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

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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 model. We simulate mandatory closures in all countries or parts of countries that had imposed them as of April 7 for three-month and six-month cases. For the three-month scenario, we estimate a 20.3% decline of U.S. GDP on an annual basis, or $4.3 trillion. The employment decline of 22.4% in the U.S. for the three-month closure represents 35.2 million workers for that period. If the mandatory closures are extended to six months because of a second wave, these negative impacts would slightly more than double. 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 "essential" 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.

Keywords: COVID-19; mandatory closures; economic impacts; employment

JEL Codes: C68, E37, F19, I18

I. 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 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, 2019). 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 are robust. Still, we note that the combination of assumptions is such that the results presented 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 possibility 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).

II. The Computable General Equilibrium Model

We use the ImpactECON Supply Chain model (IESC) CGE model, developed by Walmsley and Minor (2016),[1] which has been used to analyze the supply chain impacts of several recent U.S. trade policy initiatives. The model is based on, and includes all the features of, the widely used GTAP model (Hertel and Tsigas, 1997; Corong et al., 2017), considered a benchmark for analysis for global trade and other policy issues. The database contains input-output tables and trading relations for 65 commodities and 141 countries from the GTAP database (Aguiar et al., 2019), as well as additional detail on the source of final and intermediate goods.

The IESC model adapts the GTAP model to include detailed trade and tariff data on the source of imported intermediate and final goods, thereby improving the analysis of global supply chain effects. In this specific case, we have more detailed information about the extent to which China and other countries supply U.S. firms with intermediate inputs used in the production process. This additional detail improves our ability to examine how the delay or disruption of these imported intermediate inputs from the rest of the world, impacts U.S. firms' ability to produce and export commodities.

IESC model is a comparative static CGE model that provides a theoretically consistent method for analyzing the impact of global shocks on the U.S. economy. The model consists of demand for domestic and foreign goods by households, government, firms and for investment, and supply of those goods by domestic and foreign firms. It also consists of the demand (by firms) and supply (by households) of eight factors of production (five labor categories, capital, land and natural resources).

To capture the impact of the mandatory closures we reduce the production of the affected sectors, using an expedient device known as a "phantom tax" to raise prices and lower demand.[2] This is done in several iterations to take account of the indirect effects of closing sectors on other sectors. One of the benefits of these models is that they capture the indirect effects of business closures in one sector on the other sectors. For instance, as restaurants are forced to close, demand for fruit and vegetables used in producing restaurant meals, also declines. In some cases, these indirect effects are larger than the

[1] See also Walmsley and Minor (2020) for a detailed explanation of model and data used in this analysis.
[2] The taxes are set at a level that achieves a reduction in output reflecting the business closures. It is a "phantom" because the "taxes" are implicitly returned to the businesses as revenue increases associated with the higher price; essentially, the business customers (both other businesses and consumers) cover this revenue by their expenditures at the higher price, and there is no effect on government revenues.

share of that sector subject to the mandatory closure, and hence we allow these indirect effects to dominate and sectoral production to decline by more than the share of the sector subject to the mandatory closure. For instance, the mandatory closure of accommodation, food and service activities tends to have a significant impact on other sectors that are only partially closed, such as beverages and tobacco products and other business services that are important intermediate inputs into the accommodation, food and service sector. As a result, we only need to impose a decline in production in those sectors where the direct impacts of the mandatory closure are greater than the indirect effects from the other sectors, primarily construction and recreational services.[3] Limitations of the model in relation to its application are discussed below.

III. 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 April 7, 2020 (see Appendix Table A1), for a three-month closure duration scenario, but only a three-week closure for China. We also simulated the economic impacts for the case where the closures for the U.S. and the ROW are for six months, and six weeks for China.[4] 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 orders, but only for those that can produce output by telecommuting to some extent (see Appendix Table A2). However, we did not factor in deaths and hospitalizations,[5] health care expenses, 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 three-month closure scenario, the estimated 20.3% decline of U.S. GDP on an annual basis translates into losses of $4.3 trillion due to the direct and indirect declines in production.

[3] The same situation applies to services trade, where the mandatory closure of businesses and increased unemployment cause imports and exports to decline further than the decline expected due to restrictions on the tourism and the movement of people.

[4] The equivalent three-week mandatory closures in China is calculated based on actual closures of businesses in Hubei Province and Wuhan City in China and extension of the Chinese new year holidays in rest of the country, as well as partial closures as the businesses across the country gradually resume production in late February through early April. The six-week closure for China assumed under the six-month scenario for the U.S. represents a combination of the equivalent three-week actual closures occurred in the country between February and early April and the contingency of a possible further need for China to shut down some of its economic activity due to the re-emergence of the COVID-19 threat in the country.

[5] The numbers of deaths and hospitalizations during the mandatory closures were considered to be too small to have any perceptible effect on the labor force. However, we note that this study does not estimate the cost of death separate from the impacts on GDP, which can be calculated by applying the value of statistical life.

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

Country/Region	3-Month Closures (China 3-weeks)	6-Month Closures (China 6-weeks)
USA	-20.3	-44.6
China	-4.0	-8.3
ROW	-6.7	-14.8

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

Country/Region	3-Month Closures (China 3-weeks)	6-Month Closures (China 6-weeks)
USA	-22.4	-49.3
China	-3.8	-7.6
ROW	-6.6	-14.4

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

Country/Region	3-Month Closures (China 3-weeks)	6-Month Closures (China 6-weeks)
USA	-20.1	-46.4
China	-2.4	-5.8
ROW	-6.4	-14.5

Some interesting aspects of the results are as follows. The losses are greatest to the U.S. economy because it produces and exports[6] 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, while 95.7 percent of U.S. economy is impacted by the mandatory closures in almost all states. The increase in GDP losses is a slightly more than the double for the six-month case than in the three-month case for all three countries. As the mandatory closures are extended, households must give up more non-essentials to maintain their purchases of essential items, and thus, real GDP declines further.

The employment decline of 22.4% in the U.S. for the three-month closure represents a decline in demand of 35.2 million workers as reduced production from the mandatory closures and their indirect effects leads to a reduction in demand for labor and hence employment. In Scenario 2, demand for workers declines further, by 49.3 percent. Since the same industries are closed or indirectly impacted in both scenarios, this further decline in employment reflects the doubling of the mandatory closure period and hence the doubling of the period these workers are no longer required, rather than the doubling of the unemployment rate. That said, the longer the mandatory closures remain in place the

[6] 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.

more likely the decline in demand for workers is likely to increase unemployment, as firms can no longer keep under-employed workers on their payroll. 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, processed food, and other essential manufacturing, 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, economic welfare (well-being), approximated by personal consumption, is projected to decline by 22.4% in the U.S. in the three-month closure scenario as incomes fall due to lower production and unemployment. 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), and hence is a better measure of personal and aggregate economic well-being.

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).[7] 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.

IV. Interpretation and limitations

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. We have also omitted the spending of the small percentage of teleworkers who will continue to be employed in non-essential sectors, primarily as office staff.[8] Finally, we have omitted some sources of business resilience, such as the use of inventories and relocation.

As is the case in most GTAP-based analysis, we assume that, with the exception of factor markets, all other markets clear and firms are perfectly competitive. In addition to unemployment, factors of production are also assumed to be immobile across sectors, consistent with this paper focusing on very short-run impacts of the pandemic. Our results also rely on the estimated elasticities taken from the literature and used in the GTAP database.

We conduct sensitivity analyses on some of our assumptions regarding investment and the trade balance, as well as our assumption that real consumption of essential goods and services will be maintained in the aggregate. Fixing the trade balance limits the potential for capital flight out of those economies most affected by the virus. When foreign capital flows are permitted (i.e., the trade balance

[7] 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.
[8] See section A (6b) of Appendix for details on the type of telework covered in the analysis.

is assumed endogenous), the already considerable decline in investment in the U.S., due to the mandatory closures, is exacerbated due to the outflow of capital from the U.S., causing the U.S. economy to contract even further.[9] Our assumptions regarding real consumption of essentials ensures that consumers continue to purchase and firms continue to produce essential items, despite declining incomes and the closure of non-essential businesses, although our sensitivity tests indicate that it has only a small impact on the macroeconomic impacts.

Finally, we summarize our results in comparison to other studies that have examined the impact of mandatory closures in isolation or single them out in their broader analyses. Del Rio-Chanona et al. (2020) analyzed closures through both demand- and supply-side analyses but of only direct effects, and estimated a 22% short-run impact on U.S. GDP. This is similar to the direct shock estimates of 25% in an OECD (2020) study. Mandel and Veetil (2020), using an "out-of-equilibrium" model that captured supply-chain effects, estimated a 23% drop in global GDP at its peak. Our study is consistent with the lower range of estimates of these others for the three-month closure scenario even though we factor in general equilibrium effects. The difference is probably due primarily to our incorporation of the offsetting effect of telework. Dixon et al. (2020), using a dynamic CGE model, estimated a 19% reduction in GDP at the trough of the economic downturn at the end of the first quarter of 2020 and 12% decline by the end of the second quarter. They have incorporated our estimates of telework, and also include government expenditures on health care and some countervailing fiscal policies, such as unemployment compensation and tax relief, all of which dampen the negative impacts.

V. Conclusion

The U.S. GDP losses are estimated to be $4.3 trillion (20.3%), and the employment decline is estimated to be 35.2 million (22.4%) for a 3-month mandatory closure. Negative impacts are estimated to be slightly more than doubled for a 6-month closure. U.S. impacts are estimated to be higher than those for China and the ROW because a relatively higher proportion of the U.S. economy is impacted by the mandatory closures and because the U.S. produces and exports a higher share of non-essential goods and services. Our results should be considered upper bounds because they do not factor in countervailing fiscal or monetary policies, consumer pent-up demand, future development of coronavirus vaccine, and medications, and the full set of potential resilience tactics.

Note also that, although very large, the negative impacts on U.S. GDP 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 (partial adherence to social distancing and face covering requirements and admonitions, no vaccine, as well as sizable avoidance behavior). Depending on disease spreads, there is a possibility that the economic and human cost of the pandemic would exceed the costs of the mandatory closure policy

[9] Since the pandemic is global and uncertainty is high, the impact on foreign capital flows is unclear and best analyzed using a more sophisticated model of investment. We therefore assume that this tendency for capital to flow out of the U.S., due to the more severe mandatory closures, is counteracted by the increase in global uncertainty, which tends to draw investors towards the U.S. This is achieved by fixing the trade balance.

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.

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Appendix. Assumptions, Variables and Parameters

A. Assumptions:

1. Mandatory Sector Closings:

a. U.S.: Status as of April 7. 43 U.S. states have implemented statewide shutdown of non-essential sectors.

b. China and ROW: Status as of April 7. China and most other large countries have implemented shutdowns of non-essential sectors within only parts of their borders.[10] We assume smaller countries with shutdowns[11] have implemented shutdowns throughout. We assume the closures in China and the ROW are in the same sectors as those in the U.S.

2. Duration: Three and six months of mandatory closures in the US and ROW. In the three-month scenario we assumed mandatory closures in China of three weeks, in line with actual shutdowns experienced in that country since the beginning of 2020. In the six-month scenario we assumed China would undertake six weeks of mandatory closures, implying that China would also be forced to close parts of the country for an additional three weeks, or six weeks in total.

3. Consumer Expenditures:

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

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

[11] 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.

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. Other Closure assumptions

a. 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.

b. Labor and capital were 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.

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 6b – 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)[a]

#	Sector	Mandatory Closure Category[b]	% U.S. Output Reduction during Closure	Notes
26	Beverages and Tobacco products	2	23.2%	Closure: Tobacco products
27	Manufacture of textiles	1	98.3%	
28	Manufacture of wearing apparel	1	97.6%	
29	Manufacture of leather and related products	1	97.6%	
35	Manufacture of rubber and plastics products	1	94.2%	
36	Manufacture of other non-metallic mineral products	1	94.9%	
40	Manufacture of computer, electronic and optical products	1	98.4%	
45	Other Manufacturing: includes furniture	1	94.8%	
49	Construction	2	72.2%	Closure: all construction except for emergency repair or maintenance
50	Wholesale and retail trade; repair of motor vehicles and motorcycles	2	40.7%	Closure: Retail except for Grocery Stores, Special Food Stores, Gas Stations, etc.
51	Accommodation, Food and service activities	2	72.7%	Open: Accommodation; Closure: Food services except for take out
56	Information and communication	2	5.0%	Closure: Motion Picture and Video Industries, Sound Recording Industries, etc.
57	Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding	2	11.5%	Closure: Securities, Commodity Contracts, and Other Financial Investments and Related
59	Real estate activities	1	46.5%	
60	Other Business Services (not elsewhere classified)	2	36.3%	Closure: All except for Scientific Research & Development Services, Waste Management, and some Administration & Support Services
61	Recreation & Other Services	1	90.3%	
62	Other Services (Government)	2	34.0%	Closure: All except for emergency services
63	Education	1	73.4%	

[a] Telecommuting adjustment is based on data presented in Table A2.

[b] The following designations pertain to entire states or parts of some states that had implemented "Stay-at-Home" orders as of April 7 (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. Note that all sectors that fall under the third category are assumed to experience zero reduction in their production level. Therefore, we have omitted these sectors in this table. The reader is referred to the following link for a description of the full list of GTAP sectors https://www.gtap.agecon.purdue.edu/databases/contribute/detailedsector.asp.

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).