYA Prior 5 Yrs	Percent Change VS Year Ago													
		2019M08	2019M09	2019M10	2019M11	2019M12	2020M01	2020M02	2020M03	2020M04	2020M05	2020M06	2020M07	2020M08	
Computers:	n Units (PCs)														
China All Computer Output (Million)	358.0	(6.6%)	7.2%	7.2%	4.0%	12.0%	(31.4%)	(31.4%)	3.5%	25.8%	28.4%	4.4%	20.0%	15.3%	
Taiwan IP Mfg: Computers	27.7%	108.6%	84.0%	45.0%	87.0%	40.7%	9.7%	10.2%	25.3%	24.4%	56.0%	77.6%	45.7%		
Taiwan Portable computer (#)	3.8	105.0%	119.8%	118.1%	284.2%	262.1%	15.2%	22.8%	26.9%	91.6%	261.0%	273.6%	102.2%		
Taiwan Industrial computer (#)	3.5	(7.0%)	(1.6%)	6.1%	(0.2%)	27.2%	(8.1%)	29.6%	6.7%	(7.2%)	(6.4%)	17.8%	11.2%		
Taiwan Server (#)	3.1	74.2%	84.6%	102.1%	70.5%	36.0%	22.3%	63.6%	73.7%	79.5%	59.0%	115.4%	38.7%		
Japan IP 6204 Computer Production	(2.8%)	60.5%	72.2%	54.4%	38.8%	42.3%	51.2%	20.1%	(7.9%)	19.4%	(14.3%)	(20.1%)	(18.2%)	(32.8%)	
Japan Notebook Units	5.1	77.7%	114.5%	60.8%	42.1%	37.8%	25.3%	2.9%	(8.9%)	16.0%	6.5%	(14.6%)	(30.0%)		
Japan Desktop Units	3.0	72.6%	126.5%	67.9%	78.9%	75.9%	102.6%	51.4%	2.8%	21.8%	(48.3%)	(55.1%)	(50.6%)		
Japan PC Server Units	0.3	7.0%	27.0%	10.8%	3.9%	3.6%	2.9%	(32.6%)	(1.3%)	(42.3%)	(44.8%)	(21.3%)	(38.2%)		
U.S. IP (SA) Computers and peripheral equipment 3341	6.1%	(0.0%)	(0.5%)	(2.4%)	1.0%	1.0%	0.5%	0.6%	1.0%	0.9%	(2.5%)	0.9%	4.0%	4.8%	
Peripherals:															
Korea IP (SA) Mfg of Computers and Peripheral Equipment	(4.1%)	(25.2%)	1.5%	(16.0%)	(16.9%)	(10.8%)	(13.8%)	(15.3%)	(16.0%)	(0.8%)	(14.6%)	(4.6%)	(12.5%)	(3.9%)	
Taiwan IP Mfg: Other Computer Peripheral Equipment	9.8%	5.0%	(3.3%)	2.6%	6.0%	20.5%	(17.8%)	27.9%	12.9%	16.2%	20.1%	24.1%	14.3%		
Taiwan IP Mfg: Monitors and Terminals	3.9%	(18.8%)	10.1%	(15.2%)	(14.1%)	(13.8%)	(22.8%)	22.9%	(26.9%)	(21.6%)	(11.5%)	(2.3%)	5.1%		
SGP IP Computer Peripherals & Data Storage (33412)	(7.4%)	9.7%	4.6%	2.2%	(14.1%)	(2.8%)	1.3%	(30.2%)	(22.6%)	(28.7%)	(17.5%)	(38.8%)	(20.5%)	(17.7%)	
Mobile Phone/Communications:															
Korea IP (SA) Mfg of Telecommunication and Broadcasting Apparatuses	(12.7%)	20.9%	7.2%	10.5%	8.2%	(1.9%)	5.4%	0.9%	(1.9%)	(24.7%)	(26.6%)	(14.1%)	(11.7%)	(37.3%)	
China Mobile Phone Output (Million)	2.4%	(2.3%)	7.6%	4.2%	3.9%	4.1%	(41.3%)	(41.3%)	(18.8%)	(26.0%)	(24.5%)	(14.1%)	(12.9%)	(9.7%)	
Taiwan IP Mfg: Telephones and Cellular Phones	(35.3%)	(42.5%)	19.5%	(13.9%)	(29.6%)	(38.5%)	(30.9%)	33.1%	(31.0%)	27.1%	11.9%	(14.7%)	6.2%		
Taiwan IP Mfg: Other Communication Equipment	7.1%	59.2%	51.4%	29.7%	25.8%	30.7%	(1.4%)	29.3%	13.9%	8.1%	1.6%	19.4%	13.9%		
U.S. IP (SA) Communications equipment 3342	2.9%	9.7%	8.8%	8.7%	9.1%	6.6%	1.3%	(2.1%)	(2.9%)	(0.8%)	1.5%	0.4%	(0.1%)	0.8%	
Video/Audio Equipment:															
Korea IP (SA) Mfg of Electronic Video and Audio Equipment	(17.8%)	(9.3%)	(12.9%)	(12.6%)	(12.6%)	2.6%	(7.4%)	(15.5%)	(3.7%)	(11.3%)	(28.1%)	(5.8%)	(8.6%)	(2.9%)	
Taiwan IP Mfg: Audio and Video Equipment	3.7%	(0.8%)	0.2%	14.4%	16.0%	21.6%	(9.1%)	67.7%	(5.0%)	25.7%	(3.5%)	19.5%	41.7%		
U.S. IP (SA) Audio and video equipment 3343	4.5%	39.7%	45.1%	39.4%	26.3%	6.3%	7.0%	3.3%	(2.4%)	(8.2%)	(21.2%)	(12.9%)	(4.8%)	4.4%	
Navigation/Measuring/Electromedical/Etc.															
U.S. IP (SA) Navigational, measuring, electromedical, and control instrum	1.9%	3.9%	6.3%	5.4%	6.2%	4.9%	5.8%	8.6%	5.8%	(0.7%)	(2.0%)	3.3%	4.5%	6.0%	
Taiwan IP Mfg: Measuring, Navigating and Control Equipment	7.2%	29.9%	21.4%	(5.4%)	8.5%	3.3%	(11.7%)	16.4%	16.0%	3.0%	(4.3%)	(16.5%)	(6.5%)		
Taiwan IP Mfg: Irradiation and Electromedical Equipment	9.7%	19.4%	(17.6%)	34.9%	(11.2%)	21.7%	(22.6%)	9.5%	34.0%	37.3%	41.6%	71.8%	46.3%		
Consumer (Other and Miscellaneous):															
SGP IP Infocomms & Consumer Electronics	(3.9%)	3.0%	7.4%	(1.0%)	3.8%	(14.3%)	33.7%	(19.0%)	(12.4%)	(2.3%)	5.5%	0.5%	(16.9%)	(14.5%)	
Japan IP 6203 Consumer electronics 61.4	(1.7%)	(13.7%)	(9.7%)	(16.9%)	(20.4%)	(25.5%)	(16.2%)	(21.4%)	(30.7%)	(31.7%)	(37.8%)	(32.3%)	(22.5%)	(19.5%)	
Number of Rising Indicators		17	22	19	19	20	14	18	12	15	12	14	14	5	
Number of Falling Indicators		11	6	9	9	8	14	10	16	13	16	14	14	8	
Net (Rising minus Falling)		6	16	10	10	12	0	8	(4)	2	(4)	0	0	(3)	

Summary

- **Downstream: Real GDP and components in deepest recession since 1930s**
 - Outlook for recovery modest “V” per the Consensus
 - Pandemic causing monthly forecast revisions: the greater the pandemic impact, the sharper the revisions to the forecasts
 - Responses to the pandemic ultimately will drive the economics
- **Most technology goods markets growing or at least not in steep decline**
 - Initial surge from work-from-home; educate-from-home policies
 - Trade sanctions causing another disturbance to normal market function
- **Semiconductors**
 - So far, healthy recovery from 2019 downturn continues
 - Pandemic changed behavior relative to past recessions. Outlook depends in part on whether behavior reverts to “typical” in the months and quarters ahead.
 - Range of possible outcomes necessitates flexibility, scenarios and constant willingness to revise forecasts as new data become available