

A Disaster Economics Framework for Estimating the Consequences of COVID-19

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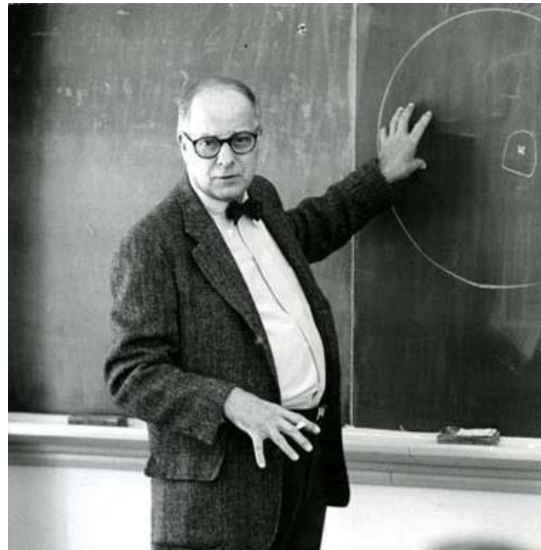
November 10, 2021

Disasters and Regional Science

- In the U.S. nearly all disasters are regional
- Disaster impacts spread spatially thru trade & contact
- Impacts estimated thru Regional Science methods
- Regional Science is an eclectic field
- Disasters overlap with Peace Science
- Disaster research a tradition at NARSC for 30 years

Disaster Sessions at NARSC Since 1992

Stephanie Chang
University of Washington
University of British Columbia

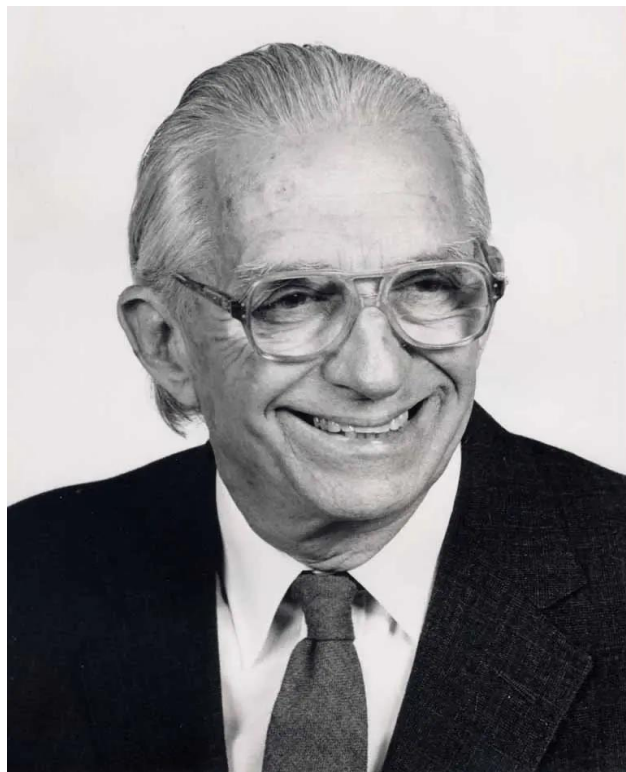


Barclay Jones
Cornell University

Yasuhide Okuyama
West Virginia University
University of Kitakyushu



Peace Science: War & Terrorism



Minerva Study: “Economic Viability, Resilience and Sustainability of Logistics Systems in Post-Conflict Zones”

- Adam Rose
- Kieran Donaghy
- Geoff Hewings
- Peter Nijkamp
- Karima Kourtit
- Laurie Schintler
- Terry Clower

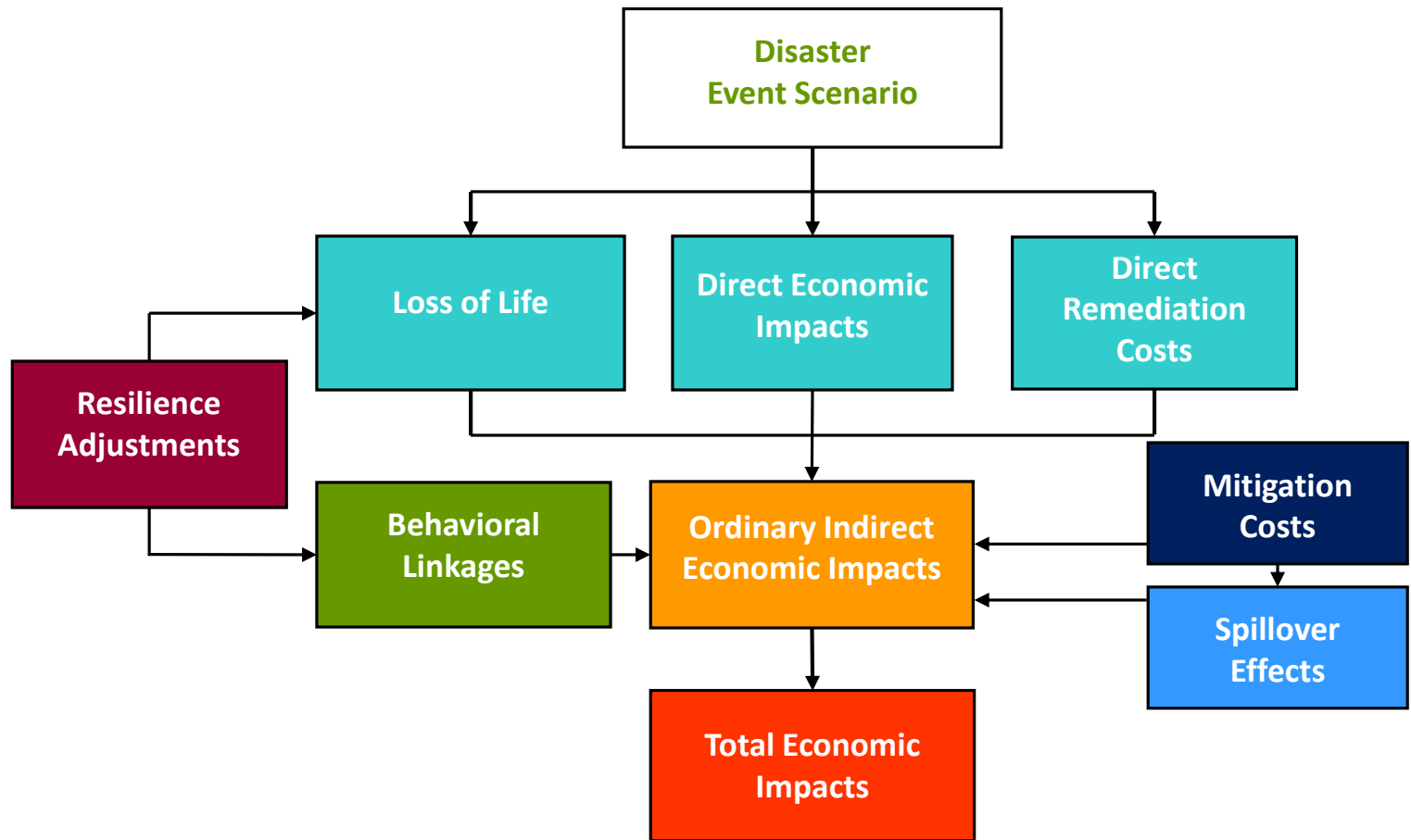
Overview

- Economic Consequence Analysis Framework
 - bottom-up identification of causal factors
 - resilience
 - behavioral responses
- COVID Case Study
 - model and data
 - scenarios
 - U.S. results
 - Global impacts through international trade
- Conclusion
 - limitations
 - future research

Background

- Recent major economic downturns caused by financial or real estate imbalances/bubbles
 - Most analyses of COVID to date have used conventional macro or financial models and/or variables
 - But COVID is closer to disaster cases of downturns
- Disaster micro-macro modeling: Economic Consequence Analysis (ECA) Framework
 - Bottom-up approach
 - Typically based on CGE analysis as an organizing framework
 - Advance over ordinary impact analysis for disasters

Economic Consequence Analysis Framework



Economic Consequences of Bioterrorism Attacks

(gross output impacts in billions of 2007 dollars)

Type of Attack	Loss of Life	Ordinary Business Interruption	Behavioral Linkage	Resilience	Total Gross Output
Stadium	- 57.2	- 0.5	- 16.2	8.5	- 65.4
Urban center	- 2.2	- 8.2	- 46.0	4.4	- 52.0
Airport	- 1.0	- 0.1	- 110.0	59.5	- 51.6
Foot and mouth		- 5.4	- 40.8	4.2	- 42.0
Water service		- 27.3	- 2.6	26.7	- 3.2

Economic Resilience

- Static:
 - General Definition: Ability of a system to *maintain function* when shocked.
 - Econ Definition: *Efficient use of remaining resources* at a given point in time to produce as much as possible.
- Dynamic
 - General: *Ability & speed* of a system to *recover*.
 - Economic: *Efficient* use of resources *over time* for investment in repair and reconstruction, including expediting the process & adapting to change
- *Metric: averted losses as % of potential losses*

Measuring Econ Resilience of 9/11

- 95% of over 1,100 WTC area firms relocated after 9/11
- If all of firms in the WTC area went out of business, direct business interruption (BI) loss would = \$58.4B
- If all relocation were immediate, then BI = \$0
- Businesses relocated 2 to 4 months, BI = \$16.1B
- Resilience Metric: $\text{Avoided Loss} \div \text{Max Potential Loss}$

$$\$42.3\text{B} \div \$58.4\text{B} = 72\%$$

Resilience Tactics (Production Theory)


Resilience Tactic	Definition (Activities Involved)
Conservation	Maintaining intended production using lower amounts of an input or inputs
Resource Isolation	Modifying a portion of business operations to run without a critical input
Input Substitution	Replacing a production input in short supply with another
Inventories	Continuing business operations using emergency and ordinary stockpiles
Excess Capacity	Using idle plant or equipment idle in place of a damaged ones
Relocation	Moving some or all of the business activity to a new location, telework
Management Effectiveness	Improving the efficiency of business operations in the aftermath of a disaster
Import Substitution	Importing needed production inputs when not available from local suppliers
Technological Change	Improvising the production process without requiring a major investment
Resource Pooling/Sharing	Recontracting, selective exchange of resources, creating new partnerships
Production Recapture	Making up for lost production by working overtime or extra shifts

Behavioral Linkages

- Off-site responses associated with behavioral changes (business, household, investor, worker)
- Emanates from social amplification of risk & stigma effects (media coverage, rumor, notoriety)
- Fear feeds on itself and spreads
- Translates into direct and indirect BI losses
- Can be 2 to 3 orders of magnitude higher

Behavioral Linkage Examples

- 9/11 led to a 2-year reduction in air travel
- Other terrorist attacks or regular disasters
 - Workers fear of riding the subway/bus
 - Businesses fear of staying open after dark
 - Fear of returning to weakened buildings
- COVID-19
 - Fear of personal contact
 - Fear of contaminated locations (e.g. hospitals)
- Avoidance vs. Aversion Behavior



Macroeconomic Consequences of the COVID-19 Pandemic

Terrie Walmsley, Richard John, Dan Wei,
Jakub Hlávka, and Adam Rose

Report to the Center for Accelerating
Operational Efficiency (CAOE)

October 18, 2021

Causal Factors for COVID Impacts

- Mandatory closures [Behavioral Linkage]
- Reopenings [Behavioral Linkage]
- Telework [Resilience]
- Workforce declines due to health issues
- Consumption & workforce declines due to avoidance [Behavioral Linkage]
- Changes in net demand for health care services [Behavioral Linkage in part]
- Increases in communication demand [Resilience]
- Pent-up demand [Resilience]

Ten Avoidance Behavior Domains

1. Staying home from work
2. Keeping children home from school
3. Canceling or postponing medical/dental appointments
4. Canceling or postponing travel
5. Canceling or postponing grooming and spa treatments
6. Avoiding in-person shopping
7. Avoiding local leisure activities, e.g., dining out, bars
8. Avoiding recreational activities,
9. Avoiding large crowds, e.g., sports events, concerts, etc.
10. Avoiding public transportation

Decreases in Activities during COVID Attributable to Avoidance Behavior (percentage change from pre-pandemic levels)



Modeling of Pandemic Scenarios

- Use SEIR modeling and intervention scenarios to indicate possible pandemic outcomes for scenarios:
 1. **Real-world scenario** (matching reported deaths under and over 65)
 2. **High-efficacy scenario** (suppressing exponential growth from April 2020)
 3. **Low-efficacy scenario** (higher behavioral response)
 4. **Very low-efficacy scenario** (limited behavioral response)
 - Draw on literature estimates and expert interviews
 - Adjust for seasonality, uptake of vaccinations & age

Computable General Equilibrium Model

- State-of-the-art dynamic global computable general equilibrium (CGE) model: IMPACTEcon version of GTAP
 - Global (US, China and ROW) and 65 commodities/sectors
 - Production & sales for each country linked by supply-chains
 - Dynamics:
 - Short-run unemployment equilibrium for labor and capital
 - Capital accumulation (investment driven by rates of return & changes altered capital stocks)
 - Eight, six-month periods from 2020_1 to 2023_2
 - Results are changes in 6-month period growth

Figure 1. Percent Changes in Semi-annual GDP by Causal Factor

(cumulative percent change over time)

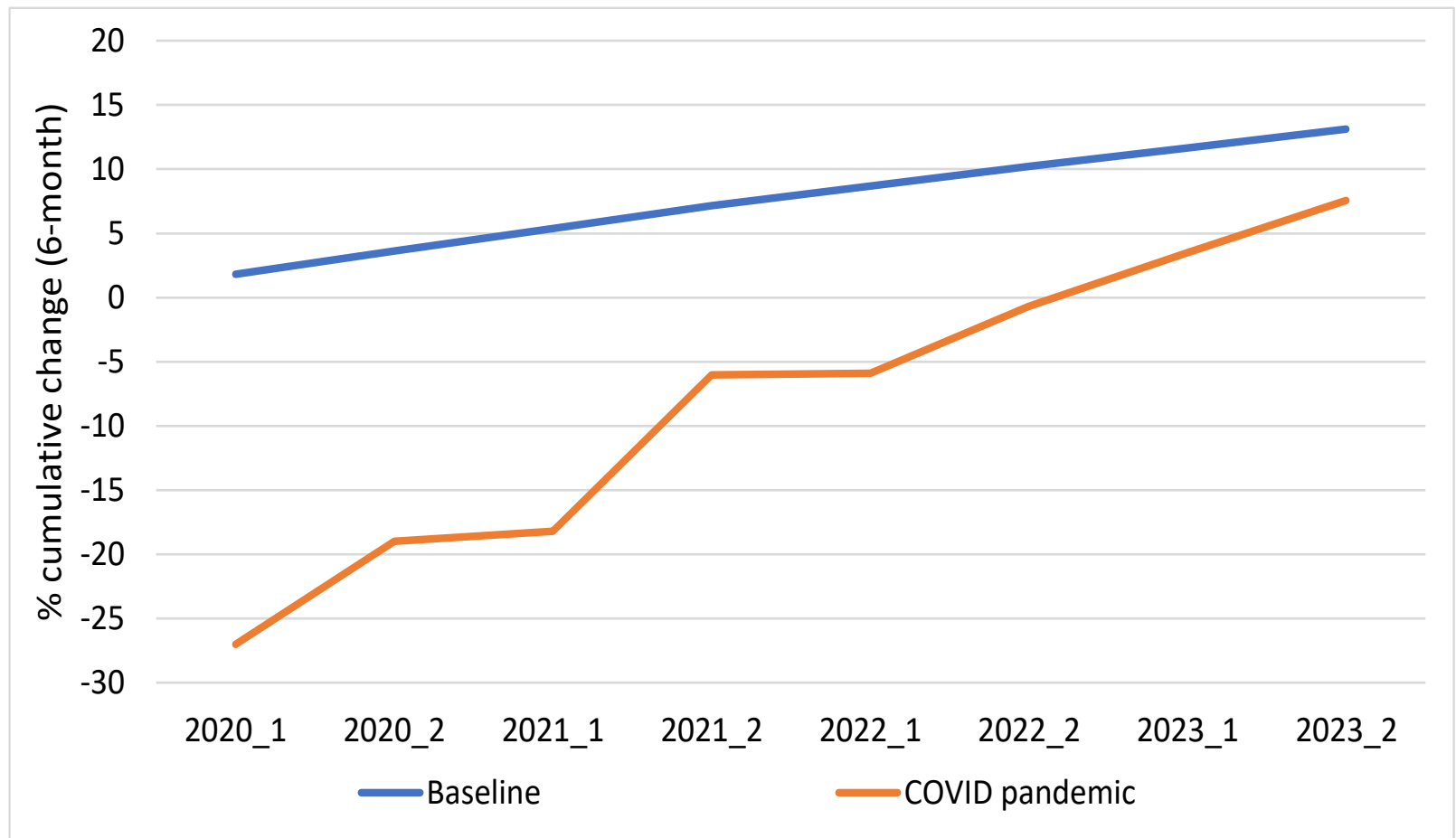


Table 1. Changes in Semi-annual U.S. GDP

(billions of dollars, unless otherwise specified)

	2020_1	2020_2	2021_1	2021_2	2022_1	2022_2	2023_1	2023_2
Difference (% change)	-27.6	-21.6	-22.3	-12.4	-13.7	-10.8	-8.8	-6.5
Baseline	10,909	11,104	11,292	11,480	11,645	11,810	11,965	12,120
COVID	7,898	8,705	8,774	10,057	10,050	10,534	10,912	11,332
Difference in Semi-annual GDP	-3,011	-2,398	-2,518	-1,424	-1,595	-1,275	-1,053	-788

Table 2. Percent Changes in Semi-annual U.S. GDP Decomposed by Causal Effect

(cumulative % differences from baseline unless otherwise noted)

	2020_1	2020_2	2021_1	2021_2	2022_1	2022_2	2023_1	2023_2
Mandatory Closures	-26.3	-22.9	-21.7	-15.9	-12.3	-10.3	-8.9	-7.8
Avoidance Behavior	-12.2	-11.3	-10.2	-5.4	-4.6	-4.1	-3.8	-3.6
Labor Supply	0.0	-0.1	-0.3	-0.5	-0.6	-0.7	-0.8	-0.8
Health Care Demand	0.8	0.9	0.8	0.7	0.6	0.5	0.5	0.4
Pent-up Demand	3.0	2.9	5.0	5.4	6.1	5.8	6.2	6.9
Fiscal Policy	7.1	8.9	4.1	3.3	-2.9	-2	-2	-1.6
Total (US\$ billions)	-3,011	-2,398	-2,518	-1,424	-1,595	-1,275	-1,053	-788

Figure 2. Percent Changes in Semi-annual Growth by Region

(cumulative percent differences from baseline)

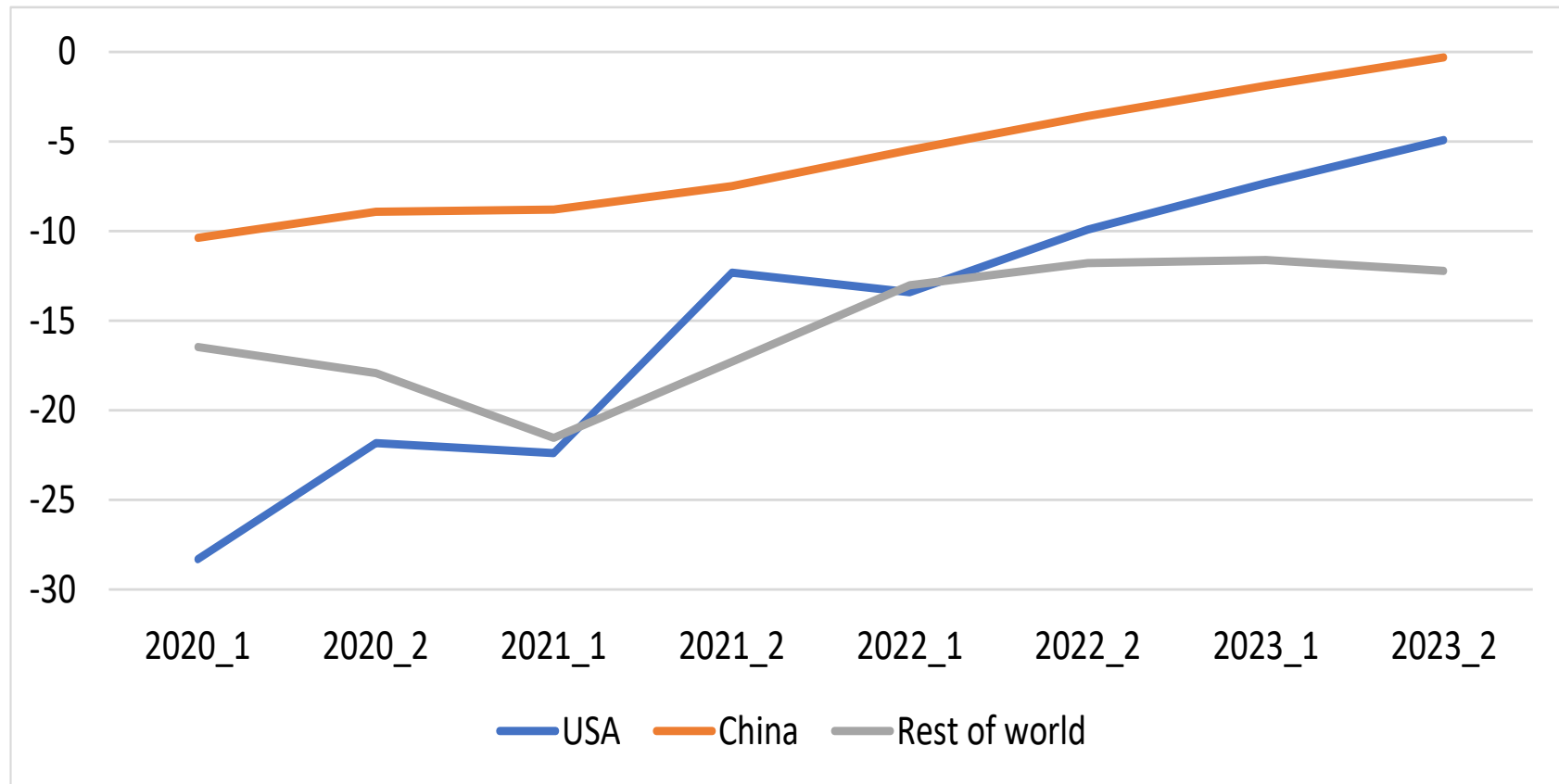


Table 3. Changes in GDP Due to Mandatory Business Closures Across Regions, 2020

(percentage changes)

Country/Region	China Closures Only	USA Closures Only	ROW Closures Only	All Closures
Impact on China	-2.46	-0.28	-1.43	-4.16
Impact on USA	0.00	-9.18	-1.72	-10.90
Impact on ROW	-0.13	-1.96	-6.33	-8.42
Impact on World	-0.61	-2.71	-4.58	-7.89

Percentage Changes in GDP by Region Due to Mandatory Business Closures

- Results for impacts of mandatory closures in each region in isolation and across the two other regions
 - Impacts greatest on own region (diagonals)
 - ROW impacts on other countries/world the largest of all
 - China's closures had no impact on the US (so short)
 - US closures on China very small (US exports to China are relatively small and in products not impacted by closures)
- Relative impacts on own region
 - US impacts most insulated (84% of own total GDP impacts due to own closures)
 - China impacts least insulated (59%)

Conclusion

- Economic Consequence Analysis is a worthy approach to estimating impacts of disasters (including COVID)
- Decomposition of impacts by causal factor is valuable to policy-makers for fine-tuning policy responses
- Future research to overcome study limitations:
 - validate modeling thus far (post-audit)
 - collect and refine more primary data (health & reopenings)
 - provide more detail on the rest of the world
 - factor in the effect of supply-chain bottlenecks

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Additional Slides

Survey of Avoidance Behavior during COVID

- Sample recruited using Prolific
<https://www.prolific.co/>
- Representative sample of US adults by sex, age, & race/ethnicity
- N=1600
- 15-minute survey of current and expected avoidance behavior six months later
- Survey completed in April 2021

Avoidance Summary of Findings Pre-Pandemic to 10/2020 to 4/2021

- Travel & Transportation decreased 60-90%
- Routine Medical Appointments: Average of over 6 medical appointments of various types per person cancelled
- Dining decreased 60-80% depending on type; take-out & drive-thru dining increased 37%
- In store shopping decreased 43-61% depending on type; Online shopping increased 44-54% depending on type
- Indoor recreational activities decreased by 66%
- Attendance at large events decreased by 74-89% by type

Table 6-2. Total Health Outcome by Scenario

Scenario	Total Cases	Outpatients	Hospitalizations non-ICU	Hospitalizations ICU	Fatalities
Scenario 1	159,405,342	92,833,762	7,549,358	1,389,690	909,602
Scenario 2	21,144,175	12,313,849	725,453	139,578	64,663
Scenario 3a	269,078,407	156,704,666	13,279,568	2,509,544	1,993,084
Scenario 3b	220,348,512	128,325,570	11,026,625	2,043,115	1,504,389

Modeling Assumptions

- Business closures
 - Unspent money is saved and as businesses reopen savings rates return
 - Consumption of essentials, government spending and health fixed
 - Business closure rates were maximums – most declined more due to indirect effects
- Avoidance
 - Survey was used for 2020_1, as well as survey period (2020_2 and 2021_1)
 - Health care – considered to be primarily avoided
 - Unspent money is saved and as avoidance abates, savings rates rise
 - Consumption of essentials and government spending fixed
 - business closure rates were maximums – most declined more due to indirect and avoidance effects
- Morbidity and mortality (labor)
 - Population decreases reduced demand
 - Consumption of essentials and government spending fixed
 - Business closure rates were maximums
- Increased health care
 - Money spent on health care came out of savings
 - Consumption of essentials and government spending fixed
 - Business closure rates were maximums
- Fiscal policy
 - Money spent on fiscal policy came out of savings
 - Fiscal policy could raise production above maximums
- Pent-up demand
 - Money spent on pent-up demand came out of savings
 - Model results used to extract pent-up and other causal factors from demand
 - Pent-up demand could raise production above maximums