COVID-19 and Strategic Sectors in Brazil: A Socially-Embedded Intersectional Capabilities Approach

Haider, Khan and Szymanski-Burgos, Adam

Josef Korbel School for International Studies, University of Denver

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Haider A. Khan and Adam Szymanski-Burgos

University of Denver

Author Details

Haider A. Khan is a John Evans Distinguished University Professor, Policy Research Institute Distinguished International Advisor, European Economic and Social Committee Former Senior Scholar and Senior Research Fellow, Asian Development Bank Institute, Tokyo, Japan; and a Professor of Economics at the University of Denver Josef Korbel School of International Studies. He is on the board of editors and advisor to several economics and social science journals. Correspondence concerning this article should be addressed to Haider A. Khan, Phone Number: 720-748-2555. Email: Haider.Khan@du.edu

Adam Szymanski-Burgos holds an MA degree from the University of Denver, Department of Economics and is a research assistant for the Frederick S. Pardee Center for International Futures. Email: szymanskiburgos@gmail.com

Abstract

COVID-19 impacts have exacerbated socioeconomic inequalities and the threat of hunger and absolute poverty for vulnerable populations globally. Brazil, as a large Southern engine of growth, is a complex case. In responding to the public health impacts and economic challenges of the pandemic, the case of Brazil stands out for several reasons. First, what was distinctive about Brazilian public health policy and what have been the consequences so far? Second, what circumstances and economic policy measures have led to a V-shaped recovery? Finally, what is the further prognosis for Brazil over the next few years and what are the points of leverage to ensure a sustained recovery? Our analysis highlights the salience of considering development and the economic and social shocks of pandemics from a Socially Embedded Intersectional Approach (SEICA) perspective. Using an economy-wide modelling methodology, we identify 'strategic' sectors in the Brazilian economy defined as sectors critical for both pulling the wider economy out of a recession and for supporting widespread income growth, particularly for those in the bottom 40% of households. Additionally, we are able to draw some conclusions that may be relevant for the case of other economies in various stages of development, particularly those with sharply uneven development patterns and large rural populations.

1. Introduction

The social and economic impacts of COVID-19 present lasting policy challenges for governments around the world. These economic impacts have exacerbated socioeconomic inequalities and the threat of hunger and absolute poverty for vulnerable populations. Localized outbreaks of COVID-19 in Latin America first identified in March 2020 were met with a diversity of containment measures across the continent. However, country differences in public health capabilities and lockdown severity meant that the spread of infection could not be rapidly contained. In addition, new COVID-19 variants with higher potential for spread had emerged in Brazil overloading the public health systems of the country and its regional neighbors.

By June 2020, Latin America had become the new epicenter for the pandemic, accounting for more than a third of new COVID-19 cases globally (Etienne 2020). The majority of new infections in Latin America remain concentrated in Brazil which, until recently, has had the second highest number of COVID-19 cases globally. [1] As of July 2021, the number of confirmed cases in Brazil totaled higher than 19 million people, far above Argentina (4.1 million), Colombia (3.6 million), Mexico (2.4 million), Peru (1.9 million), and Chile (1.45 million). The combined economic impact of lockdowns, consumption shocks, and the collapse of international trade have resulted in an estimated 8.1 percent decline in regional GDP for Latin America, far above the estimated 4.4 percent decline of global GDP (Cottani 2020)

Aside from exposure to the more infectious delta variant of COVID-19, the ongoing severity of the pandemic across the continent is due to a number of important reasons. Generally speaking, Latin American countries tend to suffer from fiscal burdens and high levels of informality leading to weakness in public health capabilities. For instance, countries like Argentina and Peru have tended to suffer higher rates of infection than Chile and Uruguay. In addition, significant responsibility for the crisis at the level of individual countries falls on the impact of government mishandling during critical periods. This is true in Brazil, which has one of the strongest healthcare systems in Latin America (World Bank 2020). Despite this, the initial containment response led by the Brazilian president has been characterized as an “underestimation” (Marson and Ortega 2020) of the public health threat leading to a policy that was “loose, inarticulate, and insufficient” (Pires et al. 2020).

Matters are made worse by the fact that Brazil’s public health capabilities are distributed highly unevenly across the country, leaving poorer regions more vulnerable to the spread of infections, particularly in the North and Northeast (World Bank 2020a). This highlights an additional risk factor for pandemic severity in the high levels of inequality that persist in Latin America between racial groups, regions, and social classes. The interaction between socio-economic inequality and the spread of infections operate in a vicious cycle. On one hand, the spread of infections is aggravated by structural inequalities. Low-income communities find themselves more exposed to infection due to employment patterns that are more intensive in face-to-face activities and because of low capacity for social distancing and sanitation in smaller houses and

[1] Brazil has had the second-highest number of cases from May 2020 until April 2021 when it was surpassed by India.

crowded neighborhoods. Minorities and other socially disadvantaged groups including black and indigenous communities are uniquely susceptible to these issues due to the impacts of structural racism, leading to their overrepresentation in essential face-to-face-intensive jobs and spatial concentration in poorer areas. Lacking sustained access to quality healthcare and suffering in higher likelihood of comorbidities, the poor are overall more likely to experience worse health outcomes, including hospitalization and death (Pires et al. 2020).

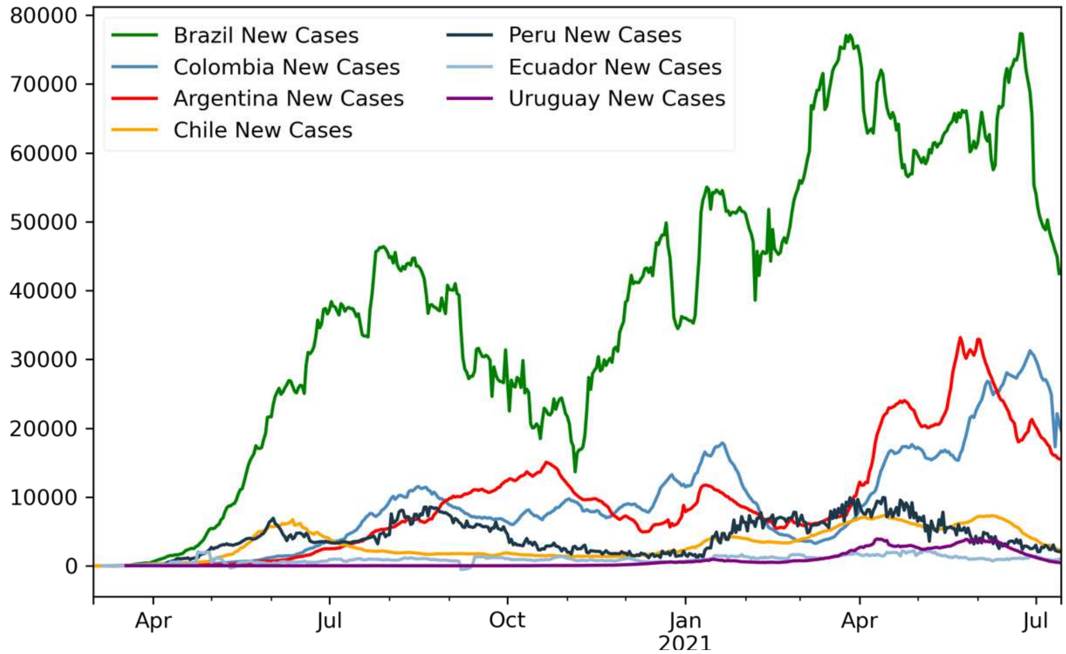
On the other hand, the economic and social impacts of the pandemic are known to make income and racial inequalities worse. Not only in Latin America but around the world, the loss of incomes during the pandemic-driven recession appears to disproportionately affect workers in the informal sector, lower-skilled workers, workers in services, retail, and construction, and the self-employed (Pires et al. 2020). The disproportionate impact on the poor has directly led to an increase in extreme poverty and hunger for hundreds of millions of Latin America's poor and vulnerable populations (ECLAC 2021). Moreover, the economic impacts of COVID-19 are made worse given the ongoing developmental challenges in Brazil: stagnant productivity growth and dependence on foreign investment.

Using Brazil as case study, we take a 'key sectors' approach to support a framework for sustainable and inclusive recovery. We apply standard methods to rank economic sectors based on their "power of pull" (PoP), defined as a sector's capacity to influence other sectors through inter-industry linkages and their degree of network centrality (Luo 2013). Using standard weighted indicators for backward linkages and PoP we can produce a ranking of key sectors in Brazil based on the extent of their backward linkages and their degree of *connectedness*. These describe the extent to which economic influences are transmitted sector-to-sector in the event of a stimulus. In addition to interindustry linkages and sector-level stimulus it is also important that policy considerations in Latin America be examined through an intersectional lens with an emphasis on targeted poverty reduction and the alleviation of structural inequalities as a means of achieving longer-term recovery. Our framework is framed at the outset by a socially-embedded intersectional capabilities approach (SEICA) (Khan 1998). This approach views development as a democratic process where important feedback loops link macro-level outcomes with the material well-being of disadvantaged and minority groups. Accordingly, the practical importance of a sector is the direct or indirect impacts that is has on household income and consumption. We focus additionally on the role of consumption linkages by estimating income, employment, and Type 2 output multipliers.

2. Case Study: Brazil

After initial government attempts to flatten the curve failed, Brazil has suffered from relatively high infection rates since May 2020 that have not shown any indications of slowing. The time series in Figure 1.1 shows the comparative rate of infections in Latin America, with the 7-day rolling average of new infections in Brazil greatly outpacing other major countries in the region. The country has so far accumulated the highest level of infections and confirmed COVID-19 deaths in Latin America with upwards of 19 million accumulated cases and 540 thousand dead. The continuing high rate of spread in Brazil has been linked to resurgent waves of infections in neighboring countries (Schnirring 2021). Table 1.1 shows that, although Brazil leads all other countries in terms of country-wide rates of infections and deaths, per capita rates have drifted higher in countries like Uruguay and Argentina, which exceed Brazil in terms of average new cases per million and Peru, where the rate of new deaths per million far exceeds the rest of the panel.

Figure 1.1 New COVID-19 Cases in Latin America, 7-day Rolling Averages



Source: Data sourced from Ritchie et al. (2020).

Table 1.1 COVID-19 Public Health Impacts in Latin America: May 2020 to July 2021

Location	Total Cases	Total Deaths	Avg. New Cases per Day	Avg. New Cases per Million per Day	Avg. New Deaths per Day	Avg. New Deaths per Million per Day
Argentina	4,769,142	101,955	9,481	209	204	4
Brazil	19,391,845	542,756	38,202	179	1,108	5
Chile	1,600,883	34,539	3,142	163	71	4
Colombia	4,655,921	116,753	9,278	183	241	5
Ecuador	476,312	21,958	946	53	45	2
Peru	2,094,445	195,243	4,213	127	390	12
Uruguay	379,072	5,889	774	221	12	3

Source: Data sourced from Ritchie et al. (2020).

Among the major differences in the observed rates of infections and deaths between Latin American countries is the adequacy of public health capabilities and the effectiveness of government response in terms of treatment and containment. Table 1.2 provides a comparative snapshot of Latin American public health capabilities in response against COVID-19. Despite having a strong overall healthcare system with significant coverage for public insurance, Brazil's capacity to provide quality healthcare is unevenly distributed throughout the country and health systems around the country quickly became overwhelmed with the growing number of individuals needing medical care.

Table 1.2 Public Health Capabilities in Latin America: May 2020 to July 2021

Location	Avg. New Tests per Day	Hospital Beds Per Thousand	Total Vaccinations	Total Vaccinations Per Hundred	People Fully Vaccinated Per Hundred	Avg. New Vaccinations per Day	Avg. New Vaccinations per Million per Day
Argentina	26,218	5.00	27,430,531	61	12	156,724	2,902
Brazil	57,309	2.20	124,113,911	58	16	650,362	3,094
Chile	38,840	2.11	24,761,379	130	61	120,785	6,258
Colombia	51,711	1.71	23,631,963	46	20	141,547	2,980
Ecuador	3,439	1.50	8,178,327	46	11	75,267	2,288
Peru	10,226	1.60	10,781,431	33	12	67,384	1,950
Uruguay	6,576	2.80	4,542,957	131	60	31,990	9,117

Source: Data sourced from Ritchie et al. (2020).

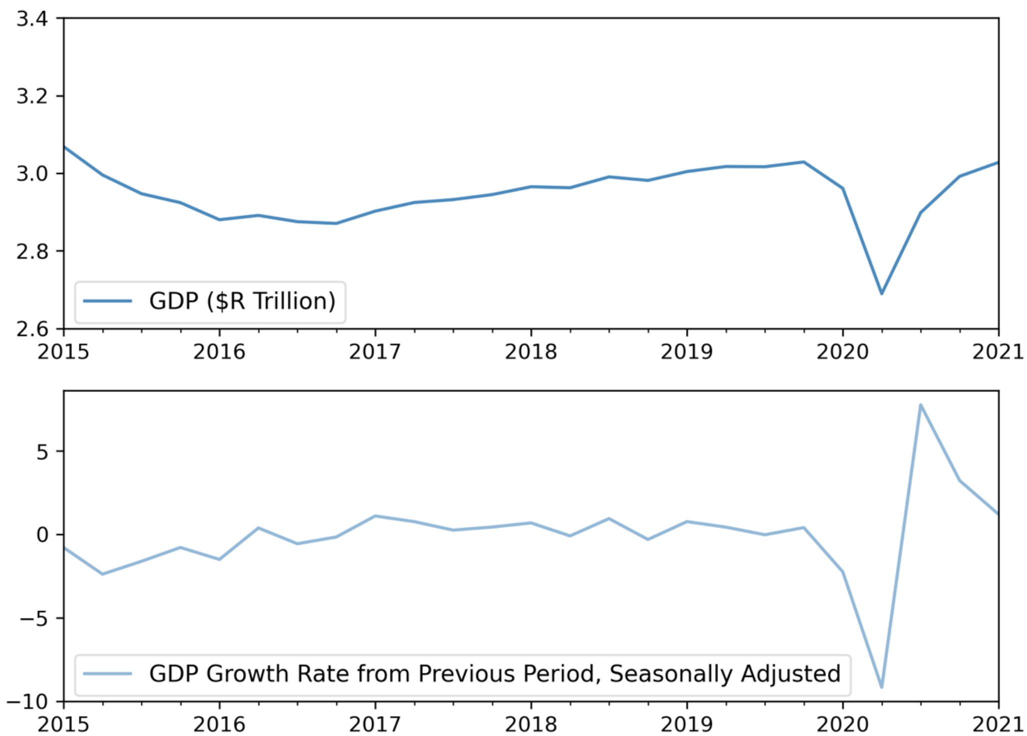
While Brazil had adequate supply of medical equipment (including hospital beds, ventilators, and oxygen supplies) for the first wave of infections, these were not distributed equally across regions. Most of the country's intensive care units (ICUs) and hospital beds are located in urban areas and state capitals, with the highest concentration of ICUs in three states: Sao Paulo, Rio de Janeiro, and Minas Gerais (Marson and Ortega 2020). This has left rural groups and indigenous populations at a structural disadvantage, facing additional barriers to access to quality healthcare and disease prevention and sanitation equipment. Social and economic inequalities in general have severely exacerbated the spread of infection and the rate of casualty. The bottom 40 percent of households and the growing population of newly poor are highly disadvantaged by increased susceptibility to infections. This is especially true for those living in urban favelas where basic sanitation infrastructure is lacking and high population density makes social distancing exceedingly difficult.

The total severity of the pandemic in Brazil has worsened the economic impacts on a country already struggling to generate a meaningful recovery from the latest recession and political crisis in 2015. This recession marked the end of a 'golden decade' of rapid growth and development in Brazilian history. From around 2000 to 2015, Brazil saw a deep reduction in income inequality and poverty driven by a boom in export commodities and positive labor market developments enabled by fruitful policy shifts including the universalization of basic education in the 1990's and the elevation of the real minimum wage over time (Firpo and Pieri 2018). Poverty decreased most rapidly in the North and Northeastern regions where poverty rates are the highest (this remains true) and sustained declines in income inequality were driven by a narrowing of earnings gaps between regions, gender, and race (Soares et al. 2016; World Bank 2020a).

The 2015 recession was caused in part by the 'disarray of expectations' that arose in light of a series of policy shocks and scandals in 2015 (Arestis et al. 2021). A set of fiscal austerity measures were introduced during the inauguration of Dilma Rouseff's second term a bid to reverse Brazil's slowing economic growth performance of 2014 by reducing inflation and restoring investor confidence. Austerity measures included cuts to government expenditures for social benefits, tax increases, reduction of subsidies, interest rate hikes, and the lifting of price controls of public and administered prices. Negative shocks to GDP and employment (especially concentrated in the MSE sector) resulted immediately from these measures. Despite these measures, inflation continued to increase, and Brazil's economic problems worsened as the presiding administration entered a crisis of confidence leading into the *Lava Jato* corruption scandals and Rouseff's subsequent impeachment.

Authorities in Brazil have turned in favor of further austerity reforms to pursue fiscal consolidation and achieve long-run growth under the guiding philosophy of "expansionary fiscal austerity," beginning with the highly controversial spending cap rule (Amendment 95) in 2016 under Michael Temer and more recently with 2019 pension reforms under Jair Bolsonaro. Under Amendment 95, the primary annual expenditures of the federal budget have been restricted to grow above an effective real rate of 0% over the term 2017-2037 as spending limits can only adjust with the rate of inflation. The economic recovery has thus far depended on the ability of federal and state governments to rebuild weakened fiscal buffers and restore market confidence. By 2020, however, these reforms had not led to a significantly stronger fiscal situation for state governments (World Bank 2020a). Rather, they have dramatically weakened the government's capacity to respond to the economic and health challenges of the pandemic (Arestis et al. 2021).

Figure 1.2 GDP Growth in Brazil: 2015-2021



Source: FRED

On top of this weakened fiscal and economic position, the recovery turned into a huge contraction with the onset of the pandemic. The initial shock is reflected in a 33.5 percent drop in GDP in the second quarter of 2020, an economic decline that was relatively mild compared to other countries in the region (Cottani 2021). A relatively strong V-shaped recovery began in the third quarter of 2020, driven largely by a massive injection of government funds. In addition, the aggregate shock has been buffered somewhat thanks to looser quarantine restrictions and the recovery of export-oriented sectors, which have seen positive growth in 2020 due to adjustments in the real exchange rate and the recovery of import orders from China, the country's largest export market. Overall, Brazil saw a total year-by-year decline of 4.1 percent of GDP in 2020, beating some of more pessimistic forecasts from the World Bank and IMF (McGeever 2021). Although the aggregate decline of the pandemic may have been lower than expected, there have been lasting impacts concentrated in the service industries, particularly retail trade, transportation, and accommodation.

Table 1.3 Brazil's Top Export Partners

Country	Exports (in billion USD)	Imports (in billion USD)
China	63.4	35.3
United States	29.8	30.4
Netherlands	10.1	2.1
Argentina	9.8	10.6
Japan	5.4	4.1

Source: Figures for 2019 are sourced from World Integrated Trade Solutions

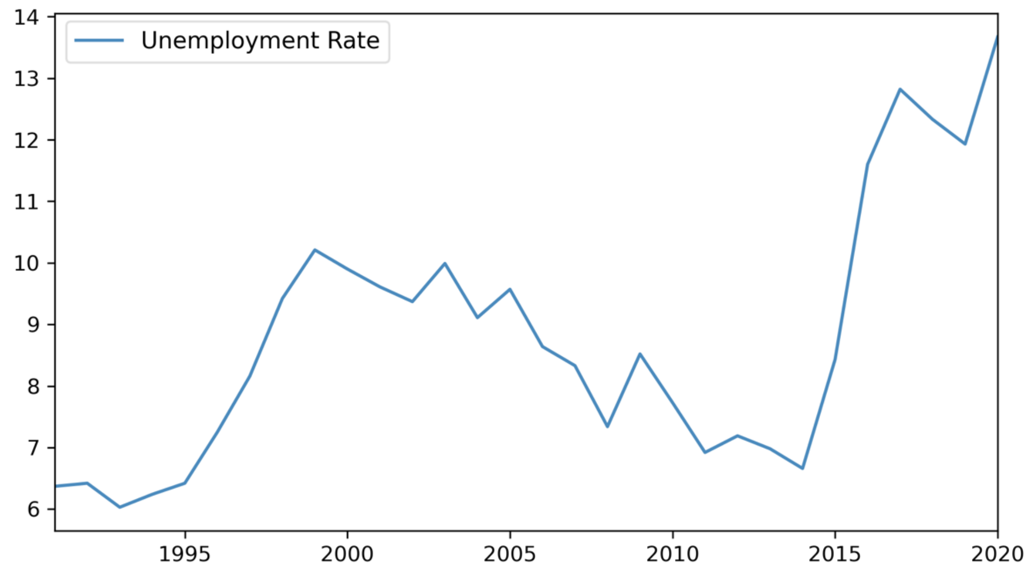
Table 1.4 Brazil's Top 10 Export Commodities

Country	Exports (in billion USD)	Percentage of Total Exports
Soybeans	26.1	11.4%
Crude Petroleum	24.3	10.6%
Iron Ore	23.0	9.99%
Corn	7.39	3.21%
Sulfate Chemical Woodpulp	7.35	3.19%
Poultry Meat	6.55	2.85%
Refined Petroleum	5.76	2.5%
Soybean Meal	5.9	2.56%
Bovine Meat	5.67	2.47%
Raw Sugar	5.33	2.32%

Source: Figures for 2019 are sourced from World Integrated Trade Solutions

The export 'boost,' which has contributed significantly to Brazil's economic recovery path, is a result of recovery in industrial production in other countries, particularly in China and other major trading partners (see Table 1.3). However, despite its apparent usefulness for providing economic buffers from crises and stimulating short-term recovery, Brazil's export model is concentrated on low value-added commodities such as agricultural products and basic materials including crude petroleum and iron as well as some semi-manufactured products (Table 1.4). This model is arguably limited for creating further growth since it embodies the well-known "middle-income trap" for many developing countries.

Figure 1.3 Unemployment Rate in Brazil: 1995-2021



Source: FRED

While unemployment rates remained relatively low from 2010 to 2014 hovering around 6-7 percent, the recession led to a sharp increase in unemployment upwards of 13 percent by around 2017 through 2020 shown in Figure 1.3. Increases in unemployment have been coupled with falling real wages and depressed government expenditures under austerity, leading to a reduction of past social welfare gains and the growing threat of poverty for millions of Brazilians. The proportion of people in Brazil living in poverty or vulnerable to poverty is estimated at around half of the total population. According to the World Bank's Report (2020a), this section of the population was especially vulnerable to the economic and social impacts of the pandemic since there was virtually no recovery of incomes since 2016 for this level. Since the onset of the pandemic, these groups have seen the largest relative declines in income. The increase in unemployment has been concentrated in the bottom 40 percent of income earners. Both income inequality and the rate of poverty have increased in 2020, with a total estimate of 7.2 million additional Brazilians facing poverty.

The government has responded to the broader public health, economic, and social crisis with significant policy measures and emergency fiscal spending. Using IMF (2021) data on cross-country COVID-related expenditures, total fiscal expenditures in 2020 in Brazil (not including direct public health expenditures) are estimated at a total of 848.6 billion BRL ($162.7 billion USD), equivalent to 11.9 percent of GDP. Despite the federal spending cap still in place, Brazil's counter-COVID 19 expenditures are among the largest in Latin America both in gross terms and as a percentage of GDP.[2] The government response is estimated to have limited the decline of GDP in 2020 to 4.1 percent and generated an overall *temporary* drop in of 8 percent in the national poverty rate in 2020 (World Bank 2021). The prevention and reduction of poverty among vulnerable group is attributed directly to household transfer and assistance programs through Auxilio Emergencial, the expansion of Bolsa Familia, and others.

Fiscal policy includes significant federal transfers to state governments experiencing budget shortages and fiscal crises. Direct fiscal expenditures were directed toward two main ends: 1) providing income supports and emergency aid for households and 2) channeling resources toward aggregate employment stabilization using a range of direct supports and employment incentives for small and micro enterprises (SMEs). Utilizing IMF (2021) data we can provide a categorized breakdown of Brazil's total package of counter-COVID 19 expenditures in 2020:

- The implementation of an emergency income protection transfer program *Auxilio Emergencial,* which pays over half of a minimum wage for up to 3 months for uncovered workers that are unemployed mostly in the informal and self-employed sectors, accounts for roughly R$ 196 billion - 23.15% of total fiscal expenditures.
- The expansion of Brazil's *Bolsa Familia* federal conditional cash transfer program by an additional 1.2 million households accounts for an additional R$ 28.7 billion – 3.38 % of total fiscal expenditures
- The implementation of the National Support Program for Micro and Small Enterprises (Pronampe) with several rounds of funding accounts for R$ 53.8 billion – 6.34% of total fiscal expenditures.
- A large package of varied fiscal supports including tax cuts and employment incentives for small and medium enterprises (SMEs) through the Brazilian Development Bank (BNDES) and other agencies totaling $R 226.6 billion – 26.7% of total fiscal expenditures
- A large package of other social assistance and emergency aid programs including unemployment insurance and food aid through a variety of agencies totaling $R 342.9 billion – 40.4% of total fiscal expenditures

The monetary policy response was characterized by rate cuts from mid-February to August 2020, to the historical low of 2 percent, and the introduction of a set of measures to increase liquidity in the financial system. These included the reduction of reserve requirements from 25% to 17% and a temporary relaxation of capital buffers and provisioning rules. Overall liquidity has also been supported by Brazil's special access to a dollar swap line with the US Federal Reserve, who has established an available line of $60 billion USD for emergency use. According to the IMF (2021) however, the majority of liquidity supports were withdrawn in 2021 including interest rates hikes to 4.25% by June.

3. Methodology

The data for this analysis comes from the 2015 harmonized OECD IO tables. This dataset offers a set of interindustry flows for 36 production activities for Brazil for all other OECD countries. Final

[2] According to our estimates using IMF (2021) data, Brazil had the largest sum of counter-COVID 19 fiscal expenditures across the region. In terms of counter-COVID 19 expenditures as a percent of GDP, Brazil's spending package is second only to Chile, which spent or set aside an estimated 19% of GDP on total counter-COVID 19 fiscal expenditures in 2020.

demand is divided into rural and urban household consumption, government consumption, gross fixed capital formation (investment in fixed assets), changes in inventory, and exports. Total value-added is then distributed among factors of production in the form of workers' compensation, gross operating surplus, production taxes, and capital depreciation.

3.1 Interindustry Linkages and Multiplier Analysis

The basis for investigating linkages and economic multipliers is the matrix of interindustry transactions. This matrix offers a model of interindustry flows of products and resources within an economy as well as resources flows to institutional accounts including households, taxes, capital incomes, and exports. The interindustry transactions matrix describes the total output of each production sector in the economy as it is distributed among purchasing sectors as intermediate goods and among households and other agents as final goods. Data for interindustry flows are used to construct the the matrix of direct sector requirements for the economy, describing the direct sector requirements of production in terms of inputs of sector i for a unit of total output in sector j.
Algebraically, this produces a system of equations with the general form (1) and matrix notation (2):

$$x_i = a_{ij}x_j + y_i \quad (1)$$
$$x = Ax + y \quad (2)$$

where a_{ij} is the technical coefficient representing the per-unit monetary value of input from sector i required to produce a monetary unit value of output in sector j. In the matrix notation, x is a column vector of total output produced by each production sector, y is a column vector of output generated by final demand, and A is a square matrix of technical coefficients a_{ij}. A fundamental assumption with the use of input-output tables is that, for a definite length of time, interindustry resource flows from sector i to sector j depend entirely on the total output of sector j for the same period of time. Conventionally in IO analysis, we assume this ratio is constant according to a fixed-proportions production function with constant returns to scale.

If there is an increase in output from sector j then there will be an increase in intermediate demand via sector j's additional purchases from sectors which provide inputs to sector j. Similarly, if there is an economy-wide increase in output for all sectors, then sector j can expect further increases in output from additional purchases from all sectors that purchase inputs from sector j. These are referred to as backward and forward linkages respectively and are considered to describe the structural paths from which increases in output for one or a cluster of sectors are transmitted throughout the wider economy in the form of interindustry flows.

If the vector of final demand y is known, the total output of each sector needed to supply both intermediate and final demand requirements may be found as the solution to the following equation:

$$x = (I - A)^{-1}y \quad (3)$$

where I denotes the identity matrix, and the inverse matrix $(I - A)^{-1}$ gives the matrix of total requirements coefficients (Fjeldsted 1980). The product of the total requirements matrix and the vector of final demand y give the necessary output required from each of the sectors to satisfy total demand in the economy. The elements of the total requirements matrix describe the direct and indirect sector output effects for a change in final demand.

If we assume this change in final demand occurs for a single sector, then we consider the indirect effects on the rest of the economy to depend on a *size effect* and a *network effect*. The size effect refers to the increased economic influence gained with economies of scale and is measured by the relative size of the sector in terms of output or value-added. The network effect can be measured in part by interindustry linkages between that sector and other sectors in addition to *consumption linkages* between that sector and factor-supplying households.

One way to measure the network effect of a sector is to estimate its output multipliers. Summing the elements of the $(I - A)^{-1}$ matrix in column j gives the output multiplier for sector j, defined as the amplified effect of an economic stimulus as money is spent and re-spent in an economy over several rounds. Formally, the output multiplier is defined in Miller and Blair (2009) as the sum of the column elements (l_{ij}) for sector j in the inverse matrix

$$m(o)_j = \sum_{i=1}^{n} l_{ij} \quad (4)$$

For a given sector, the output multiplier measures the combined direct and indirect effect of a unit change in sector output including the additional change in output of all industries in which that sector purchases inputs. To produce an additional \$100 worth of machine parts requires the additional purchasing of local inputs (e.g. steel, electrical components, and transport services) as well as the purchasing of local labor services. An output multiplier of 1.5 indicates that a direct increase of \$100 in final demand for machine parts can generate an additional increase of \$50 in intermediate demand through sector linkages, leading to a total of \$150 in economy-wide gains.

Output multipliers are known to capture both direct and indirect linkages. However, there is a long-standing debate in the literature as to the inclusion of "internal linkages" (i.e. on-diagonal elements of A or $(I - A)^{-1}$) when one is interested in estimating a sector's true "backward dependence" or it's linkages to the rest of the economy (Miller and Blair 2009). Various normalization methods have been proposed using pre-multiplication of the A matrix by a unitary vector that allow for a ranking of sectors by the magnitude of backward and forward linkages. The three most wide-ranging measures of linkages were developed by Chenery and Watanabe (1958), Rasmussen (1957), and Dietzenbacher (1992). Borrowing notation from Morrone (2017), we can express Chenery and Watanabe's weighted direct backward linkage index as:

$$m = \mathrm{n}\mathrm{e}'\mathrm{A}/\mathrm{e}'\mathrm{A}\mathrm{e} \quad (5)$$

where n is the number of sectors in our model, e refers to a column summation vector (where ei=1 for all *i*), $'$ denotes transposition, and A is the technical coefficient matrix. The sum of sector *j*'s backward linkages is divided by the simple average of all backward linkages in the economy. The average value of our index m is one so that sectors with an index value greater than one are considered sectors with direct backward linkages that are above average. Similarly, sectors with a value less than one are considered to have direct backward linkages that are below average.

In the same fashion, Rasmussen (1957) used the inverse matrix to develop an index of normalized total backward linkages that capture both direct and indirect output gains needed to match an increase in final demand for sector *j*. We can express Rasmussen's total backward linkage index as:

$$z = \mathrm{ne}'(I - A)^{-1} / [\mathrm{e}'(I - A)^{-1}\ \mathrm{e}] \qquad (6)$$

where $(I - A)^{-1}$ is our inverse matrix.

The Dietzenbacher eigenvector method builds on the Chenery and Watanabe weighted direct backward linkage index using an infinite iterative process where the vector $m1$ of linkage indicators may be used as weights in place of the column summation vector e in a new calculation of linkage indicators $m2$. In turn, the elements of $m2$ are used as weights for an additional calculation in $m3$. In this fashion, the inputs from sectors with a higher power of pull are given additional weighting than sectors with lower powers of pull. This iterative process takes the following form:

$$m_{i+1} = \mathrm{n}m_i{}'\mathrm{A}/m_i{}'\mathrm{Ae} \qquad (7)$$

Thus, our estimation of sector power, as defined by backward linkages and a sector's degree of network centrality, is improved iteratively as i approaches infinity. Dietzenbacher (1992) proved that the indicator m_{i+1} converges to a function of the normalized left-hand eigenvector corresponding to the dominant eigenvalue of the technical coefficient matrix A:

$$m_{i+1} = \mathrm{nq}'/(\mathrm{q}'\mathrm{e}) \quad \text{with} \quad \mathrm{q}'\mathrm{A} = \lambda_D \mathrm{q}'$$

where q' is the "Perron vector" i.e. the eigenvector corresponding to the dominant eigenvalue λ_D of the matrix. The elements of the resulting vector $\mathrm{nq}'/(\mathrm{q}'\mathrm{e})$ provide a robust measure of sectors' power of pull considering both the weighting of backward linkages and the 'infinite regress' of economic influences throughout a network or cluster of sectors (Luo 2003).[3]

Finally, we focus also on the demand-side role of consumption linkages in supporting a sustainable and balanced recovery. An increase in the purchases of local labor inputs following an increase in demand leads to higher household incomes and additional consumption expenditures. These consumption linkages present an additional multiplier effect on the basis of induced increases in output from increased household expenditures. By "closing" our IO model with respect to households we can derive income and Type 2 output multipliers, which collectively describe the total multiplier effects of direct, indirect, and induced increases in sector output. Closing our model with respect to households refers to the inclusion of factor-supplying households as an endogenous sector by including an additional row for labor compensation and an additional column for household consumption in our intermediate matrix that we use to calculate our technical coefficients table.

[3] In order for our model of the economy to be workable, the infinite series must be convergent since this is a fundamental condition for there to be a solution.

Identifying key sectors capable of supporting an inclusive and balanced recovery must involve identifying those sectors with above-average consumption linkages, providing relatively large flows of household income and employment. Income multipliers represent the economic impacts of a change in final demand on household earnings and describe how the benefits to growth are distributed to households. By considering household expenditures as endogenous, these multipliers capture information regarding the magnitude of induced output effects which appear in our Type 2 output multipliers. Simple income multipliers are derived using the technical coefficients for direct labor requirements when the IO model is closed with respect to households. The calculation involves weighting each element in the direct labor requirements (households) row by the output multipliers of the corresponding sector and taking the sum. This relation is described formally in equation (8) where $a_{n+1,i}$ are the row elements of household income receipts from labor compensation by sector.

$$m(h)_j = \sum_{i=1}^{n} a_{n+1,i}(l_{ij}) \tag{8}$$

The simple income multiplier denotes the direct and indirect effect of an increase in final demand for sector j on the total value of required labor services. There is another kind of income multiplier, referred to as the Type 1 income multiplier, which describe how the initial sector-household income payments $a_{n+1,i}$ are "blown up" over several rounds of direct and indirect spending effects over the economy (Miller and Blair 2009). The formula for the Type 1 income multiplier is simply the ratio of the simple income multiplier (8) and the labor input requirement coefficient $a_{n+1,i}$.

$$m(h)_j^I = \frac{\sum_{i=1}^{n} a_{n+1,i}(l_{ij})}{a_{n+1,i}} \tag{9}$$

While the simple income multiplier describes the increase of household incomes as a result of additional labor input requirements for sector j, the Type 1 income multiplier captures the relative contribution of income gains in sector j in stimulating additional income gains across sectors. Thus, viewing the results of these income multipliers from a socioeconomic lens enables the identification of critical sectors which can be leveraged to pursue strategic commitments for sustained income growth and support of domestic markets. The major limitation of IO data in this respect is the lack of delineation between various income or skill groups, accounts which prominently feature in SAMs, to allow for identifying targeted income effects for low-income households or low-skilled workers. Instead, we rely on external sources regarding the labor intensity of the sector and the given sector's demand for less-skilled labor.

Given that the household sector's main "output" are labor inputs, our income multipliers are closely related to a sector's physical employment multipliers for a change in final demand. Following (Kecek et al. 2021), we calculate $\hat{e}_j = {e_j}/{x_i^0}$ as the number of full-time employees in sector j where e_j is the total value of compensation paid to workers and x_i^0 denotes the monetary value of sector output in the base year. The physical employment multiplier formally describes the sector-to-household linkages through the labor market as the ratio of the initial increase of employment a result of additional input requirements for sector j and the sector's share of compensation for full-time employment of output:

$$m(e)_j = \frac{\sum_{i=1}^{n} \hat{e}_i(l_{ij})}{\hat{e}_j} \qquad (10)$$

This describes the number of additional direct and indirect gains in employment due to *the autonomous increase of one direct unit of employment in sector j.* Although we cannot map sectoral income effects to income or skill groups, if we know details about sector employment levels of skill groups or average wages we can utilize the employment multiplier to identify sectors more likely to impact lower-income households. Viewing the results of employment and income multipliers from a socioeconomic lens enables the identification of critical sectors which can be leveraged to pursue strategic commitments for sustained inclusive growth for those in poverty and for disadvantaged groups. The major limitation of IO data in this respect is the lack of delineation between various income or skill groups, accounts which prominently feature in SAMs.

4. Results and Interpretation

This section is structured as follows. First, we report our estimates for backward linkage indicators and identify key sectors for the Brazilian economy. These linkage indicators serve as a proxy for the power of pull of a given sector with respect to the rest of the economy and serve to clarify which sectors should be bailed out first in the event of a recession (Morrone 2017). Sectors are ranked according to their capacity to influence total economic recovery by virtue of direct indicators (gross output, value-added, employment) and their interindustry linkages. We compare rankings for sectors when all three indicators of backward linkages are considered. Following Luo (2013), we provide a comparison of sectors' power of pull using the eigenvector method with their direct indicators. Second, we detail the results of our economic multiplier analysis for Brazil. We describe our estimates for average multipliers. Then, we report a full set of multipliers for the largest sectors by value-added in the overall economy, for pandemic-sensitive service industries, the largest sectors in manufacturing, and in public health and social work. The significance of sector multipliers is assessed within the context of the social and economic impacts of COVID-19 at the level of sectors and households.

4.1 Power of Pull Analysis

Generally speaking, the relative economic importance of a sector can be considered in terms of its channels of influence structured by a particular size effect and network effect. Direct indicators (intermediate consumption, output, value-added, and others) provide measurements of the size effect while our backward linkage indicators provide measurements of the network effect. Accordingly, each of these components of sector importance should be considered in light of the others. In the context of planning for an economic recovery, it is more useful to focus on sectors' network effects in order to leverage their ability to support and stimulate economic activity in other sectors. We begin with Table 1.1 showing the top 10 sectors by Chenery and Watanabe (CW) indicators and comparing them with the ranking for Rasmussen and Eigenvector-based PoP indicators. Note that while our CW and Rasmussen indicators here are unweighted, the PoP indicators are weighted iteratively for backward linkages and become highly sensitive to a sector's centrality in a cluster of sectors. Accordingly, eigenvalues have more to do with dynamics of the system, denoting higher pull over time and the power to propel growth over the economy.

Table 1.1 Comparing Interindustry Linkage Indicators

Sector	CW	Rank	Rasmussen	Rank	PoP	Rank
Coke and refined petroleum products	1.621	1	1.429	1	3.597	3
Food products, beverages and tobacco	1.491	2	1.244	2	0.860	10
Computer, electronic and optical products	1.433	3	1.263	3	0.327	25
Manufacture of basic metals	1.421	4	1.246	4	0.768	11
Motor vehicles, trailers and semi-trailers	1.417	5	1.289	5	0.355	23
Other transport equipment	1.378	6	1.252	6	0.115	32
Chemicals and pharmaceutical products	1.366	7	1.254	7	2.839	4
Electrical equipment	1.342	8	1.232	8	0.320	26
Rubber and plastics products	1.308	9	1.225	9	0.573	15
Machinery and equipment	1.229	10	1.135	10	0.512	17

Source: Authors' calculation

Comparing indicators across sectors, we find that the ranking of sectors by CW indicators share the exact same ranking distribution as the Rasmussen indicators across all 36 sectors. This finding suggests that the structure of direct and total backward linkages in Brazil are closely related and confirms the well-known finding that CW indicators are highly correlated with Rasmussen indicators (Morrone 2017). We find that coke and refined petroleum products stands above as the sector with the largest values for both CW and Rasmussen indicators, followed by 2) food, beverage, and tobacco products, 3) computer, electronic, and optical products, 4) manufacture of basic metals, and 5) motor vehicles, trailers, and semi-trailers. These five sectors are distinguished by higher than average levels of backward linkages. Thus, these sectors are considerably well-positioned to support economic activity in connected sectors and drive overall economic growth or recovery.

Our results support the findings in Morrone (2017) which identified the relative importance of the coke/refined petroleum, chemical/pharmaceutical products, basic metals, and food, beverages, and tobacco products sectors. Although our finding of computer, electronic, and optical products (CW rank #3) and motor vehicles (CW rank #5) as key sectors are at odds with Morrone's estimated rankings. Considering that the underlying data we work with corresponds with a later year and a greater level of sector aggregation than in Morrone's (2017) analysis using 2013 input-output data with 51 production activities, we should expect some difference in our results, particularly due to differences in the level of aggregation. However, it is within the realm of possibility that the computer/electronics and automotive industries in Brazil have increased in importance in recent years.

Comparing our CW and Rasmussen indicators with our eigenvalues, we find that these indicators are very weakly correlated with eigenvalues (exhibiting Pearson coefficients of 0.007 and -0.015 respectively). Though our sector with the largest CW and Rasmussen indicators (coke and refined petroleum products) indeed presents a relatively high PoP rank (3rd), we quickly find that the top sectors by CW and Rasmussen indicators do not correspond generally with the top sectors by PoP. Thus, at first comparison it appears that our indicators for sector importance by backward linkages are dependent on different factors. It is clear that rankings between sectors by indicator tell a different story than the CW and Rasmussen indicators by observing Table 1.2, which shows the top 10 sectors by Eigenvector indicators. Notably, we find that the most important sectors by PoP vary considerably from our previous method of ranking.

Table 1.2 Comparing Interindustry Linkage Indicators (Cont.)

Sector	***PoP***	***Rank***	***CW***	***Rank***	***Rasmussen***	***Rank***
Business sector services	5.087	1	0.666	31	0.766	31
Wholesale and retail trade	5.023	2	0.696	28	0.780	28
Coke and refined petroleum products	3.597	3	1.621	1	1.429	1
Chemicals and pharmaceutical products	2.839	4	1.366	7	1.254	7
Mining and extraction of energy products	2.598	5	1.016	20	0.974	20
Transportation and storage	2.103	6	0.983	23	1.005	23

Financial and insurance activities	1.997	7	0.693	29	0.764	29
Electricity, gas, water supply, and other utilities	1.782	8	1.070	16	1.025	16
Agriculture, forestry and fishing	0.910	9	0.806	27	0.930	27
Food products, beverages and tobacco	0.860	10	1.491	2	1.244	2

Source: Authors' calculation

Comparing our CW/Rasmussen measures of backward linkages and eigenvalues yields fundamentally different results. The sectors with the largest eigenvalues generally correspond to low CW/Rasmussen rankings, with the notable exception of coke and refined petroleum products and chemical/pharmaceutical products, which do have relatively large CW/Rasmussen indicators. The business sector services has a PoP rank of 1st but is 31st in both CW and Rasmussen indicators. Similarly, wholesale and retail trade had a PoP rank of 2nd but is 28th in both CW and Rasmussen indicators. This result is unusual compared to Dietzenbacher's (1992) study of linkage indicators in the Netherlands, finding a general cross-similarity in the ranking distribution of sectors by alternative linkage indicators. This difference may be accounted for by key differences in the production structure and concentration of linkages in developed and developing countries (Laumas 1975), particularly in developing countries' greater dependence on fewer sectors.

We find that the sectors with the greatest PoP according to eigenvalues are 1) business sector services, 2) wholesale and retail trade, 3) coke and refined petroleum products, 4) chemicals and pharmaceuticals, and 5) mining and extraction of energy producing products. Of the top five eigenvalues, only one corresponds with a top five sector by CW/Rasmussen indicator: coke and refined petroleum products. Given that we find the coke and refined petroleum products and chemical/pharmaceutical products sectors on the upper end of both rankings of both PoP and CW/Rasmussen indicators they clearly represent strongly networked sectors upon which large sections of the Brazilian economy depend on for intermediate demand. The Eigenvector method accounts for the optimal weighting of sector linkages over infinite regress and is therefore sensitive to clustered sectors. Patterns of sector-to-sector concentration in intermediate purchases and sales tend to inflate eigenvalues for some sectors while reducing those for others (Dietzenbacher 1992). This well-known fact implies that the main differences in the rankings of sectors among alternative methods is related to the relative concentration of intermediate input purchases for backward linkages and intermediate output sales for forward linkages.

Sector with the greatest PoP act as major nodes for the economy as they serve to connect industrial clusters in a complex web of backward *and forward* linkages. These sectors are marked by their degree of *connectednesss* in a network made up of nodes and paths. The wholesale and retail trade sector acts as a clearinghouse of sorts for commodities in various stages of production, providing an outlet for commodities from intermediate producers to reach other firms (wholesale) or households (retail). In the case of business services, we find significant concentrations in forward linkages. The business services sector is a major sector providing critical inputs for a large variety of sectors across the economy. The size and importance of the business services sector is held to growth in importance with greater tertiarization of the economy on the basis of these linkages (Russo and Chies 2017). A high degree of concentration in forward linkages is true for a majority of sectors with large eigenvalues, denoting sensitivity to large network centrality effects.

4.2 Does Size Matter?

As shown in Luo (2013), the ranking of sectors by their Eigenvector-based PoP may differ significantly from the ranking of sectors by direct measures of importance, such as total intermediate input, total output, and value-added. We turn to the question of whether this is true for the Brazilian economy. Table 2.1 provides a comparison of sector rankings by their eigenvalues and direct indicators of importance.

Table 2.1 Comparing Direct Indicators with Sectors' Power of Pull

Sector	***PoP***	***Rank***	***Intermediate Inputs ($mn)***	***Rank***	***Sector Output ($mn)***	***Rank***	***Value-added ($mn)***	***Rank***
Business sector services	5.087	1	$ 71,446	7	$ 195,797	3	$ 124,351	4
Wholesale and retail trade	5.023	2	$ 126,676	2	$ 333,062	1	$ 206,386	1
Coke and refined petroleum products	3.597	3	$ 102,002	4	$ 112,966	10	$ 10,964	25
Chemicals and pharmaceutical products	2.839	4	$ 85,015	5	$ 109,321	11	$ 24,307	16
Mining and extraction of energy products	2.598	5	$ 27,346	19	$ 47,610	18	$ 20,263	17
Transportation and storage	2.103	6	$ 84,754	6	$ 152,926	6	$ 68,172	10
Financial and insurance activities	1.997	7	$ 65,940	9	$ 175,880	4	$ 109,941	5
Electricity, gas, water supply, and other utilities	1.782	8	$ 60,840	12	$ 97,912	12	$ 37,072	12
Agriculture, forestry and fishing	0.910	9	$ 68,028	8	$ 145,972	7	$ 77,944	8
Food products, beverages and tobacco	0.860	10	$ 158,907	1	$ 196,074	2	$ 37,167	11

Source: Authors' calculation

We find that sectors may be distinguished by PoP rankings that are higher than sector rankings by direct measures. This is true for chemicals and pharmaceutical products, which is ranked 4th in PoP, and 5th in terms of intermediate inputs, but only 11th in output, and 16th in value added. Similarly, the mining and extraction of energy products is ranked 5th in PoP, but only 19th in inputs, 18th in output, and 17th in value-added. Thus, the chemical/pharmaceutical products and raw energy products sectors are distinguished by the fact that they are not large but 'powerful' as in capable of exerting significant economic influence across sectors (Luo 2013). We find sectors also that are both large and powerful, as in the case of wholesale and retail trade which is ranked 2nd in PoP, 2nd in terms of intermediate inputs, 1st in output, and 1st in value added.

Additionally, there are sectors that are large but exhibit lower than average PoP. Such sectors may account for relatively large resource flows in the economy but not contribute large network effects. One such sector is the food, beverages, and tobacco products sector which is the 2nd largest sector in terms of output, the largest in terms of intermediate inputs and 11th in terms of value-added, however it has a PoP ranking of 10th. Overall, we find that ranking sectors by their eigenvalues yields results that are fundamentally different than when ranking sectors by their direct indicators. The distribution of different rankings across our sectors enables us to distinguish between sectors that are important because they are large and sectors that are important because they have a high PoP and identifying sectors which may be both large and powerful as well as sectors which are none. Assessing the relative importance of both direct measures (size effects) and measures of backward linkages (network effects) in addition to the scope of their interactions are important for developing sector-led recovery plans that are country-specific.

4.3 Multiplier Analysis

The PoP measure and the key sectors analysis in general in based on a gross output approach, meaning that the magnitude of backward linkages can tell us relatively little about direct welfare implications through income and employment effects. 'Bailing out' sectors with high CW/Rasmussen and/or PoP indicators through exogenous increases in final consumption (i.e. foreign investment, government spending) may result in temporary growth of income and employment, however they cannot contribute directly (via demand-side channels) to welfare implications through structural changes in the distribution of incomes or the structure of employment (Luo 2013).

The significance of large output multipliers is similarly limited given that a large multiplier is simply due to having large input coefficients. While these coefficients point to significant sources of intermediate demand and economic influence over a given production cluster, they tell us relatively little about *sustaining an economic recovery* through the stabilization of household incomes and aggregate demand. Practically speaking, key and strategic sectors are important for sustained recovery in so far as they contribute directly or indirectly to household income and consumption (ten Raa 2020).

In light of this, we integrate households in our model of sectoral interdependence and derive the relevant multipliers (Type 2 output, income, employment) to identify sectors with strong employment and consumption linkages. With this added dimension, this section aims to trace the economic impacts of the pandemic from a multi-sectoral lens inclusive of household feedback effects and ultimately guide the development of sector-led recovery plans that contribute to strong income and employment growth for the bottom 40% of households and other disadvantaged groups. Identifying "strategic sectors" capable of supporting an inclusive recovery requires identifying key sectors with above-average consumption linkages. Income multipliers represent the economic impacts of a change in final demand on household earnings. By capturing the embedded consumption linkages of sectors, income multipliers provide information regarding the magnitude of induced output effects which appear in our Type 2 output multipliers. This is one of the ways in which income distribution is linked to economic growth and recovery.

Table 3.1 Average Economy-Wide Multipliers

Type 1 Multiplier	2.120
Type 2 Multiplier	2.650
Physical Employment Multiplier	3.330
Type 1 Income Multiplier	2.636

Source: Authors' calculation

Table 3.1 describes the average multipliers estimated in our model. The average output multipliers in our model are 2.12 (Type 1) and 2.65 (Type 2). These average multipliers suggest that a 1 million USD injection in the economy will return between 2.12 million and 2.65 million in total additional sectoral output. These estimates are meant to reflect the lower- and upper-bounds of our modeled stimulus where the actual outcome depends on which sectors receive an increase in government spending as well as households' propensity to consume. We find average an average employment multiplier of 3.33 and income multiplier of 2.64. The value of the average employment multiplier suggests that aggregate employment growth in Brazil is modestly responsive to changes in final demand, where the direct increase of 1 job for the average sector indirectly support up to *3.33* additional jobs across linked sectors. In addition, consumption linkages are generally strong in Brazil, with every additional dollar of final demand in the average sector may be expected to stimulate additional household expenditures by $2.64 dollars. An average income multiplier greater than 1 in our case indicates that household expenditures indeed provide a significant channel for augmenting the effects of economic multipliers.

The magnitude of output, employment, and income multipliers vary substantially by sector, indicating significant differences between the structure of linkages of different sectors. We should expect structural differences according to the specific type of sector (i.e. manufacturing sectors will tend to have higher multipliers thanks to greater backward linkages). Observing Table 3.2, we find that it is indeed true that manufacturing sectors have larger multipliers. Specifically, we find that the highest average output multipliers are found in high-tech manufacturing while the highest employment and income multipliers are found in low-tech manufacturing. This is likely because high-tech sectors are composed of industries with more extensive backward linkages than low-tech sectors, although in addition, they tend to be less labor-intensive than low-tech manufacturing sectors leading to lower employment and income effects from increases in output.

Table 3.2 Average Multipliers by Sector Type

Primary	Type 1 Multiplier	2.072
	Type 2 Multiplier	2.474
	Employ. Multiplier	2.288
	Income Multiplier	2.846
Low-tech Manufacturing	Type 1 Multiplier	2.464
	Type 2 Multiplier	2.970
	Employ. Multiplier	4.595
	Income Multiplier	2.921
High-tech Manufacturing	Type 1 Multiplier	2.621
	Type 2 Multiplier	3.188
	Employ. Multiplier	3.544
	Income Multiplier	2.966
Services	Type 1 Multiplier	1.721
	Type 2 Multiplier	2.283
	Employ. Multiplier	2.787
	Income Multiplier	2.280

Source: Authors' calculation

Turning now to sector-level multipliers, Table 3.3 reports a full table of output, employment, and income multipliers for the top 10 sectors by value-added. Observing our table, we see that the wholesale and retail trade sector contributes the largest share of value-added (VA), followed by the public administration, real estate, business services, and the financial and insurance sectors. These figures are not surprising given the service sector in Brazil's has long occupied a high share of value-added and employment – especially during Brazil's recent wave of deindustrialization (Passoni and Freitas 2020). The largest VA sector, wholesale and retail trade, exhibits modest Type 1 output and employment multipliers relative to rest of the top 10 while exhibiting a relatively strong Type 2 output (2.16) and income multiplier (2.11). This indicates that the economy-wide impact from a change in final demand for these sectors occurs more greatly through the local household expenditures channel rather than through backward linkages with the production sector. As we saw in a previous section, this sector is a major node for the economy, bringing together a relatively wide-ranging industrial cluster through backward and forward linkages. Our results imply that the sector is also vitally connected with the 'households sector' as a source of income, driving consumption linkages with other sectors. Other sectors with significant Type 2 output multipliers are found in transportation and storage (2.66), construction (2.52), and public administration (2.34).

Table 3.3 Multipliers for Top 10 Sectors by VA (in 1 million USD)

	Wholesale and retail trade; repair of motor vehicles	***Public admin. and defense; social security***	***Real estate activities***	***Business sector services***	***Financial and insurance activities***
Sector VA	$ 206,385.90	$ 153,241.10	$ 150,153.70	$ 124,350.70	$ 109,940.80
Rank	1	2	3	4	5
%GTVA	13.32%	9.89%	9.69%	8.02%	7.09%
Type 1 Multiplier	1.650	1.539	1.196	1.625	1.621
Type 2 Multiplier	2.164	2.337	1.256	2.302	2.061

Employment Multiplier	1.776	1.778	8.125	2.079	2.498
Income Multiplier	2.110	1.819	3.005	1.965	2.179
	Education	**Construction**	**Agriculture, forestry and fishing**	**Human health and social work**	**Transportation and storage**
Sector VA	$ 100,513.80	$ 89,095.20	$ 77,943.70	$ 75,976.50	$ 68,172.10
Rank	6	7	8	9	10
%GTVA	6.49%	5.75%	5.03%	4.90%	4.40%
Type 1 Multiplier	1.359	2.059	1.973	1.664	2.131
Type 2 Multiplier	2.254	2.525	2.279	2.316	2.668
Employment Multiplier	1.607	2.545	2.235	2.082	2.232
Income Multiplier	1.681	2.635	2.994	1.989	2.526

Source: Authors' calculation

The highest employment multipliers for the top 10 VA sectors are in real estate (8.13), construction (2.55), financial/insurance activities (2.49), and agriculture (2.24). The highest income multipliers are found in real estate (3.01), agriculture (2.99), and construction (2.64), in addition to transportation and storage (2.53). These sectors should be understood as vitally important for channeling direct and indirect effects on household income and consumption. For targeted income gains for the bottom 40% of households, sectoral policy should strategize income gains in sectors employing large proportions of less-skilled labor *and with potential linkages to the informal sector*. These narrow the field down to construction, agriculture, and transportation/storage as sectors which are large and "strategic" with respect to inclusive growth.

Real estate is an interesting sector to note given that its employment multiplier is a clear outlier not just for the top VA group but across sector types as well.[4] In addition, it exhibits a very strong income multiplier which is the largest for the top VA group. While it is possible these results are due to some measurement error, it would be worth examining whether these results indeed reflect strategic importance in the Brazilian economy. The real estate sector is chiefly concerned with the buying and selling of properties for residential, commercial, and industrial uses. The sector's main 'output' or revenue source are rents derived from leasing owned properties for use by firms in commercial and industrial production, and households. Real estate services can thus be considered a wide-ranging input to production across the economy.

The relative importance of rental services as an input (forward linkages) is well-represented in the weight accorded to the sector's eigenvalue which gives the sector a rank of 12 in terms of PoP. In contrast, much weaker backward linkages are reflected in low output multipliers and a very low ranking with respect to CW and Rasmussen indicators. The large employment and income multipliers would appear to be based in part by induced gains, as in the gains brought on by the additional expenditures of real estate workers. However, care should be taken not to misinterpret multipliers here since these expenditure gains are sourced from rents and thus come at the expense of other productive activities. The extent to which these multipliers are valid over the medium-run

[4] The real estate sector's employment multiplier is second only to the low-tech manufacturing sector: coke and refined petroleum products sector.

may be contingent on the particular size and importance of real estate, since after a certain point, additional output gains in real estate may correspond with losses in the real economy.

The health services and social work, and public administration sectors constitute strategic sectors for managing the various public health challenges presented by the pandemic including the containment and treatment of disease in addition to vaccine development and disbursement. We find modest output multipliers for the health services sector of 1.66 and 2.32 coupled with a relatively strong employment multiplier of 2.08 and income multiplier of 1.99. A significant portion of the government's 2020 counter-COVID 19 expenditures[5] have been directed toward the public health sector through purchases of personal protective equipment (PPE) and other medical equipment, ventilators and other hardware, medical and emergency services, and research funding. Direct government expenditures in support of public health programs are targeted at improving basic capacity for pandemic control, treatment, and the distribution of essential goods and emergency aid. Improving capacity in this sector will require major labor inputs from both high-skilled and less-skilled workers including additional doctors and nurses, social workers, counselors, in addition to caretakers and medical aides. Similarly, the public administration sector has output multipliers of 1.54 and 2.34 with employment multiplier of 1.78 and income multiplier of 2.11. Thus, we should expect significant stimulus pressures reverberating from expenditures in the public health sector and expansions of the public administration sector.

Table 3.3 Multipliers for Severely Impacted Service Sectors (in 1 million USD)

	Accommodation and food services	*Arts, entertainment, and recreation*
Sector VA	$ 36,909.70	$ 25,104.70
%GTVA	2.38%	1.62%
Type 1 Multiplier	1.961	1.959
Type 2 Multiplier	2.413	2.490
Employment Multiplier	1.628	3.113
Income Multiplier	2.483	1.479

Source: Authors' calculation

A significant portion of employment losses have been concentrated in broadly pandemic-sensitive service sectors like wholesale and retail trade, business services, and the transportation sector in addition to accommodation and meals, and other related service sectors. An important first step to stabilization is to prevent net employment losses at their source. The most affected sectors in terms of output and employment were the consumer-facing industries in wholesale and retail trade, accommodation and other allied service industries. Many of these constitute key sectors in terms of interindustry linkages and consumption linkages, leading to widespread economic shockwaves throughout the wider economy. Given this context, one of the principle challenges of the COVID-

[5] According to our estimates, direct public health expenditures from the federal government in 2020 amounted to $R 82.3 billion (convert this to USD) or roughly 1.1 percent of GDP.

19 shock then is to restore domestic demand to pre-pandemic levels in order to boost employment in these and interconnected sectors.

Table 3.3 reports multipliers for a set of two additional service-sector industries that have experienced significant employment losses during the pandemic. We find modest output multipliers for accommodation and food services (1.96 and 2.41) and arts, entertainment, and, recreation (1.96 and 2.49). In accommodation and food services, these are coupled with a standard employment multiplier of 1.63 and relatively high income multiplier of 2.48. In the arts, entertainment, and, recreation sector we find a quite robust employment multiplier of 3.11 and standard income multiplier of 1.48. Altogether, job losses in these sectors represent the loss of mainly middle and low-skill jobs in both the formal and informal sectors (Firpo and Piero 2018). Given our estimated multipliers, the abrupt declines in service sector output and employment left immediate impacts on the employment and incomes of households across Brazil, including those in poverty or vulnerable to poverty.

Table 3.4 Multipliers for Top 10 Manufacturing/Utilities Sectors by VA (in 1 million USD)

	Food products, beverages and tobacco	*Electricity, gas, water, and other utilities*	*Chemicals and pharmaceutical products*	*Other manufacturing*	*Textiles, wearing apparel, leather and related products*
Sector VA	$ 37,167.00	$ 37,072.20	$ 24,306.50	$ 16,120.70	$ 15,602.80
Rank	1	2	3	4	5
%GTVA	2.40%	2.39%	1.57%	1.04%	1.01%
Type 1 Multiplier	1.650	1.539	3.031	2.198	2.229
Type 2 Multiplier	3.013	2.337	3.439	2.722	2.799
Employment Multiplier	4.575	3.702	4.358	2.653	2.462
Income Multiplier	3.107	3.007	3.184	2.671	2.576
	Motor vehicles, trailers and semi-trailers	**Machinery and equipment**	**Coke and refined petroleum products**	**Manufacture of Basic metals**	**Fabricated metal products**
Sector VA	$ 12,287.80	$ 11,329.80	$ 10,963.80	$ 10,324.20	$ 10,324.20
Rank	6	7	8	9	10
%GTVA	0.79%	0.73%	0.71%	0.67%	0.67%
Type 1 Multiplier	2.733	2.407	3.031	2.643	2.347
Type 2 Multiplier	3.332	3.013	3.439	3.106	2.905
Employment Multiplier	3.589	2.775	16.422	4.482	2.429
Income Multiplier	3.009	2.709	3.821	3.171	2.673

Source: Authors' calculation

Brazil is a regional and global leader in industrial production, however they have also been of the hardest hit by deindustrialization (Castillo and Martins 2016). Despite this they remain one of the world's largest producers of food products, motor vehicles, chemical products, and fabricated metal products. Manufacturing sectors contribute substantial spillover in terms of multiplier effects given that manufacturing requires a wide-ranging list of inputs, stable manufacturing employment tends to support a large volume of additional output and employment in related sectors and local communities.

Table 3.4 shows the estimated multipliers for the largest manufacturing sectors by VA. The largest greatest value-added among the manufacturing sectors are found in food products, utilities, chemical and pharmaceutical products, other manufacturing, and textiles. The highest Type 1 output multipliers are found in the coke and refined petroleum products (3.03), chemicals and pharmaceutical products (3.03) sectors, and motor vehicles (2.7). The highest Type 2 output multipliers are found again in the coke and refined petroleum products (3.44), chemicals and pharmaceutical products (3.44) sectors, and motor vehicles (3.33). These high multipliers represent the combined total effects of backward linkages and induced consumption effects. The sectors with the largest estimated employment multipliers are coke and refined petroleum products (16.42), food, beverage, and tobacco products (4.58), other manufacturing and repair (4.48) sectors, and chemical products (4.36). The greatest income multipliers are found in coke and refined petroleum products (3.82), chemical and pharmaceuticals products (3.18), and manufacture of basic metals (3.17). We have seen that these sectors already constitute key sectors by way of backward linkages. Our present results also indicate that these sectors constitute strategic sectors in terms of the income effects and driving consumption linkages.

5. Discussion

The present stimulus has focused on 1) maintaining demand-side channels through income supports and emergency aid, and 2) employment stabilization through subsidies and incentives for SMEs. The broad package of income supports have been directly responsible for poverty prevention and recovery, providing a necessary pillar of support for steady recovery of consumption spending from households. However, these effects are temporary and the social welfare effects of income supports are expected to run-out. Moreover, unemployment rates remain high as the spread of COVID-19 continues with little abatement, threatening to extend the recession farther into the future. These facts justify the use of sector policy to drive economic recovery by stimulating interindustry production, reducing unemployment, and raising household incomes for the bottom 40 percent. Key sectors may be assessed in terms of interindustry linkages and sector clustering and in terms of consumption linkages and employment effects. In this section we identify three classes of key sectors: a) key sectors, those critical in terms of backward linkages and as a site of clustering, b) income-driving sectors, those critical in terms of household consumption and employment effects, and c) strategic sectors, those critical in both.

For both CW and Rasmussen indicators, we find key sectors in traditional and advanced manufacturing industries. The sectors with the largest backward linkage indicators are 1) coke and refined petroleum products, 2) food, beverage, and tobacco products, 3) computer, electronic, and optical products, 4) manufacture of basic metals, 5) motor vehicles, trailers, and semi-trailers, 6) other transport equipment, 7) chemical and pharmaceutical products, 8) electrical equipment, 9) rubber and plastic products, and 10) machinery and equipment. These sectors also tend to the have the highest output multipliers, as confirmed by very strong correlation coefficients between Type 1 output multipliers and CW indicators (0.97) and Rasmussen indicators (unity).[6]

Accounting for both backward linkages and sector clustering, key sectors from the PoP lens are in sectors which serve also as critical inputs for the production of other sectors. Such critical input sectors tend to be found in wide-ranging service industries like business services, transportation,

[6] These indicators are also well-correlated with Type 2 output multipliers: CW (0.84) and Rasmussen (0.87)

financial activities, as well as important input commodities like chemical/pharmaceuticals, utilities, and agricultural products. We find the sectors with the greatest eigenvalues are 1) business sector services, 2) wholesale and retail trade, 3) coke and refined petroleum products, 4) chemicals and pharmaceuticals, 5) mining and extraction of energy producing products, 6) transportation and storage, 7) financial and insurance activities, 8) electricity, gas, water, and other utilities, 9) agriculture, forestry, and fishing, and 10) food, beverage, and tobacco products.

Given that we find the coke and refined petroleum products and chemical/pharmaceutical products sectors on the upper end of both rankings of both PoP and CW/Rasmussen indicators they clearly represent strongly networked sectors in the Brazilian economy strategically placed along the supply chains for various other sectors of the economy. Other notable sectors along these lines include manufacture of basic metals and food, beverage, and tobacco products. These and other key tradable sectors provide the foundation for Brazil's present model of export, from which the country has leaned significantly on to support the present recovery. It is important to note however that many of these sectors, particularly coke and refined petroleum products and chemical/pharmaceutical products, are highly carbon-intensive and contribute to climate change via high emissions. Planning for a sustainable development path should seek to phase-out the economy's dependence on these sectors over the long-run. On one hand, transitioning to a low-carbon economy means foregoing high multiplier effects in these sectors and will likely coincide with a net decrease in overall employment (McIsaac and Bastidas 2017). On the other hand, however, the disadvantages to a sustainable transition can be mitigated by a 1) pro-poor development strategy that commits to raising incomes and relying on consumption linkages, and 2) constructing robust national innovation systems (NIS) to develop advanced manufacturing and quaternary industries that are low-carbon and provide strong multiplier effects.

Ignoring carbon-intensive sectors and real estate, the highest employment multipliers for the top 10 VA sectors are in construction (2.55), financial/insurance activities (2.49), and agriculture (2.24). The sectors with the largest overall employment multipliers are food, beverage, and tobacco products (4.58), other manufacturing and repair (4.48). The highest income multipliers for the top 10 VA sectors are found in agriculture (2.99), construction (2.64), and transportation and storage (2.53). The greatest income multipliers are found in the manufacture of basic metals (3.17), food, beverage, and tobacco products (3.11), and machinery and equipment (2.71). These sectors are understood as highly important in terms of direct and indirect effects on household income and consumption. Supporting healthy economic growth in these sectors should be expected to generate large multiplier effects through induced gains in output from higher incomes and consumption expenditures. It appears that the sectors with the strongest income effects coincide with the largest PoP indicators. Thus, in addition to generating powerful network effects on the basis of linkages and sector clustering, these sectors also constitute strategic sectors in terms of driving income effects and consumption linkages for the benefit of the rest of the economy.

6. Conclusion

Planning for economic recovery as income and employment supports run-out and over the medium-run may come to depend on a new policy paradigm aimed at overcoming structural inequalities and pursuing more sustainable development. Within the backdrop of these economic troubles, Brazil prepares for another polarized election in 2022. The hotly contended question of

Brazil's post-pandemic political economy will come to be very important in deciding the country's future path of recovery and development.

In order to pursue a program of fiscal consolidation and stability while simultaneously pursuing increases in the standard of living through employment gains and real wages increases, Brazil must overcome its central macroeconomic challenge of stagnant productivity growth. Facing this challenge will necessitate a robust new set of fiscal and microeconomic reforms including improving the efficiency of public spending to support fiscal balancing, consolidation and improvement of access to financial markets and credit, improving the business environment by relieving regulatory and uneven tax burdens, and to develop advanced policy frameworks for the use and conservation of natural resources (World Bank 2020a).

Going further, we argue that Brazil will require a new growth model in order to protect and sustain social welfare gains from before the 2015 recession. As we have shown, sustaining the present recovery over the short to medium term may rely on sector-led stimulus. Policymakers in Brazil have the choice of continuing traditional investment and industrial policy around export-led growth and carbon-intensive production in the coke and refined petroleum products and chemical/pharmaceutical products sectors or pursuing a sustainable development path that sees the transition to a low-carbon economy. Such a transition will require pro-poor policies that generate widespread gains in household incomes as well as the development of robust NIS. A great deal of resources will need to be mobilized so such development including the use of national and regional innovation banks, education policy, industrial policy, and optimal incentive structuring through the provision of grants, education spending, and high-tech infrastructure spending.

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