Impacts on the U.S. Macroeconomy of Mandatory Business Closures in Response to the COVID-19 Pandemic

Terrie Walmsley, Adam Rose, and Dan Wei[1]

Center for Risk and Economic Analysis of Terrorism Events (CREATE)
and Sol Price School of Public Policy
University of Southern California (USC)

Abstract

We estimate the macroeconomic impacts of mandatory business closures in the U.S. and many other countries in order to control the spread of the COVID-19. The analysis is based on the application of a modified version of the GTAP computable general equilibrium (CGE) model. We simulate mandatory closures in all countries or parts of countries that had imposed them as of March 26 for one-month and four-month cases. For the latter, we estimate a 21.6% decline of U.S. GDP on an annual basis, or $4.6 trillion. The employment decline of 23.0% in the U.S. for the 4-month closure represents 36.1 million workers for that time period. The employment impacts are slightly greater in percentage terms than the GDP impacts because most service sectors, which are generally more labor-intensive, are much more negatively impacted by the closures than are manufacturing sectors and other critical sectors. Our results should be considered upper-bound estimates given such assumptions as businesses laying off workers no longer paying them wages or salaries. Note also that the paper examines the mandatory closures alone and does not factor in any countervailing fiscal or monetary policies.

Introduction and Overview

The COVID-19 pandemic is expected to have devastating economic consequences. A related concern is the extent of the economic impacts of mandatory business closures in the U.S. and many other countries under "Stay-at-Home" orders to control the spread of the virus. This paper summarizes the results of the formal analysis of the economic impacts of this policy.

The analysis is based on the application of a computable general equilibrium (CGE) model, a state-of-the-art economic modeling technique. CGE is defined as a multi-market model of the behavioral responses of producers and consumers to changing prices, regulations and other conditions in the workings of interconnected markets, subject to basic resource constraints. CGE models have the

[1] The authors are, respectively, Research Fellow, Center for Risk and Economic Analysis of Terrorism Events (CREATE), University of Southern California (USC); Director and Senior Research Fellow, CREATE, and Research Professor, Sol Price School of Public Policy, USC; Research Fellow, CREATE, and Research Associate Professor, Price School, USC. The authors wish to thank Scott Farrow and Richard John for their helpful comments on the manuscript, as well as Juan Machado and Konstantinos Papaefthymiou for their valuable research assistance. The authors are, however, responsible for any remaining errors or omissions. This research was funded by a contract from the DHS Center for Accelerating Operational Efficiency (CAOE), headquartered at Arizona State University. Corresponding Author: Adam Rose, adam.rose@usc.edu

advantage of characterizing the economy as a set of interconnected supply chains. These models have been applied successfully to examine economic impacts of health threats, such as influenza pandemics (see, e.g., Dixon et al., 2011; Prager et al., 2017). In particular, we use the ImpactECON Supply-Chain Model (Walmsley and Minor, 2016, 2017). This Model is adapted from one of the most widely-used CGE models, GTAP (Hertel and Tsigas, 1997; Corong et al., 2017) and has the extended capability for examining employment and supply chain impacts linked to economic activity and policies in the rest of the world.

In performing the analysis, we utilize the assumptions, variables and parameters presented in the Appendix. The assumptions are invoked primarily to keep the analysis manageable. Sensitivity tests have been performed on some of the major assumptions and parameters to make sure the results presented below are robust.[2] Still, we note that the combination of assumptions is such that the results presented below should be considered upper-bound estimates. Also, this study does not include the economic impacts of not imposing mandatory closures. Under some epidemiological scenarios of disease spreads, there is a likelihood that the economic and human cost of the pandemic would exceed the costs of the mandatory closure policy approach to mitigation (see, e.g., Thunström, 2020).

Results

We first simulated the economic impacts for the U.S. and the rest of the world (ROW) for mandatory closures in place as of March 26, 2020 (see Appendix Table A1), for a one-month closure duration scenario. We also simulated the economic impacts for the case where the closures for the U.S. and the ROW are for four months, but only one month for China.[3] The analysis was one of comparative statics (i.e., isolating the effects of the closures without considering extenuating circumstances or offsetting subsequent behavioral or policy responses). We factored in telecommuting for non-essential sectors covered under the mandatory closure order, but only for those that can produce output by telecommuting to some extent (see Appendix Table A2).[4] However, we did not factor in deaths and hospitalizations, pent-up demand, or various resilience tactics (Rose, 2017; Dormady et al., 2019) for reasons explained in the Appendix. Also, we did not factor in avoidance behavior (see, e.g., Prager et al., 2017), because the mandatory closures were assumed to overwhelm such effects. We also did not include any stimulus packages that would act as countervailing effects.

The results are presented in Tables 1 to 3 in terms of impacts on GDP, employment, and economic welfare, respectively. In the 4-month closure scenario, the estimated 21.6% decline of U.S. GDP on an annual basis translates into losses of $4.6 trillion. Some interesting aspects of the results are as follows. The losses are greatest to the U.S. economy because the U.S. (and in particular the States that have

[2] Sensitivity analyses are performed to different assumptions regarding investment and the trade balance and to parameters used in modelling employment.

[3] A major region of China was closed and then reopened prior to the closures in the U.S. However, the impacts on the U.S. are likely to be relatively small because of inventory holdings in the U.S. and rescheduled (recaptured) production in China. The one-month scenario here represents a contingency of a possible further need for China to shut down some of its economic activity over the next few months due to an emergence of the COVID-19 threat elsewhere in the country.

[4] We assume the closures in China and the ROW are in the same sectors as those in the U.S.

implemented lockdown procedures) produce and export[5] a higher share of non-essential goods and services than both China and the ROW. Moreover, not all countries in the ROW have implemented mandatory closures on producers of non-essential goods and services. Despite China suffering only one-month of mandatory closures in both scenarios, the negative impacts on its GDP are higher in the four-month case because of the interconnectedness of the Chinese and world economy. The increase in GDP losses for the U.S. is a significantly higher percentage for the four-month case than in the one-month case in relation to the ROW, because of the greater importance of non-essentials to the U.S. economy and exports.

The employment decline of 23.0% in the U.S. for the 4-month closure represents 36.1 million workers for that time period. The employment impacts are slightly greater in percentage terms than the GDP impacts because service sectors, which are an important part of U.S. non-essential production, are much more negatively impacted than agriculture and processed food, and a large share of U.S. workers are employed in the former. In China and the ROW, non-essential businesses are less important to the economy and employ a much smaller portion of the workforce. Finally, an economic welfare (well-being) measure in terms of "equivalent variation", approximated by personal consumption, is projected to decline by 20.8% in the U.S. The difference between this and GDP is that the latter also includes investment and government expenditures, as well as export demand, while the former is focused entirely on losses to consumers (the general population).

Table 1. GDP Impacts (percent reduction from 2019 Baseline)

Country/Region	1-Month Closures	4-Month Closures (China 1 Month)
USA	-6.1	-21.6
China	-5.2	-5.9
ROW	-4.3	-12.3

Table 2. Employment Impacts (percent reduction from 2019 Baseline)

Country/Region	1-Month Closures	4-Month Closures (China 1 Month)
USA	-6.5	-23.0
China	-3.8	-4.1
ROW	-3.6	-10.4

Table 3. Economic Welfare Impacts (percent reduction from 2019 baseline per capita private consumption)

Country/Region	1-Month Closures	4-Month Closures (China 1 Month)
USA	-6.2	-20.8
China	-3.0	-3.7
ROW	-4.7	-12.9

[5] Based on GTAP trade data, we estimate 19 percent of U.S. exports are in non-essential goods and services, compared to 3 percent of ROW exports.

Note that the percentage reductions in the macroeconomic indicators presented in Tables 1 to 3 are higher than the direct percentage of the economy mandated to be closed in both the U.S. and other countries. This is because of upstream and downstream supply-chain effects (often referred to as quantity multiplier, or, more broadly, both quantity and price general equilibrium, effects).[6] Moreover, the U.S. is linked to the world economy, where demand for some U.S. exports is significantly reduced, and where the situation causes some import prices to rise significantly.

Our results should be considered upper-bound estimates. For example, we have assumed that reductions in business output are accompanied by reductions in wages and salaries paid as people become unemployed, though some businesses will continue paying their employees.[7] We have also omitted the spending of the small percentage of teleworkers who will continue to be employed in non-essential sectors.

Note also that, although very large, the negative impacts on U.S. GDP of $4.6 trillion stemming from the mandatory closures should be juxtaposed to the economic impacts of not imposing this policy. This pertains to the economic consequences of allowing the pandemic to spread unabated under non-mandatory closure conditions (no vaccine but sizable avoidance behavior). Depending on disease spreads, there is a likelihood that the economic and human cost of the pandemic would exceed the costs of the mandatory closure policy approach to mitigation (Cornwall, 2020; Thunström, 2020). The results presented here might also be juxtaposed to estimates of the benefits of various economic countervailing policies, both fiscal and monetary.

References

Cornwall, W. 2020. "Can you put a price on COVID-19 options? Experts weigh lives versus economics," *Science*, March 31. https://www.sciencemag.org/news/2020/03/modelers-weigh-value-lives-and-lockdown-costs-put-price-covid-19

Corong, E., T. W. Hertel, R. McDougall, M. E. Tsigas, and D. van der Mensbrugghe. 2017. "The Standard GTAP Model, Version 7," *Journal for Global Economic Analysis* 2(1): 1-119. https://www.gtap.agecon.purdue.edu/resources/jgea/ojs/index.php/jgea/article/view/47

Dixon, P., M. Rimmer, B. Lee, A. Rose et al. 2010. "Effects on the U.S. of an H1N1 Epidemic: Analysis with a Quarterly CGE Model," *Journal of Homeland Security and Emergency Management* 7(1): Article 7. doi.org/10.2202/1547-7355.1769

Dormady, N., A. Rose, A. Roa-Henriquez, and H. Rosoff. 2019. *Measuring Business and Economic Resilience in Disasters*, Final Report to the Critical Infrastructure Resilience Institute (CIRI), University of Illinois, Urbana, IL.

Hertel, T. W. and M. E. Tsigas. 1997. "Structure of GTAP," in T.W. Hertel (ed.), *Global Trade Analysis: Modeling and Applications*, New York: Cambridge, pp. 13-73.

[6] In some sectors subject to mandatory closures, these general equilibrium effects led to overall production declines larger than the exogenously imposed declines directly emanating from the mandates.

[7] Labor and capital were also assumed immobile across sectors in response to the mandatory shutdowns because of their relatively short durations, leading to larger unemployment of both factors of production.

Prager, F., D. Wei, and A. Rose. 2017. "Total Economic Consequences of an Influenza Outbreak in the United States," *Risk Analysis* 37(1): 4-19. doi:10.1111/risa.12625

Rose, A. 2017. "Benefit-Cost Analysis of Economic Resilience Actions," in S. Cutter (ed.) *Oxford Research Encyclopedia of Natural Hazard Science*, New York: Oxford. doi: 10.1093/acrefore/9780199389407.013.69

Thunström, L., S. Newbold, D. Finnoff, M. Ashworth, and J. Shogren. 2020. "The Benefits and Costs of Flattening the Curve for COVID-19, Department of Economics, University of Wyoming, Laramie, WY. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3561934

U.S. Bureau of Labor Statistics. 2019. "Table 1. Workers who could work at home, did work at home, and were paid for work at home, by selected characteristics, averages for the period 2017-2018." https://www.bls.gov/news.release/flex2.t01.htm

Walmsley T. L., and P. Minor. 2016. "ImpactECON Global Supply Chain Model: Documentation of Model Changes," Working Paper No. 06, ImpactECON, Boulder, CO. https://impactecon.com/resources/supply-chain-model/

Walmsley, T. L., and P. Minor. 2019. "Demand Shifts and Willingness to Pay in Applied Models," *World Economy* (electronic early view). https://onlinelibrary.wiley.com/doi/10.1111/twec.12890.

Appendix. Assumptions, Variables and Parameters

1. Mandatory Sector Closings:

a. U.S.: Status as of 10 am on March 26. 21 U.S. states have implemented statewide shutdown of non-essential sectors, while another 15 states have implemented shutdowns in parts of the state.[8]

b. China and ROW: Status as of March 26. China and most other large countries have implemented shutdowns of non-essential sectors within only parts of their borders.[9] We assume smaller countries with shutdowns[10] have implemented shutdowns throughout.

2. Duration: 1 and 4 months of mandatory closures in the US and ROW.[11] In both cases we assumed that China would undertake 1 additional month of mandatory closures.

3. Consumer Expenditures:

[8] In the U.S., partial shutdowns are with respect to the geographic area of the state (e.g., only some of the counties in a state have implemented the shutdown order). The shutdowns are not with respect to the non-essential sectors in a shutdown area (i.e., it is not the case that part of the non-essential sectors is still open in a county that has implemented the shutdown order).

[9] Partial or full lockdowns have occurred in Argentina, Australia, Belgium, Bolivia, Colombia, Czech Republic, Germany, Denmark, Spain, France, Britain, Indonesia, India, Ireland, Israel, Italy, Jordan, Kenya, Kuwait, Morocco, Malawi, Malaysia, Norway, New Zealand, Poland, Portugal, Saudi Arabia, El Salvador, Slovenia, Tunisia and South Africa.

[10] In terms of geographic area, the dividing line between large and small countries is exemplified by Germany, UK, South Korea, Egypt, and Thailand as the lower limit. Countries that have not implemented shutdowns are assumed to have reduced production of non-essentials by 5 percent.

[11] To determine the one month shocks, we use the following formula: ((1+X/100)^(1/12)-1) * 100, where X is the annual cumulative change expected from the shut downs, calculated using information on mandatory closures and telework by sector and provided in Tables A1 and A2.

a. Consumption. All available income is spent on trying to maintain pre-pandemic essentials spending levels by private consumers, i.e., they are assumed to consume the same amounts (in real terms) of essential items. Remaining income is spent on trying to maintain pre-pandemic non-essential levels, and savings.

b. Savings. Total savings (private and government) falls. While the GTAP database does not separately identify private savings from government savings/deficit, private consumption falls more than factor income due to the significant decline in purchases of non-essentials, indicating that private households are reallocating income to consumption of essentials and savings. The increase in savings could be used to purchase non-essentials at a later date (pent-up demand).

4. Imports:

a. Changes in imports and exports are primarily determined by the business closures assumed in the U.S., China and the ROW. These mandatory closures and the resulting lower incomes of their citizens lead to reductions in the supply of exports and demand for imports.

b. Restrictions on trade in services were incorporated, based on importance of tourism and movement of persons who must accompany the supply of the services used by such sectors as construction, accommodation, food and services, recreational services, education. Trade in services is assumed to be restricted for all U.S. States and countries, reflecting the fact that most countries have placed restrictions on the movement of people across national borders.

5. Investment and trade balance: The trade balance is assumed to be fixed relative to income. This determines the level of investment in each region of the world.

6. Telecommuting: We distinguish between two categories of non-essential sectors that experience mandatory closure:

a. Sectors for which an output can be produced by telecommuting (e.g., professional services, finance, education). In this case telecommuting percentages tell us how much of the output of the sectors will still be produced.

b. Sectors for which an output cannot be produced by telecommuting (e.g., most manufacturing). In this case, we assume the percent of the "output" of the sectors representing the sectors' baseline telecommuting potential will continue in the form of administrative/clerical work. We assume that this produces no products for the supply chain, and hence such sectors are still modeled as a complete shutdown. However, the income associated with the telecommuting activity will be considered disposable income and the majority of it will be injected into the spending streams.

B. Considerations we did not include, as well as the reasons for not doing so, are:

1. Deaths and hospitalizations – It is assumed that the impact of deaths and hospitalizations on the labor force is relatively small at these early stages and is also overwhelmed by the reduced demand for labor by the mandatory closings. We have also abstracted from any increase in demand for health care services.

2. Telecommuting in non-essential sectors that fall into the second category defined in 6a – It is doubtful that telework would lead to the actual production of goods and services in these non-essential sectors (especially for manufacturing and construction), but would be applied to administrative/clerical/security aspects of the enterprises, rather than production line or direct service provisions.

3. Pent-up demand – This refers to the likelihood that money saved on goods and services that cannot be purchased during the mandatory closures, and are not needed for other expenditures due to loss of income, are spent once the closures are lifted and businesses resume operation. This is extraneous to the actual mandatory closings.

4. Resilience tactics – Some of these tactics (e.g., input substitution) intrinsic to the modeling are included; others are very limited (e.g., inventories, relocation, and technological change) due to the durations of the mandatory closure simulated.

Table A1. Percentage Reduction of Output by Sector under Mandatory Closure (with Telecommuting)

#	Sector	Mandatory Closure Category[a]	% U.S. Output Reduction during Closure	Notes
1	Rice	3	0.00%	
2	Wheat	3	0.00%	
3	Other Grains	3	0.00%	
4	Veg & Fruit	3	0.00%	
5	Oil Seeds	3	0.00%	
6	Cane & Beet	3	0.00%	
7	Fibres crops	3	0.00%	
8	Other Crops	3	0.00%	
9	Cattle	3	0.00%	
10	Other Animal Products	3	0.00%	
11	Raw milk	3	0.00%	
12	Wool	3	0.00%	
13	Forestry	3	0.00%	
14	Fishing: hunting, trapping and game propagation	3	0.00%	
15	Coal: mining	3	0.00%	
16	Oil: extraction of crude petroleum	3	0.00%	
17	Gas: extraction of natural gas	3	0.00%	
18	Other Mining Extraction	3	0.00%	
19	Cattle Meat	3	0.00%	
20	Other Meat	3	0.00%	
21	Vegetable Oils	3	0.00%	
22	Milk: dairy products	3	0.00%	
23	Processed Rice: semi- or wholly milled, or husked	3	0.00%	
24	Sugar and molasses	3	0.00%	
25	Other Food	3	0.00%	
26	Beverages and Tobacco products	2	15.90%	Closure: Tobacco products
27	Manufacture of textiles	1	59.56%	
28	Manufacture of wearing apparel	1	82.39%	
29	Manufacture of leather and related products	1	82.39%	
30	Lumber	3	0.00%	
31	Paper and Paper Products	3	0.00%	
32	Petroleum and Coke Products	3	0.00%	
33	Manufacture of chemicals and chemical products	3	0.00%	
34	Manufacture of pharmaceuticals, medicinal chemical and botanical products	3	0.00%	
35	Manufacture of rubber and plastics products	1	67.11%	
36	Manufacture of other non-metallic mineral products	1	68.82%	
37	Iron & Steel: basic production and casting	3	0.00%	
38	Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, and silver	3	0.00%	

39	Manufacture of fabricated metal products, except machinery and equipment	3	0.00%	
40	Manufacture of computer, electronic and optical products	1	79.36%	
41	Manufacture of electrical equipment	3	0.00%	
42	Manufacture of machinery and equipment n.e.c.	3	0.00%	
43	Manufacture of motor vehicles, trailers and semi-trailers	3	0.00%	
44	Manufacture of other transport equipment	3	0.00%	
45	Other Manufacturing: includes furniture	1	74.10%	
46	Electricity; steam and air conditioning supply	3	0.00%	
47	Gas manufacture, distribution	3	0.00%	
48	Water supply; sewerage, waste management and remediation activities	3	0.00%	
49	Construction	2	51.83%	Closure: all construction except for emergency repair or maintenance
50	Wholesale and retail trade; repair of motor vehicles and motorcycles	2	29.78%	Closure: Retail except for Grocery Stores, Special Food Stores, Gas Stations, etc.
51	Accommodation, Food and service activities	2	51.11%	Open: Accommodation; Closure: Food services except for take out
52	Land transport and transport via pipelines	3	0.00%	
53	Water transport	3	0.00%	
54	Air transport	3	0.00%	
55	Warehousing and support activities	3	0.00%	
56	Information and communication	2	3.97%	Closure: Motion Picture and Video Industries, Sound Recording Industries, etc.
57	Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding	2	8.98%	Closure: Securities, Commodity Contracts, and Other Financial Investments and Related
58	Insurance	3	0.00%	
59	Real estate activities	1	34.88%	
60	Other Business Services nec	2	26.53%	Closure: All except for Scientific Research & Development Services, Waste Management, and some Administration & Support Services
61	Recreation & Other Services	1	68.35%	
62	Other Services (Government)	2	23.61%	Closure: All except for emergency services
63	Education	1	54.92%	
64	Human health and social work	3	0.00%	Mostly open; exception: Civic and Social Organizations
65	Dwellings: imputed rents of owner-occupied dwellings	3	0.00%	

The following designations pertain to entire states or parts of some states that had implemented "Stay-at-Home" orders as of March 26 (see https://www.nytimes.com/interactive/2020/us/coronavirus-stay-at-home-order.html):

1. Sector is entirely non-essential and thus is completely shut down
2. Sector for which only some subsectors are non-essential (see notes in the last column)
3. Sector that is essential and thus still able to operate in its usual manner to the extent possible

Telecommuting adjustment is based on data presented in Table A2).

Table A2. Percent of Workers Who Could Work at Home and Who Did Work at Home in 2017-2018

Industry	% of workers who could work at home	% of workers who did work at home at least occasionally	average
Agriculture, forestry, fishing, and hunting	11.1	10.4	10.75
Mining, quarrying, and oil and gas extraction	*estimate is suppressed*	*estimate is suppressed*	
Construction	17.2	14.4	15.8
Manufacturing	30.3	25.7	28
Wholesale and retail trade	16.5	13.9	15.2
Transportation and utilities	14	12.5	13.25
Information	53.3	45.1	49.2
Financial activities	57.4	46.7	52.05
Professional and business services	53.4	47.4	50.4
Education and health services	25.9	23.7	24.8
Leisure and hospitality	8.8	6.8	7.8
Other services	27.7	22.6	25.15
Public administration	29.8	21.8	25.8
Federal government	31.4	24.5	27.95

Source: Adapted from BLS (2019).