



# The impact of COVID-19 on global value chains: Disruption in nonessential goods production

Joao-Pedro Ferreira<sup>1</sup> | Pedro Ramos<sup>2</sup> | Eduardo Barata<sup>2</sup> |  
Christa Court<sup>1</sup> | Luís Cruz<sup>2</sup>

<sup>1</sup>Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida, Florida, USA

<sup>2</sup>CeBER – Centre for Business and Economics Research, Faculty of Economics, University of Coimbra, Portugal

## Correspondence

Joao-Pedro Ferreira, Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida, Florida, USA.  
Email: joao.ferreira@ufl.edu

## Abstract

Public health measures enacted to mitigate the spread of coronavirus disease 2019 (COVID-19) have dampened economic activity by shuttering businesses that provide ‘nonessential’ goods and services. Not surprisingly, these actions directly impacted demand for nonessential goods and services, but the full impact of this shock on the broader economy will depend on the nature and strength of value chains. In a world where production chains are increasingly fragmented, a shock in one industry (or a group of industries) in one country will affect other domestic industries as well as international trade, leading to impacts on production in other countries. We employ the World Input–Output Database to depict the interdependencies among both industries and countries, which provides a full representation of global value chains. By assuming a homogeneous impact on demand for nonessential goods and services around the world, we demonstrate asymmetric effects on production by industry and international trade, leading to asymmetric relative impacts on national economies. Our results indicate that if demand for nonessential goods and services decreases by 50%, the global gross domestic product will decline by 23%, leading to relative impacts that are larger in China, Indonesia, and some European countries. Also,



international trade declines by almost 30%, largely due to a reduction in economic activity associated with the production of raw materials and certain types of manufacturing. This work highlights the relevancy of going beyond measuring the direct effects of COVID-19 and provides insights into how international trade linkages will induce broader economic impacts across the globe.

#### KEYWORDS

COVID-19, global value chain, input-output, international trade, WIOD

## 1 | INTRODUCTION

In January 2020, the World Health Organization acknowledged the existence of a novel coronavirus (later labeled SARS-CoV-2) and by March had declared the associated novel coronavirus disease (COVID-19) a pandemic. Concerns about the infection rate and severity of COVID-19 led national and local governments around the world to enact restrictive public health measures to mitigate its spread. The various public health measures imposed significantly affected both the supply and demand sides of the economy. Forced and voluntary business closures significantly affected the supply of goods and services in many industries. Employee absences due to illness or quarantine and the implementation of physical distancing measures within the workplace have also altered production within firms that have remained operational. The impacts were severe. In the case of the USA, after experiencing a 50-year low in unemployment levels in February of 2020 (3.5%, 5.8 million people unemployed), over 16.5 million individuals were unemployed by 4 April 2020 (approximately a 15% unemployment rate), just 6 weeks/months after the first pandemic-related shutdowns within this country.

In addition, travel bans and social/physical distancing measures enacted by national and local governments or by individual businesses as well as consumers' willingness to risk personal infection significantly altered aggregate demand for various goods and services. Consumers were forced to adapt to limited offerings or availability, quantity restrictions, and the closure of businesses, which all affected spending patterns. Consumer behavior was also impacted by changes in household income levels resulting from layoffs, furloughs, and reductions in work hours. This will also affect intermediate consumption of inputs in a way we are still far from understanding. So, despite all of these insights and the time that has now elapsed since the beginning of the pandemic, the ultimate impacts of COVID-19 in each sector and each region (or country), as well as worldwide, are still far from being fully observed and understood.

To overcome our lack of knowledge and limited capacity to comprehend the complexity of this crisis, Krugman (2020) provided a theoretical model of the economy during this pandemic. He describes an economy 'consisting of two sectors, nonessential services (N) that we can shutdown to limit human interactions and hence the spread of the disease, and essential services that we can't (or perhaps don't need to, because they don't involve personal interactions).' The closure of nonessential businesses can also be thought of as declines in demand for nonessential goods and services. Whether declines in business activity result from mandated closures or changing consumption patterns, the resulting declines in sales revenues for operations that are deemed nonessential, and are often reliant on tourism, mass gatherings, or personal interactions with customers, are only the tip of the iceberg in terms of the economic impacts of the COVID-19 pandemic. The metaphorical iceberg of economic impacts extends well below the surface, comprising indirect effects resulting from altered supply chain purchasing of the shops and firms that were closed or saw direct reductions in sales. Even activities deemed as essential are affected. The study



of value chains has demonstrated that the indirect effects of a shock can redistribute the initial impacts through international trade, which can affect both national and international production. The overall impacts of this crisis will be determined by interdependencies among industries, consumers, and national economies on a global scale.

To shed light on the role of these global interdependencies, this work assesses the direct and indirect impacts associated with three scenarios. The first scenario consists of a global homogeneous decline in demand for nonessential goods and services. While such a homogeneous shock is unrealistic, it is used to demonstrate how global value chains captured within a multicountry input–output (I–O) framework can highlight the heterogeneous effects of an ‘apparently’ identical shock. Two additional scenarios are presented to complement the insights provided in the first. The second scenario assumes a heterogeneous decline in nonessential products based on data measuring changes in consumption behavior that occurred during the pandemic. A third scenario is performed to provide insights on the potential impacts of a global increase in government and nonprofit institutions serving households (NPISH) health-related expenditures. Results from all three scenarios demonstrate that trade relationships as well as heterogeneous production technologies determine country-level impacts, which can be significantly different than the distribution of the initial shock. The results also highlight the potential for significant effects within industries deemed essential and allowed to continue operations even under lockdown measures as they often provide critical inputs for the production of nonessential goods and services.

## 2 | GLOBAL VALUE CHAINS, COVID-19, AND INDIRECT IMPACTS

As a society, we are still trying to understand the changes in behavior experienced by both firms and consumers due to the changing nature of normal activities being banned and/or discouraged amidst effort to curb the spread of COVID-19. Forecasts of socioeconomic impacts of these behavior changes that are based on historical data seem useless in attempts to understand such an unprecedented event. Yet, there is an established literature that has identified how production and international trade are increasingly interlinked and fragmented through a mechanism known as global value chains (GVCs). Countries, regions, and economic structure matter (Yeung, 2015). De Gortari (2019: 1) argues that ‘quantifying the effects of economic shocks in a world of highly fragmented production requires a more accurate and systematic understanding of the global value chains (GVCs) underlying world trade’. The literature on GVCs has inspired this attempt to provide insights on the impacts of a disruption in nonessential products.

In the last 50 years, the share of exports in global gross domestic product (GDP) went from 13% in 1970 to 30% in 2018. Arndt and Kierzkowski (2001) use the term ‘fragmentation’ to describe the growing trend of international sprawling of production supply chains, whereby different parts of a certain final product are produced all around the world. This process is also described by Del Prete et al. (2017) for the case of North African countries, while Schwörer (2013) puts a major emphasis on the outsourcing of services. As economies become more interdependent, final products can include components made in more than 50 countries.<sup>1</sup> This phenomenon suggests that when a certain industry located in a specific region suffers a shock, indirect impacts of that event will be felt throughout the world. The magnitude of the impacts experienced by a sector in each country will depend on the origin and value of inputs used in the sector’s production phase but also on the origin and value of the input goods and services associated with these inputs, and so on through multiple rounds of spending.<sup>2</sup>

The release of the 2016 version of the World Input–Output Database (WIOD) provided new macroeconomic evidence of increasing international dependence. Using this database, Los et al. (2015) concluded that the share of value added that ‘escapes’ from the country where the final transaction takes place has increased substantially since 1995. Caraballo and Jiang (2016) also conclude that, between 1995 and 2008, many countries experienced a decline in the sectoral shares of domestic value added within exports, as the country becomes more integrated into GVCs – a phenomenon that they termed ‘value-added erosion’. Galbusera and Giannopoulos (2018) underline the capacity for I–O models to transparently estimate the indirect effects that emerge from an initial shock. Accounting for the



totality of economic activity involved in a commodity's production through GVCs is critical when faced with estimating the impacts of global disasters. Okuyama and Santos (2014) and Koks and Thissen (2016) argue that an I-O model allows for the identification of (i) the production losses in the affected regions and other regions, (ii) the required production in other regions necessary to take over lost production in the affected regions, (iii) the required production to satisfy reconstruction of infrastructures, and (iv) the regional welfare distribution effect of the increased production inefficiencies in the economic system due to the disaster. Hence, the incorporation of knowledge on trade, global interdependencies, heterogeneous technological production, and geography can help to shed some light on additional economic impacts of the current pandemic.

As Krugman (2020) points out, the extent of the COVID-19 shock is more akin to a global disaster than a simple recession, with a substantial part of the economy shutting down or limiting production overnight, with reopening or returning to some semblance of normality often not occurring for weeks or even months. From an economic perspective, the ignition of this crisis is the adoption of public health measures that lead to the total or partial shutdown of nonessential businesses. This direct shock was followed by indirect effects throughout GVCs as directly affected businesses reduced their intermediate consumption and distribution of income. This sharp decline in revenues within nonessential industries was observed in several industries (Watanabe, 2020). There are several examples of declining industries worldwide. True Car's ALG (2020) reported a decline in sales revenue of 52% in March and April 2020. The International Civil Aviation Organization (ICAO) reported a decline of more than 60% in total flights, with international flights declining by more than 70% in some countries (ICAO, 2021). The United Nations World Tourism Organization (UNWTO) predicted a decline of 60–80% in the number of tourists in 2020 (UNWTO, 2020). The sales of clothing and footwear in the United Kingdom alone declined by more than £11 billion (Entrepreneur, 2020). From cars to clothing sales, these are just a few examples of nonessential industries directly impacted by public health measures to limit social interactions in an attempt to mitigate the spread of COVID-19. In this analysis, we defined non-essential according to the rules put in place by different countries.<sup>3</sup> Arndt et al. (2020) also distinguish essential and nonessential industries to study the economic impacts of COVID-19-related lockdowns in South Africa. Bonet-Morón et al. (2020) use another terminology and refer instead to the existence of vulnerable sectors in Colombia.

Near the beginning of the pandemic, other works aimed to analyze how direct impacts reverberate throughout the economy. Arndt et al. (2020) studied the implications of lockdown policies for income distribution and food security in South Africa and concluded that social protection measures (such as stimulus checks and government expenditures) can have a positive economic effect during the pandemic. Fadinger and Schymik (2020) used I-O techniques to assess the regional distribution of economic impacts in Germany and highlighted that the regions that could potentially benefit the most from loosening restrictions were the ones with an industry structure that was not conducive to working from home. Finally, Bonet-Móron et al. (2020) studied the impacts on the Colombian economy via seven scenarios that vary according to the percentage of total workers complying with isolation measures. By using a multiregional I-O model, the authors produce valuable insights about regional vulnerability in Colombia. In the works mentioned, the I-O model is applied exclusively at the regional and national level. The present analysis employs a multicountry framework to endogenize the role of GVCs and international linkages in the propagation of a shock.

It is important to recall that the unprecedented nature of this pandemic reduces the forecast capacity of all economic models that are based on historical data. However, detailed economic data reflecting the actual changes in firm and consumer behavior throughout this event will likely not be available for several years. Distinct scenarios are used to simulate the macroeconomic implications of specific economic features of international trade. Characteristics that have been developed in more advanced I-O models are not addressed here as it is still too soon to determine how COVID-19 affected final demand, as well as intersectoral and international relationships. As an example, we could theoretically consider the impacts of price changes as suggested by Kratena and Streicher (2017); however, according to the International Monetary Fund (Ebrahimi et al., 2020), data on price changes are currently scarce and preliminary, and reflect contradictory changes across countries and products. Nevertheless, modeling price changes and changes in trade patterns is an important avenue for future research. Additional advances and applications will



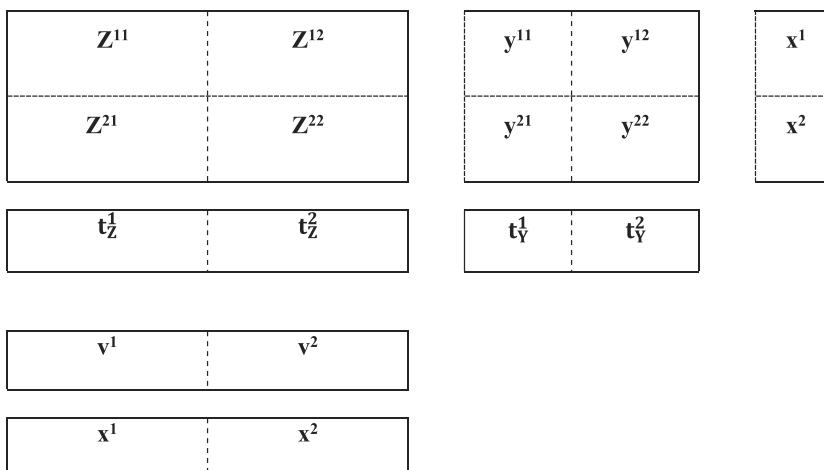
surely emerge as soon as better data become available, allowing researchers to make better use of advanced I-O techniques, incorporate changes in the economic structure, model the existence of substitution effects, account for uncertainty regarding inflation or wages, and provide a better specification of changes in government expenditures as they responded to the pandemic and its aftermath.

### 3 | MULTIREGIONAL I-O ANALYSIS AND WIOD

To trace the GVC and to accurately allocate a hypothetical decline in the production of nonessential goods and service by sector and country, we employ the World Input-Output Database (WIOD). This framework incorporates information on production technologies and trade amongst different industries and countries and allows for the estimation of spillover effects that characterize the GVCs. The structure of the WIOD database is similar to the design shown in Figure 1, but it has 1,936 submatrices representing the interaction of 44 economies (43 countries plus the Rest of the World [ROW]). WIOD is a multicountry I-O table containing yearly data for 56 industries from 2000 to 2014 (Dietzenbacher et al., 2013; Timmer et al., 2015). This application makes use of the most recent data year available (2014).<sup>4</sup> Values are presented in US\$ millions.<sup>5</sup>

WIOD follows the traditional form of a symmetric MRIO table as described by Miller and Blair (2009). This structure is shown in Figure 1 for a two-country example, where the two countries exhaust the world, such that no exports or imports to/from the rest of the world are taken into account.

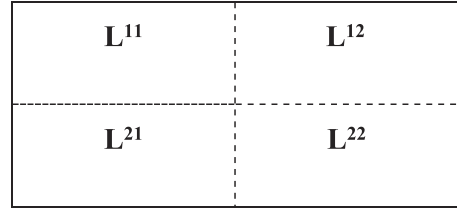
$Z$  is the intermediate consumption matrix and comprises the value of inputs consumed by each sector within the respective production process.  $Z^{11}$  and  $Z^{22}$  are the value of intermediate consumption produced and consumed in the same region.  $Z^{12}$  comprises the value of products produced in region 1 and used by industries located in region 2.  $Z^{21}$  and  $Z^{11}$  correspond to the value of international trade associated with intermediate consumption. In the case of WIOD, the upper-left matrix  $Z$  ( $2,464 \times 2,464$ ) represents value of global intermediate demand. Next,  $y$  refers to the value of final demand for products produced in both regions. As in the case of intermediate consumption,  $y^{11}$  and  $y^{22}$  are vectors representing the value of products produced and sold in the same region/country.  $y^{12}$  and  $y^{21}$  are the values of international exports (and simultaneously imports) of products.  $y^{11}$  and  $y^{12}$  are the total value of sales in region 1 to satisfy final demand, independent of the origin of production (region 1 or 2). The columns in both  $Z$  and  $y$  represent the requirements of products by industries (in their production process,  $Z$ ) and final demand components ( $y$ ). The rows represent the uses of each industry.



**FIGURE 1** Input-output structure with two regions



**FIGURE 2** Structure of a multiregional Leontief inverse matrix



Vector  $v$  corresponds to the value-added of the industries that are located in both regions ( $v^1$  and  $v^2$ ).  $t_z$  and  $t_y$  correspond to the value of taxes on products (less subsidies) falling upon the intermediate consumption or the final demand purchases.  $x$  is the vector that corresponds to the value of total output from industries (at basic prices) in both regions ( $x^1$  and  $x^2$ ). The value for each industry in each row and column must be the same. The value in the bottom row corresponds to the sum of total production costs including compensation of employees and capital compensation in both regions. All these values must be equal to the total of sales by each sector in each region.

In this case, we calculate an ‘open’ Leontief matrix, where intermediate consumption is endogenous while all final consumption and other demands are exogenous. The Leontief matrix ( $L$ ) is calculated as follows. First, estimate the direct requirements matrix,  $A$ , by dividing each column representing the intermediate consumption of each industry (in the  $Z$  matrix) by the total output per industry ( $x$ ). The Leontief matrix can then be estimated as the matrix inverse of the difference between the identity matrix,  $I$ , and the direct requirements matrix.

$$L = (I - A)^{-1} \tag{1}$$

where  $I$  has the same dimension as matrix  $A$ . This matrix can be partitioned in different submatrices as follows:

Submatrices  $L^{11}$  and  $L^{22}$  allow us to calculate the impact (in terms of total output  $\Delta x$ ) of changes in the final demand ( $\Delta y$ ) directed towards sectors of activity in the same location where the shock occurs. Otherwise, the other off-diagonal submatrices represent the interregional multipliers that are commonly associated with spillover effects. In the two-region example, a shock in region 2 will also have an impact on industries located in region 1, and the relationships that will determine these spillover effects are represented in the quadrant  $L^{12}$ .

The multiplier matrix is typically defined in terms of industry output but can be converted to represent other economic indicators such as gross value added (GVA), which is a close representation of the GDP. To do this, a simple step must be applied:

$$W = \hat{w}L \tag{2}$$

where  $\hat{w}$  is a diagonal matrix of value-added coefficients (value-added per unit output ratios) for each industry in each country. The same can be done in terms of employment by applying instead a diagonal matrix of employment per unit output ratios.

$$E = \hat{e}L \tag{3}$$

The multipliers represented in each matrix ( $L$ ,  $W$ , and  $E$ ) include the direct and indirect effects and are used to estimate the impacts of real or hypothetical changes in the final demand ( $\Delta y$ ).

In the case of WIOD, the final demand is disaggregated in ‘Households expenditures’, ‘Non-profit organizations (NPISH)’, ‘Government expenditures’, ‘Gross fixed capital formation’, and ‘Changes in inventories and valuables’. WIOD also includes information on the aggregate ‘Direct purchases abroad by residents’ and ‘Purchases on the domestic territory by non-residents’, which allows for the characterization of the exports and imports associated



with tourism. Finally, on the WIOD webpage, a socioeconomic accounts appendix is available, which contains industry-level data on jobs and the compensation of employees, among other variables.

## 4 | SCENARIOS: NONESSENTIAL GOODS DECLINE AND THE INCREASE OF HEALTH-RELATED EXPENDITURES

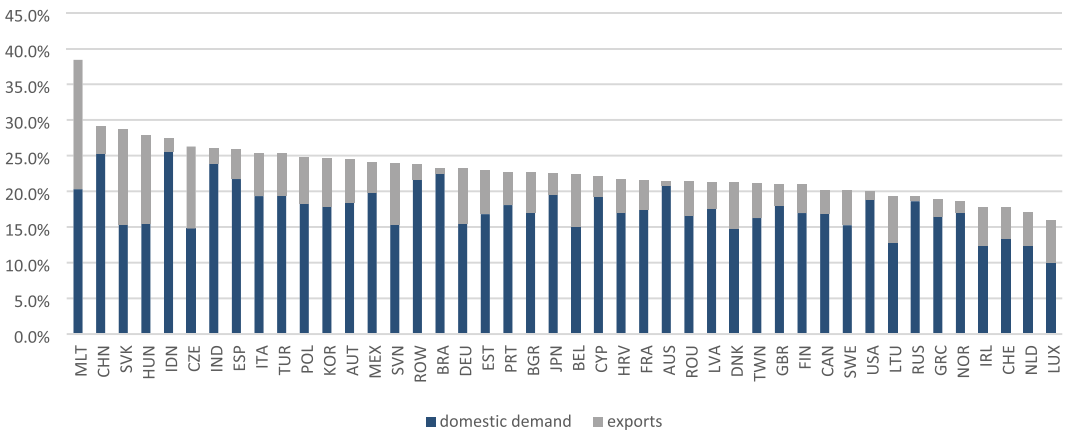
Linkages established through international trade determine the distribution of economic shocks throughout distinct national economies. In the context of the economic crisis associated with the COVID-19 pandemic, the assessment of a shock in nonessential goods and services production is critical to understanding which nations are more vulnerable to significant impacts. In this work, the nonessential goods are defined as those mentioned in official documents for the USA (Identifying Critical Infrastructure during COVID-19, CISA, 2020), the UK (Critical Workers information, GOVUK, 2020), and the European Union (Policy measures taken against the spread and impact of the coronavirus – 7 May 2020, EC, 2020). The duration and nature of the economic changes brought about by lockdowns, social distance measures, and the ‘new normal’ behavior are far from being understood. This exercise is not a forecast of the total economic impacts of the COVID-19 pandemic but merely a scenario analysis to provide information and insights upon accounting for GVCs. Two of the scenarios implement a hypothetical shock in the nonessential goods and services. The list of 31 (out of the 56) industries assumed to be nonessential is based on the restrictive measures adopted by several countries (detailed in Section 2) and is presented in Appendix 1.<sup>6</sup> Then, a third scenario reallocates expenditures towards health-related products, namely through the increase of expenditures within government and nonprofit institutions serving households (NPISH). The results for each of these three scenarios are presented in this section.

Each scenario serves a specific purpose. The first and most comprehensive scenario highlights the distortions that international trade, production, and value chains create in the global context. The goal is to understand how, due to sectoral interdependencies, a hypothetical homogeneous decline ends up generating heterogenous impacts in terms of value added, employment, and trade balance. Understanding such relationships and their implications is essential to promote better national, regional, and sectoral policies. For the sake of simplicity, this scenario assumes a 50% decline of total final demand in nonessential products in every country.<sup>7</sup> This reduction in demand is assumed to affect equally the demand satisfied by domestic supply and that resulting from imports.

The second scenario has similarities with the first, as it specifically targets nonessential products. However, the decline in nonessential products is now based on the relative decline in the number of visitors to places of retail and recreation in 2020 - Google COVID-19 Community Mobility Trends (Google, 2020).<sup>8</sup> In this second scenario, countries that have imposed more restrictive measures suffer a relatively more severe shock. Finally, the third scenario assumes a 10% increase in the expenditures of government and nonprofit organizations associated with the health sector as a possible way to (partially) counterbalance the negative effects of this pandemic.

### 4.1 | Scenario 1 – a homogenous decrease in nonessential goods final demand

In this subsection we present the results for the first scenario. A homogeneous shock equally affects the final demand of all nonessential goods and services (a 50% decrease) in all economies. Macroeconomic imbalances transform this apparent equal shock into an asymmetric impact for two main reasons: (1) the share of nonessential products in the national demand is different in each economy and (2) some countries provide a higher share of such products for other economies. These global interdependencies should be accounted for when providing information and insights to decisionmakers. To exemplify how this homogeneous shock instantly generates a distinct impact in the different economies, Figure 3 displays the decline in the share that was due to a decrease in domestic



**FIGURE 3** Decrease in the final demand directed towards industries located in each country due to domestic and abroad expenditure (as % of final demand)

destinations or, alternatively, to a decrease in the demand of other countries (and, therefore, a reduction of exports to those countries).

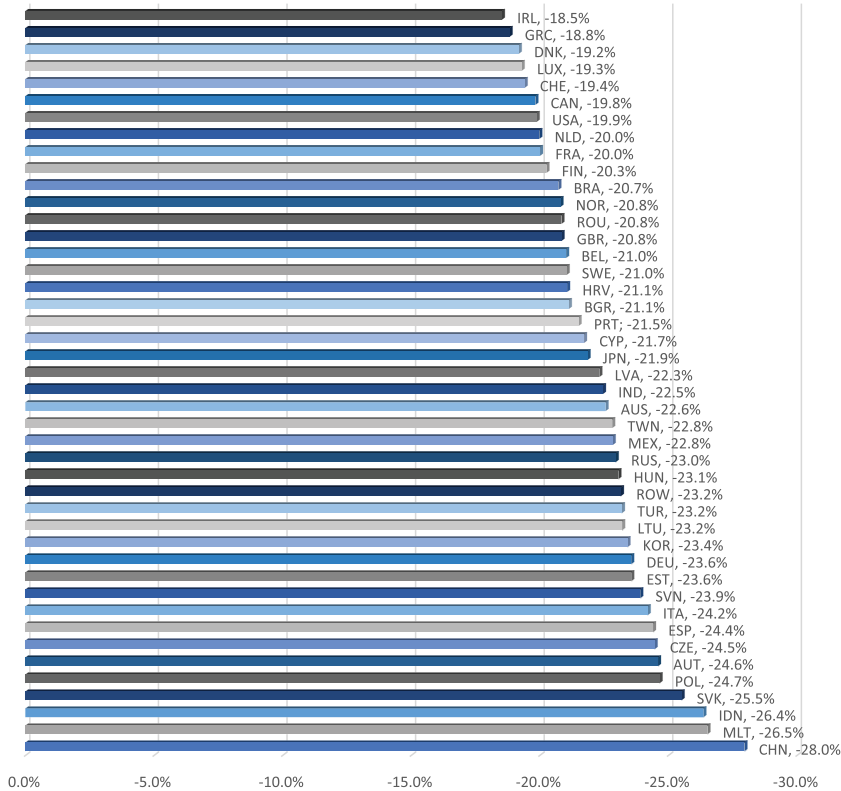
Figure 3 indicates that Malta is the country that is ‘most affected’ by the direct impacts of this hypothetical scenario in terms of final demand changes. Total final demand decreases by 38%, 47% of which results from a decline in exports and 53% from decreases in domestic final demand. Other countries with significant exposure to declines in the final demand of nonessential goods and services in other countries are Slovakia, Hungary, and Cyprus. For these economies, the decline in overall final demand is 47%, 45%, and 44% motivated by the decline in exports for final demand, respectively. At the world level, this initial impact results in a reduction of world output by 10.6% and a reduction of world final demand by 22%.

Now applying Equation (1) to (3), we estimate how such impacts in final demand will reverberate through the rest of the economy via global supply chains. The composition of global value chains, international trade, and economic structures determines the manner in which the initial shock affects distinct sectors and different countries. Figure 4 shows the total GVA impacts for each country, after accounting for indirect impacts across all sectors.

By comparing with the results in Figure 3, it is clear that the indirect impacts of the initial final demand shocks, and hence the total impacts, are distributed across countries in a different pattern than direct impacts. Such results highlight the asymmetric nature of indirect impacts. The economy with the sharpest decline in total GVA impacts is China, followed by Malta, Indonesia, and Slovakia. These economies observe a decline of more than 25% of their GVA. Alternatively, seven economies, all from Europe and North America, each experience a decline of less than 20% of GVA. Ireland and Greece are the two countries with the smallest reduction in GVA, followed by Denmark, Luxembourg, Switzerland, Canada, and the USA. Overall reduction in global GVA for this scenario is 22.5%. Economic impacts of such magnitude imply that significant impacts in international trade are also expected, which indicates that the balance of payments of countries will also be affected. Figure 5 displays how these combined effects impact exports from each country.

On the global scale, exports decline by 29.9%. Turkey, Japan, and Italy experience the largest declines in exports. Twenty economies observe a decline in exports of more than 30%, only two experience a decline of less than 25% (Luxembourg and Switzerland), and only one declines less than 20% (Ireland). However, exports are only one side of the trade balance. As countries experience different impacts in terms of exports, they also experience distinct impacts on imports. On a global scale, change in exports will balance with the change in imports; however, some countries are expected to experience negative impacts to their balance of payments while others are expected to





**FIGURE 4** Total GVA impacts by country

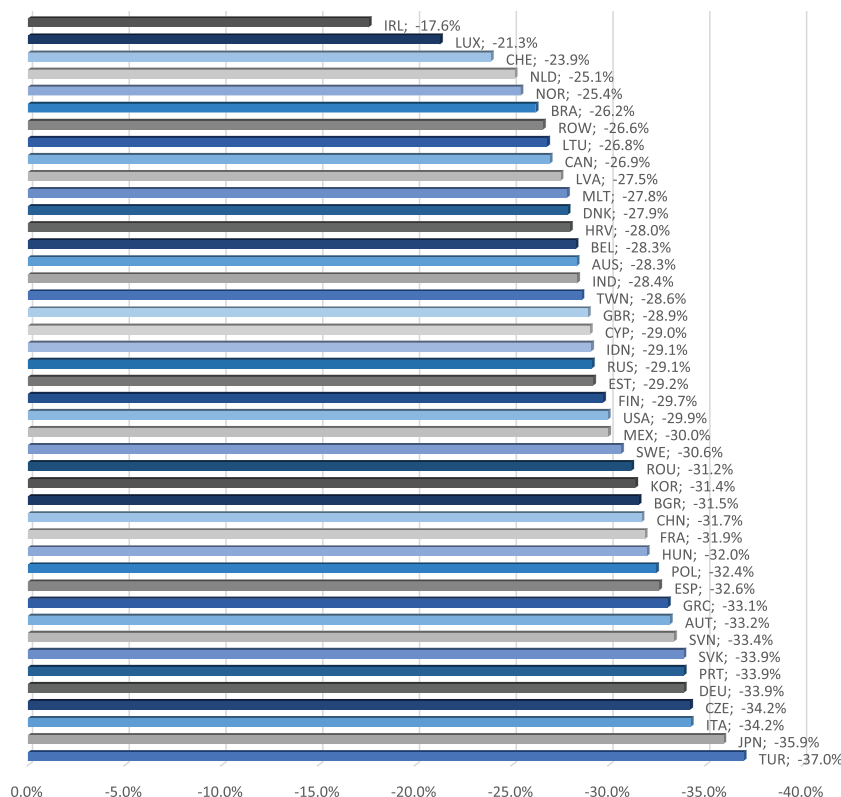
experience positive impacts depending on how exports and imports change. The results for each economy in terms of net exports are shown in Figure 6.

Measured as a share of GVA, Luxembourg, Czech Republic, and Malta experience the largest declines in terms of net exports. Other countries are expected to experience a decline in imports that is larger than their decline in exports. In this scenario, the Rest of the World region, Australia, Brazil, and Latvia improve their balance of payments. The only other country from the European Union that might expect a positive outcome in terms of its balance of payments is Ireland. Acknowledging and understanding the implications of changes in international trade that result from COVID-19 mitigation measures is an important insight for policymakers as they consider implementing or retracting such measures during the remainder of the pandemic and as they design post-COVID policies.

Impacts in terms of employment are displayed in Figure 7. Owing to differences in national economic structure and national/sectoral differences in labor productivity, the magnitude of total impacts on employment are different than those experienced on GVA for each country (see differences in Figure 4 and Figure 7).

In terms of total employment impacts, Southern European countries are now relatively more affected. Italy, Spain, Cyprus, Malta, and Portugal are all in the top 15 affected economies. Alternatively, India and Romania are expected to lose less than 20% of their employment. Results from Figures 4 and 5 indicate that countries such as Italy and Spain will experience significant impacts in low-labor-productivity sectors, while countries such as Romania or Indonesia will experience the opposite. This brings to light how sectoral changes, which result from different national economic structures, are crucial to an understanding of the scope and magnitude of results. Figure 8 shows results in terms of output decline due to indirect effects for each sector of the global economy.

Figure 8 highlights how results are influenced by the way industries produce inputs that are then incorporated into nonessential products. Indeed, 'Manufacture of basic metals' (C24) declines almost 36%, in terms of industry

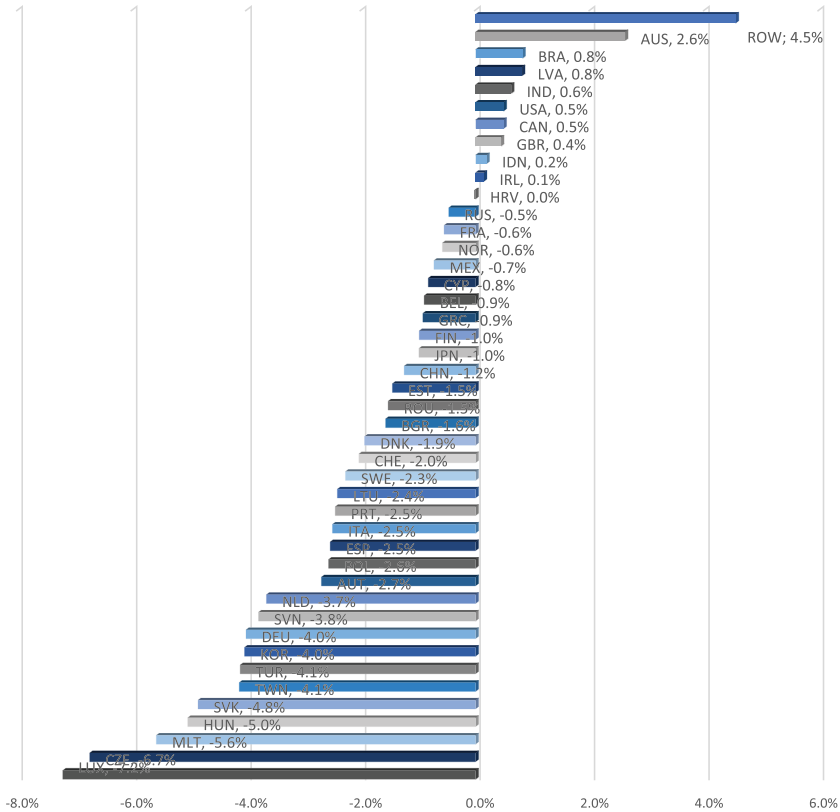


**FIGURE 5** Decline in exports in the different economies

output, exclusively owing to indirect effects. As shown in Appendix 1, only 4% of this sector’s production is directed towards final demand, implying that simple analyses based only on direct shocks to final demand, that do not consider sectoral linkages and global value chains, would miss such a substantial impact in this sector. Similar impacts are demonstrated for ‘Mining’ (B), the second-most affected sector. In this hypothetical scenario, the indirect effects account for a decline of 32% in this sector, in terms of global output. The other three sectors experiencing global output declines of more than 20% due to indirect effects alone are ‘Wholesale trade, except of motor vehicles and motorcycles’ (G46) (27%), ‘Electricity, gas, steam and air conditioning supply’ (D35) (23%), and ‘Manufacture of chemicals and chemical products’ (C20) (23%). The shock in the electricity sector is critical. This is an essential good and, even if no initial reduction is considered, this sector ends up being one of the most affected. This type of information can support better national and regional policies in the context of the current economic decline. Finally, the sectors that are less affected correspond to industries that are essential and, simultaneously, do not provide relevant intermediate inputs to the production of nonessential goods. Among the industries that experience a decline of less than 1% are ‘Human health and social work activities’ (Q) (−0.6%), ‘Fishing and aquaculture’ (A03) (−0.9%), and ‘Water collection, treatment and supply’ (E36) (−0.9%).

Finally, having demonstrated that the hypothetical shock to the final demand of nonessential goods and services and tourism will reverberate across sectors and national economies in different ways, Table 1, presents for each country, the three products that experience the largest decline in terms of exports, in the context of this first hypothetical COVID-19 scenario, and the share of each country’s total exports that these declines represent.

This table illustrates how the role of different sectors varies across the different countries in terms of production for exports. For example, ‘Mining’ (B) is the major contributor to reduced exports in countries such as Australia,

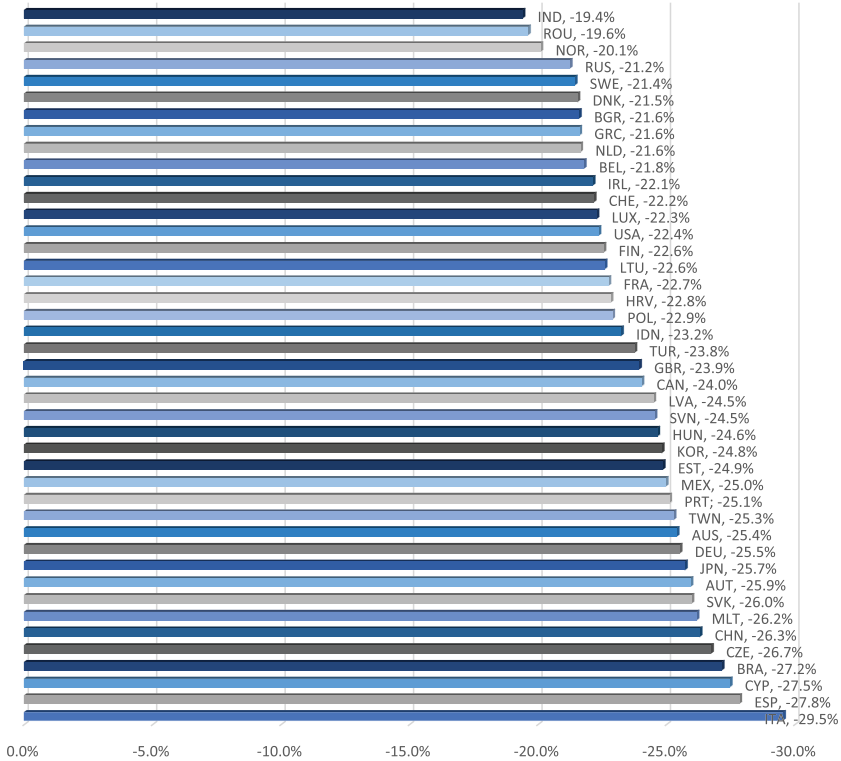


**FIGURE 6** Changes in net exports as a share of the national GVA

Brazil, Canada, Indonesia, Norway, Russia, and the Rest of the World. Alternatively, the reduction in nonresident expenditures (NRE) is the major contributor to the decline in exports in five countries, mostly Mediterranean countries and the USA, and it is among the top three sectors in 17 countries. ‘Manufacture of basic metals’ (C24), the industry shown to be most affected by indirect effects in Figure 8, is primarily responsible for the decline in exports in only one country, indicating that this decline is mostly a result of the manner in which this sector interacts with other industries in terms of intermediate domestic trade. Indeed, the other sectors that significantly influence exports are ‘Manufacture of motor vehicles, trailers and semi-trailers’ (C29), ‘Wholesale trade, except of motor vehicles and motorcycles’ (G46), ‘Manufacture of machinery and equipment n.e.c.’ (C28), and ‘Manufacture of textiles, wearing apparel and leather products’ (C13–C15). Finally, the potential of this technique can be underscored by showing how it is capable of identifying the indirect impacts in distinct countries that occur in ‘outlier’ sectors that majorly affect the decline in exports such as ‘Computer programming, consultancy and related activities; information service activities’ (J62–J63) in Ireland and ‘Financial service activities, except insurance and pension funding’ (K64) in Luxembourg.

## 4.2 | Scenario 2 – a heterogeneous decrease in nonessential goods final demand

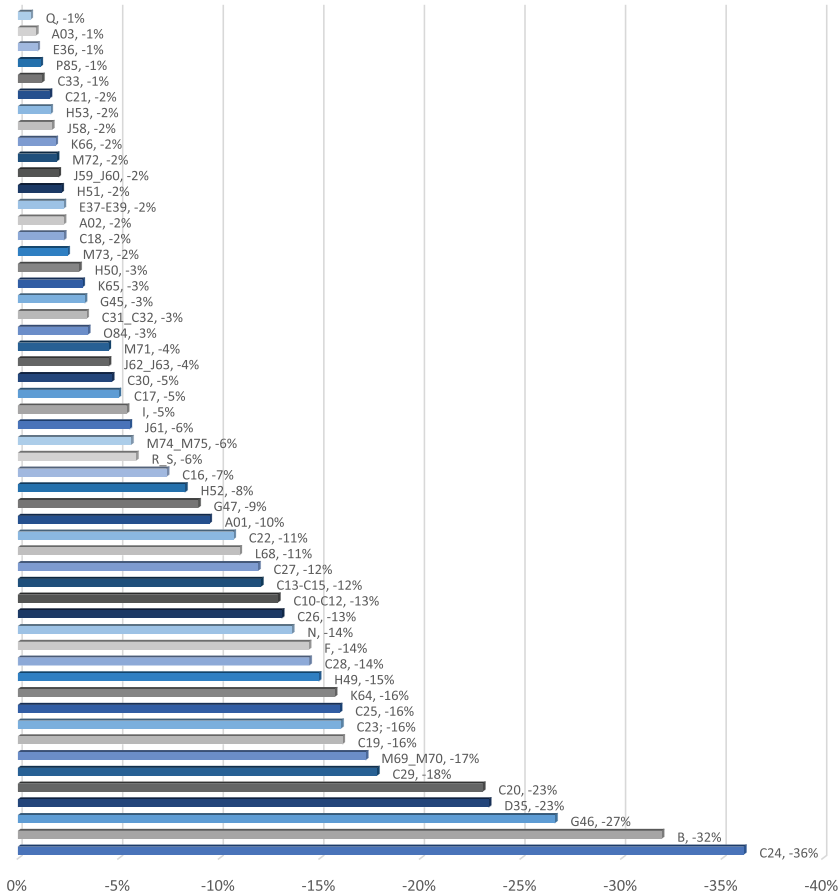
Scenario 2 also involves a decline in the demand for nonessential goods and services, but at different scales for each country. Google COVID-19 Community Mobility data, which provide a measure of the scale of reduction in visitors



**FIGURE 7** Decline in employment by country

to retail and recreation places such as grocery and specialty food stores, drug stores, restaurants and cafes, shopping centers, theme parks, museums, libraries, and movie theaters, are used to approximate country-specific declines in production. Once again, the changes in production within this scenario are hypothetical, as changes in visitation are unlikely to translate directly into changes in expenditures and economic activity. As in Scenario 1, and in the absence of better data, Scenario 2 assumes that the country-specific reductions in demand approximated by the Google COVID-19 Community Mobility data apply equally to all sectors producing nonessential goods and services. Table 2 presents the estimated decline in demand for nonessential goods and services together with the initial shock. Any shock can be measured in terms of production or also in terms of place of production, as consumption in country A can be satisfied by production from country B. Table 2 presents the shock both in terms of place of consumption and place of production. The final four columns present the results of the scenario, that is, the total (direct and indirect) economic impacts in terms of both GVA and employment.

In this scenario, India, China, Spain, Turkey, and Malta continue to experience large declines in GVA. In this case, it is a result of the initial shock but, as depicted in scenario 1, it is also a consequence of economic structure and participation in global value chains. In this scenario, China and Brazil experience a similar decline in their nonessential goods and services consumption, but China is expected to suffer major declines in GVA. However, this is not true in terms of employment, again demonstrating that economic structure can influence each economic dimension or variable differently. When compared with GVA, the impact on employment is relatively higher in countries such as Italy, Brazil, Spain, Ireland, Great Britain, and Portugal that are more reliant on labor-intensive activities such as tourism and food services. Finally, this scenario also suggests a significant reduction in world GVA (11.3% decline) and employment (14.9% decline).



**FIGURE 8** Output decline due to indirect effects by sector, at the world level

### 4.3 | Scenario 3 – an increase in health-related expenditures

Confronted with the obvious decline in economic activity brought on by the COVID-19 pandemic, national governments are being called on to provide incentives and to stimulate their economies. This has been happening in two distinct ways. On the one hand, governments adopt economic packages that include fiscal, monetary, and financial policy measures to counterbalance losses incurred by households, firms, and the financial system (Elgin et al., 2020). The nature of these interventions varies significantly in breadth and scope across countries (Weder, 2020). On the other hand, governments have increased expenditures associated with health-related goods and services to combat the pandemic and protect public health. Such increases in health-related expenditures have been addressed in Porsse et al. (2020) for the case of Brazil. The ongoing nature of both types of stimuli and the heterogeneity in their application across countries makes the development of realistic scenarios quite difficult. Here, we assess the (direct and indirect) economic impacts of a hypothetical 10% increase in expenditures by governments and nonprofit institutions serving households (NPISH) in the ‘Manufacture of basic pharmaceutical products and pharmaceutical preparations’, ‘Scientific research and development’, and ‘Human health and social work activities’.<sup>9</sup> Initial levels of final expenditures on health-related products by governments and the ‘third sector’ (NPISH) can represent very different weights in the economy, influencing the size of the initial shock. Table 3 illustrates both the initial shock to final demand for Scenario 3 and the total economic impacts of these expenditures’ changes.

**TABLE 1** Top three sectors contributing to declines in national exports

Country	Top 1	Top 2	Top 3
AUS	B (47.2%)	C24 (13.4%)	G46 (6.9%)
AUT	C28 (12.5%)	NRE (10.4%)	C29 (6.3%)
BEL	C20 (11.2%)	C29 (9.0%)	C19 (8.0%)
BGR	C24 (12.8%)	NRE (7.5%)	G46 (5.6%)
BRA	B (19.1%)	C24 (10.7%)	C29 (7.8%)
CAN	B (14.4%)	C29 (13.6%)	C24 (8.6%)
CHE	G46 (19.5%)	NRE (11.3%)	C26 (8.5%)
CHN	C26 (22.7%)	C13-C15 (14.8%)	C27 (9.8%)
CYP	NRE (19.2%)	H50 (13.3%)	H52 (5.8%)
CZE	C29 (26.9%)	C28 (9.7%)	C26 (9.0%)
DEU	C29 (22.2%)	C28 (15.3%)	C20 (7.2%)
DNK	H50 (24.9%)	G46 (13.0%)	C28 (8.6%)
ESP	NRE (16.0%)	C29 (5.9%)	C20 (5.4%)
EST	C26 (13.7%)	C16 (10.1%)	NRE (8.5%)
FIN	C28 (16.9%)	C17 (10.9%)	C26 (8.2%)
FRA	G46 (11.8%)	C30 (10.9%)	NRE (9.0%)
GBR	G46 (11.0%)	NRE (8.3%)	C29 (6.4%)
GRC	NRE (27.1%)	H50 (13.0%)	C19 (6.0%)
HRV	C25 (9.3%)	B (9.2%)	G47 (6.5%)
HUN	C29 (29.6%)	C26 (11.6%)	C28 (7.9%)
IDN	B (20.3%)	C13-C15 (14.5%)	C10-C12 (7.3%)
IND	C13-C15 (14.9%)	C19 (8.3%)	C24 (8.1%)
IRL	J62_J63 (13.2%)	G46 (10.0%)	C26 (8.6%)
ITA	C28 (18.0%)	C13-C15 (11.5%)	NRE (7.8%)
JPN	C29 (22.7%)	C26 (11.6%)	G46 (9.7%)
KOR	C26 (22.0%)	C29 (13.2%)	C30 (10.6%)
LTU	G46 (14.8%)	C19 (12.1%)	C31_C32 (9.0%)
LUX	K64 (35.8%)	NRE (9.5%)	G46 (8.9%)
LVA	C16 (13.6%)	G46 (10.1%)	H52 (7.5%)
MEX	C29 (22.8%)	C26 (19.0%)	B (7.9%)
MLT	R_S (31.8%)	K64 (22.6%)	NRE (3.9%)
NLD	G46 (11.7%)	C20 (10.7%)	M69_M70 (8.5%)
NOR	B (40.5%)	H50 (11.0%)	C24 (6.5%)
POL	C29 (11.4%)	G46 (7.5%)	G47 (6.3%)
PRT	NRE (11.5%)	G46 (9.5%)	C13-C15 (9.4%)
ROU	C29 (12.7%)	C27 (8.5%)	H49 (7.1%)
RUS	B (33.6%)	G46 (12.5%)	H49 (11.2%)
SVK	C29 (30.9%)	C26 (11.0%)	C28 (6.7%)
SVN	C29 (13.6%)	NRE (9.0%)	C27 (8.8%)
SWE	C29 (10.9%)	C28 (10.1%)	NRE (7.5%)
TUR	C13-C15 (18.5%)	NRE (9.4%)	C29 (9.0%)

(Continues)



TABLE 1 (Continued)

Country	Top 1	Top 2	Top 3
TWN	C26 (32.1%)	G46 (10.6%)	C20 (10.0%)
USA	NRE (11.9%)	G46 (8.1%)	C30 (7.1%)
ROW	B (23.8%)	C26 (11.6%)	C13-C15 (9.0%)

<sup>a</sup>NRE – nonresident expenditures

As expected, and perhaps through design, the increase in health-related expenditures has a more moderate (but expansive) impact than the ones estimated in scenarios 1 and 2. In the most positive cases, such impacts represent increases of approximately 1.5% in GVA (Sweden, Denmark, and Finland). In this scenario, European countries tend to fare much better than other countries, while low-income countries such as Turkey, India, Indonesia, Mexico, and Bulgaria are the ones that benefit less. In the case of employment, Norway is the top country (2.2% increase), with several other countries coming close to the 2% threshold (Sweden, Denmark, Netherlands, and Finland). Indeed, a comparison with scenarios 1 and 2 highlights that these and other types of stimuli should be considered if governments aim to offset the negative impacts of reductions in final demand, but these results indicate that such stimuli might only marginally contribute to offsetting the overall losses that might be expected throughout the world economy. In this scenario, world GVA is expected to grow by 0.8% and global employment by 0.7%.

The understanding that shocks suffered in one country reverberate through global value chains and that these shocks and reverberations impact countries differently in accordance with national economic structure is critical to policymakers. As an example, tourism-dependent countries should expect relatively larger declines in employment, even if they do not close their tourism-related sectors, as these are more ‘labor-intensive’ sectors that are typically highly dependent on foreign visitors. Also, countries that export nonessential goods or services might experience deep contractionary effects independent of the measures they apply internally. Countries that do not export final products, but instead produce raw materials that are incorporated in sophisticated nonessential products (e.g., mining products or the manufacture of basic metals), might also experience relatively larger effects due to their involvement in the global value chains. In cases such as Brazil, Turkey, or Mexico, this can imply a higher exposure to and risk of shocks and declines felt abroad since the resource-related sectors are relatively important to their national economies. Finally, changes in international trade resulting from initial shocks can contribute to deterioration of the balance of payments of some economies and increase their trade deficits. Importantly, global value chains, heterogeneous national economic structures, and international trade can all complicate the planned recovery process, potentially requiring more targeted monetary and fiscal policies as well as other sectoral incentives that can be informed by analyses such as those presented. Finally, increased health-related expenditures, which might be considered a necessary burden of the COVID-19 pandemic, might have some positive economic impacts, but could inevitably be far too low to balance the significant declines expected in overall activity throughout the world economy.

## 5 | CONCLUSIONS

Restrictive public health measures imposed around the world to mitigate the spread of COVID-19 brought with them unprecedented shocks to the global economy. As the pandemic continues around the world, some countries are slowly easing restrictions in bids to ‘reopen’ their economies. With vaccinations just beginning to be distributed, the COVID-19 pandemic is far from over, and we are likely many years away from fully understanding the short- and long-term economic impacts of this pandemic. While some attention and, in some cases, disaster relief payments have been given to businesses directly impacted by public health measures implemented, researchers and policymakers tend to forget the indirect impacts that arise from sectoral linkages, international trade, and globalization mechanisms.

**TABLE 2** Scenario 2 – reduction in the final demand of nonessential goods

	Approximated % change in total demand for nonessential goods and services	Initial impacts		Total economic impacts			
		Change in final demand	Change in production directed towards final demand	Change in GVA	% change of GVA	Change in employment	% change of employment
AUS	-19%	-122,259	-111,501	-125,222	-9.2	-1,203	-10.1
AUT	-27%	-50,527	-49,837	-49,396	-12.7	-576	-13.5
BEL	-31%	-61,192	-62,235	-56,048	-11.8	-561	-12.3
BGR	-16%	-3,750	-4,055	-4,267	-8.7	-317	-8.8
BRA	-33%	-326,876	-315,962	-275,440	-13.3	-18,290	-17.6
CAN	-22%	-152,633	-147,255	-145,822	-8.7	-1946	-10.6
CHE	-26%	-63,579	-61,788	-67,299	-9.9	-578	-11.4
CHN	-33%a	-1,821,593	-1,910,890	-1,782,915	-17.3	-140,272	-16.4
CYP	-25%a	-2,804	-2,273	-2,240	-10.6	-48	-13.5
CZE	-21%	-16,135	-21,728	-20,810	-11.2	-619	-12.1
DEU	-19%	-259,167	-345,361	-362,807	-10.4	-4,668	-10.9
DNK	-4%	-4,399	-12,459	-14,335	-4.8	-121	-4.4
ESP	-38%	-237,915	-235,560	-216,286	-17.2	-3,566	-19.9
EST	-9%	-1,025	-1,269	-1,648	-7.0	-44	-7.2
FIN	-15%	-14,314	-15,965	-17,027	-7.3	-196	-7.8
FRA	-32%	-333,539	-336,888	-306,007	-12.1	-3,787	-13.9
GBR	-40%	-469,188	-421,617	-396,464	-14.9	-5,365	-17.5
GRC	-21%	-18,890	-16,968	-17,379	-8.3	-374	-9.4
HRV	-13%	-2,840	-3,261	-3,649	-7.6	-130	-8.3
HUN	-14%	-7,161	-11,746	-10,550	-9.0	-386	-9.1
IDN	-21%	-98,498	-100,722	-99,216	-11.4	-16,851	-9.9
IND	-49%	-489,993	-488,140	-403,353	-20.2	-116,425	-17.7
IRL	-39%	-33,928	-28,109	-26,354	-11.6	-288	-15.0
ITA	-31%	-277,436	-291,024	-273,275	-14.2	-4,268	-17.5
JPN	-13%	-243,803	-289,180	-300,351	-6.8	-4,698	-7.7
KOR	-12%	-63,540	-96,911	-106,800	-8.3	-1982	-8.1
LTU	-26%	-4,863	-4,165	-4,929	-11.3	-146	-11.1
LUX	-31%	-6,232	-5,302	-5,983	-10.3	-49	-12.2
LVA	-8%	-1,043	-1,228	-1758	-6.3	-58	-6.5
MEX	-36%	-198,743	-195,313	-180,143	-14.7	-6,556	-16.8
MLT	-22%	-1,090	-1968	-1,297	-13.7	-25	-13.0
NLD	-17%	-45,865	-52,242	-68,122	-8.6	-773	-8.9
NOR	-10%	-18,579	-18,273	-29,114	-6.5	-147	-5.4
POL	-18%	-41,119	-46,674	-49,313	-10.2	-1,465	-9.4
PRT	-29%	-26,455	-26,178	-24,439	-12.1	-649	-14.3
ROU	-24%	-17,597	-18,340	-18,012	-10.2	-849	-9.6

(Continues)





TABLE 2 (Continued)

	Approximated % change in total demand for nonessential goods and services	Initial impacts		Total economic impacts			
		Change in final demand	Change in production directed towards final demand	Change in GVA	% change of GVA	Change in employment	% change of employment
RUS	-25% <sup>a</sup>	-193,502	-156,157	-186,028	-11.5	-7,878	-10.6
SVK	-24%	-9,678	-12,798	-11,322	-12.4	-280	-12.6
SVN	-25%	-5,041	-4,997	-5,027	-11.7	-113	-12.1
SWE	-8%	-15,936	-22,934	-30,750	-6.1	-277	-5.8
TUR	-30%	-97,468	-103,747	-93,482	-13.2	-4,370	-13.5
TWN	-8%	-16,253	-25,938	-38,684	-7.6	-1,456	-7.2
USA	-18%	-1,293,072	-1,282,699	-1,309,462	-7.6	-13,016	-8.4
ROW	-24%	-1,417,794	-1,225,658	-1,217,862	-11.4	---	---

<sup>a</sup>Data for China, Cyprus, and Russia are not available in the Google COVID-19 Community Mobility data. These values were estimated on the basis of the Oxford Restrictiveness Index.

Results from the hypothetical scenarios presented provide several important insights for consideration. The first important issue is that internal measures adopted by countries matter but that they are only one part of the economic story. As countries are exposed to international trade, they will always be exposed to what happens in other economies. For example, sharp declines in manufacturing activity might induce large losses in the mining sector for countries that are dependent on resource-based production (Australia, Brazil, Canada, Indonesia, and Norway), which can be vital for certain regions of these countries. Economies dependent on tourism, such as Southern European countries, might observe relatively higher shocks in terms of employment since the service-oriented tourism sectors tend to be labor intensive. Regions specializing in the manufacture of goods for intermediate consumption, such as Korea and other Asian economies, might experience a significant shock, even if the direct effects in their own country are not large. Finally, the third scenario also highlights the potential for offsetting positive impacts of COVID-19, specifically related to expenditures in health-related sectors, which are expected to increase. Nevertheless, even in the context of significant increase in these expenditures, the scale of the associated positive impacts is unlikely to fully offset the contractionary effects that will result from the global disruption in the production of nonessential goods and services.

These analyses and results demonstrate the usefulness of I-O techniques for providing insights and information for decisionmakers, even amidst a continued pandemic. Specifically, insights can be provided on specific sectoral impacts, the scale of a nation's balance of payments deterioration, or to the expected magnitude of employment reductions. With this information, decisionmakers can be better prepared to react by enacting policies or providing stimuli that might (partially or totally) counterbalance some of these losses, or reconsider actions that might worsen the situation. Policies to expand markets or find new economic partners in the most critical industries in each country can be effective to counterbalance sudden losses in economic production. The gradual reactivation of the economy can be made by choosing the sectors that can potentially develop a new role in the economic structure post-COVID.

The analyses presented provide insights on these often-neglected facets. Results do not represent forecasts but rather provide examples of an MRIO application to assess and highlight the role of trade and GVCs. The magnitude and global extent of the economic shocks associated with the COVID-19 pandemic are like no other event

**TABLE 3** Scenario 3 – increase in the government and NPISH expenditures in health-related products

	Initial impacts		Total economic impacts			
	Change in final demand	Change in production directed towards final demand	Change in GVA	% change of GVA	Change in employment	% change of employment
AUS	8,248	12,956	12,784	0.9%	172	1.4%
AUT	4,045	3,926	3,735	1.0%	53	1.3%
BEL	5,706	5,796	5,468	1.1%	74	1.6%
BGR	179	176	202	0.4%	15	0.4%
BRA	13,663	13,635	12,832	0.6%	618	0.6%
CAN	10,080	10,196	10,781	0.6%	155	0.8%
CHE	7,206	8,176	8,587	1.3%	83	1.6%
CHN	53,468	53,480	55,145	0.5%	5,400	0.6%
CYP	124	133	131	0.6%	2	0.6%
CZE	1,164	1,116	1,064	0.6%	37	0.7%
DEU	39,120	38,524	38,677	1.1%	654	1.5%
DNK	4,643	4,804	4,436	1.5%	56	2.0%
ESP	11,919	11,565	10,712	0.9%	169	0.9%
EST	142	134	139	0.6%	5	0.8%
FIN	3,534	3,459	3,184	1.4%	46	1.9%
FRA	32,859	31,988	31,111	1.2%	449	1.6%
GBR	31,279	31,581	26,729	1.0%	485	1.6%
GRC	1,564	1,342	1,286	0.6%	30	0.7%
HRV	312	335	326	0.7%	13	0.8%
HUN	855	860	795	0.7%	36	0.8%
IDN	1,798	1,801	2,200	0.3%	732	0.4%
IND	4,647	4,651	4,797	0.2%	1,213	0.2%
IRL	1,627	2,021	2,502	1.1%	26	1.4%
ITA	17,868	18,077	16,914	0.9%	241	1.0%
JPN	49,675	49,703	46,543	1.0%	975	1.6%
KOR	9,686	9,743	8,907	0.7%	219	0.9%
LTU	236	220	264	0.6%	11	0.8%
LUX	450	438	500	0.9%	5	1.3%
LVA	144	137	139	0.5%	6	0.7%
MEX	4,332	4,340	4,679	0.4%	145	0.4%
MLT	100	99	92	1.0%	2	1.1%
NLD	10,538	10,358	10,124	1.3%	162	1.9%
NOR	5,683	5,674	5,705	1.3%	61	2.2%
POL	3,324	3,267	3,186	0.7%	124	0.8%
PRT	2,038	1,949	1,787	0.9%	47	1.0%
ROU	914	859	883	0.5%	52	0.6%
RUS	11,187	11,175	11,652	0.7%	656	0.9%
SVK	653	538	578	0.6%	19	0.8%

(Continues)



TABLE 3 (Continued)

	Initial impacts		Total economic impacts			
	Change in final demand	Change in production directed towards final demand	Change in GVA	% change of GVA	Change in employment	% change of employment
SVN	365	400	396	0.9%	9	0.9%
SWE	7,852	7,810	7,520	1.5%	92	1.9%
TUR	2,227	2,224	2,265	0.3%	131	0.4%
TWN	2,654	2,571	2,824	0.6%	122	0.6%
USA	202,092	202,660	198,711	1.1%	2,476	1.6%
ROW	51,103	51,411	51,184	0.5%	---	---

experienced within the last century. Future research supported by updated data will improve our understanding of the complexity and scale of this shock. Ultimately, the application of input-output techniques to specific geographies or even the evolution of computable general equilibrium will support a better understanding of the economic implications and consequences of the pandemic. Nevertheless, WIOD is a unique, transparent, and valuable tool for analyzing economic interactions and GVCs that should be taken into account and, if possible, updated to recent years. Investments in maintaining and improving databases of this sort and in generating data for additional countries would be wise ahead of the next global economic shock.

With all of this in mind, it is important not to lose sight of broader societal goals. Industries, regions, and countries identified as vulnerable represent areas and populations that have an increased risk of suffering from unemployment, poverty, malnutrition, and many other undesirable effects. Maintaining goals related to these societal challenges as well as the United Nations sustainable development goals are critical to constructing a post-COVID-19 economy that is more sustainable, equitable, and resilient when faced with future crises. Timely provision of insights for informed decision making and science-based solutions are even more critical in times of great uncertainty.

## ORCID

Joao-Pedro Ferreira  <https://orcid.org/0000-0002-6726-7856>

Pedro Ramos  <https://orcid.org/0000-0002-6656-7689>

Eduardo Barata  <https://orcid.org/0000-0003-2609-4642>

Christa Court  <https://orcid.org/0000-0002-2690-9015>

Luís Cruz  <https://orcid.org/0000-0002-9280-1715>

## ENDNOTES

- <sup>1</sup> The article “iPadded: The trade gap between America and China is much exaggerated” describes fragmentation in the case of production of the iPad. (The Economist, 2012).
- <sup>2</sup> As an example, in a work concerning the Portuguese economy, Ferreira et al. (2019) highlights that 2.1% of the Port wine's final value results from “oil extraction and drilling” that happens outside the Portuguese territory.
- <sup>3</sup> This is explained in detail in Section 4.
- <sup>4</sup> Unfortunately, more recent intercountry data are not available, and the processes involved in updating a multicountry framework such as WIOD are time-consuming and labor intensive. Research applications working with national data often use data methods to update to more recent years; however, these methods are not directly applicable to applications involving a multicountry table as they do not account for uncertainty, standardization, and scarcity of data related to international trade, exchange rates, and production technologies.



- <sup>5</sup> This database is built at basic prices. The values in each cell do not include taxes, and trade and transport margins are treated as products of the respective industries included in the table. Also, for each industry, the database contains additional components that are not a part of value-added or intermediate consumption estimations, such as 'international transport margins'.
- <sup>6</sup> The representation of a national economy (and the ROW) in 56 sectors is always a source of heterogeneity within each sector. In the same industry, essential and nonessential products can be included. Alexeeva-Talebi et al. (2012) are the authors of one of the works that addresses the problem of heterogeneity and demonstrates how more data are demanding the use of disaggregated models.
- <sup>7</sup> Intermediate consumption does not suffer any direct change.
- <sup>8</sup> This includes places such as restaurants, cafés, shopping centers, theme parks, museums, libraries, and movie theaters, among others. Google COVID-19 Community Mobility Trends provides daily data. In this case, we estimated the average value for 2020. This information is available here: <https://ourworldindata.org/grapher/change-visitors-retail-recreation?stackMode=absolute&time=2020-11-27&region=World>.
- <sup>9</sup> In the case of 'Human health and social work activities', the shock scenario also increased household expenditures by 10% because of the private nature of healthcare in some countries (96% in the case of USA) and public nature of healthcare in others (the share of government and NPISH consumption corresponds to 86%, 84%, and 81% of total output, in the case of Norway, Denmark, and Sweden, respectively).

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## APPENDIX A.

		Nonessential product	WORLD final demand	% share output
A01	Crop and animal production, hunting and related service activities		1,720,495	35%
A02	Forestry and logging		60,962	16%
A03	Fishing and aquaculture		203,143	48%
B	Mining and quarrying	X	385,224	6%
C10-C12	Manufacture of food products, beverages and tobacco products		3,732,428	54%
C13-C15	Manufacture of textiles, wearing apparel and leather products	X	1,220,319	44%
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	X	75,884	8%
C17	Manufacture of paper and paper products	X	110,494	11%
C18	Printing and reproduction of recorded media	X	53,963	11%
C19	Manufacture of coke and refined petroleum products		915,714	24%
C20	Manufacture of chemicals and chemical products	X	585,270	14%
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations		407,111	33%
C22	Manufacture of rubber and plastic products	X	204,216	12%
C23	Manufacture of other non-metallic mineral products	X	106,747	5%
C24	Manufacture of basic metals	X	163,820	4%
C25	Manufacture of fabricated metal products, except machinery and equipment	X	389,481	16%
C26	Manufacture of computer, electronic and optical products		1,242,024	31%
C27	Manufacture of electrical equipment	X	707,336	30%
C28	Manufacture of machinery and equipment n.e.c.	X	1,574,112	44%
C29	Manufacture of motor vehicles, trailers and semi-trailers	X	2,299,236	51%
C30	Manufacture of other transport equipment	X	783,274	54%
C31_C32	Manufacture of furniture; other manufacturing	X	646,322	53%
C33	Repair and installation of machinery and equipment		114,640	36%
D35	Electricity, gas, steam and air conditioning supply		1,065,574	20%
E36	Water collection, treatment and supply		164,245	44%
E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services		107,529	19%
F	Construction	X	9,638,708	80%
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	X	802,516	58%
G46	Wholesale trade, except of motor vehicles and motorcycles	X	3,239,469	41%
G47	Retail trade, except of motor vehicles and motorcycles	X	3,529,145	70%

(Continues)



		Nonessential product	WORLD final demand	% share output
H49	Land transport and transport via pipelines		1,590,384	39%
H50	Water transport	X	201,960	30%
H51	Air transport	X	324,782	42%
H52	Warehousing and support activities for transportation	X	269,441	17%
H53	Postal and courier activities		41,843	11%
I	Accommodation and food service activities	X	2,661,914	70%
J58	Publishing activities	X	296,221	45%
J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	X	330,663	46%
J61	Telecommunications		1,120,769	46%
J62_J63	Computer programming, consultancy and related activities; information service activities		1,006,729	48%
K64	Financial service activities, except insurance and pension funding		1,350,191	29%
K65	Insurance, reinsurance and pension funding, except compulsory social security		1,131,146	53%
K66	Activities auxiliary to financial services and insurance activities		207,572	25%
L68	Real estate activities		6,456,706	75%
M69_M70	Legal and accounting activities; activities of head offices; management consultancy activities	X	428,326	12%
M71	Architectural and engineering activities; technical testing and analysis	X	335,591	29%
M72	Scientific research and development		411,096	51%
M73	Advertising and market research	X	79,168	14%
M74_M75	Other professional, scientific and technical activities; veterinary activities	X	228,782	20%
N	Administrative and support service activities		774,580	21%
O84	Public administration and defence; compulsory social security		7,997,598	91%
P85	Education		3,383,033	91%
Q	Human health and social work activities		6,135,295	94%
R_S	Other service activities	X	2,286,816	68%
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	X	147,138	74%
U	Activities of extraterritorial organizations and bodies		81	100%

<sup>a</sup> List of sectors is described in Appendix A.