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SELECTED ISSUES

August 23, 2021

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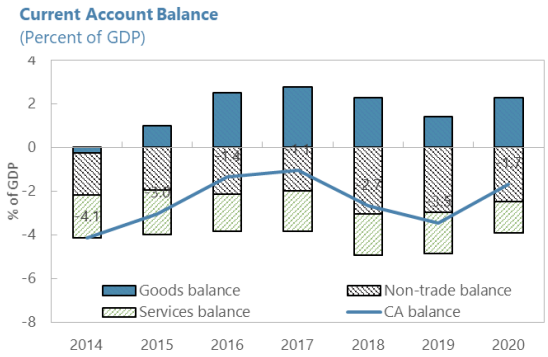
EXTERNAL SECTOR DYNAMICS DURING RECESSIONS

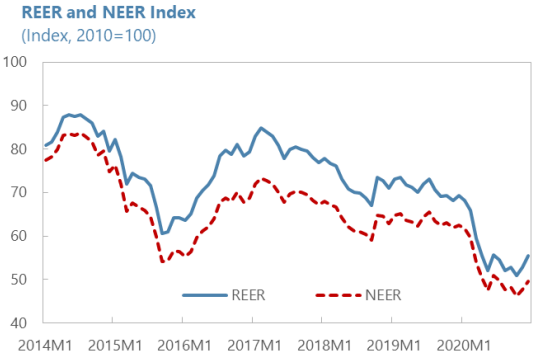
Despite the special nature of the COVID-19 crisis, Brazil's current account (CA) improvement was in line with its historical average, and not smaller as expected, due to an exceptionally strong role of private savings relative to investment. The evidence also suggests that the improvement in the CA balance could be persistent over the medium term.

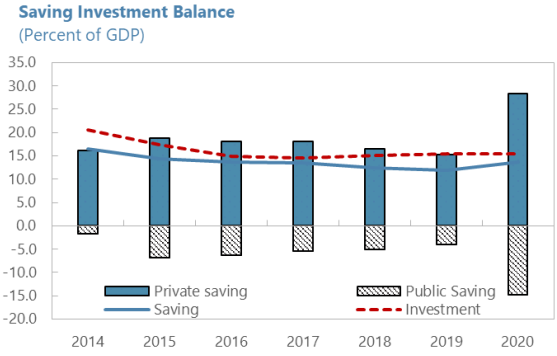
A. Brazil's External Sector In 2020

1. Brazil's current account balance improved by 1.8 percent of GDP in 2020 due to a sizable import compression. The CA deficit narrowed from -3.5 percent in 2019 to -1.7 percent in 2020, mainly driven by an improvement in the goods and services balance. Imports declined by substantially more than exports, as a strong currency depreciation (about 20 percent year-on-year for the REER in 2020) and domestic lockdowns early in the pandemic induced a demand slowdown. Tourism and business travel fell sharply, reducing the deficit in the services account by around 0.5 percent of GDP. Investment to GDP remained broadly constant while aggregate saving to GDP increased, narrowing the saving-investment balance.

2. While imports fell sharply, exports were less affected thanks to Brazil's trade exposure to China. Goods imports (in value) declined almost in tandem with domestic lockdown measures from March to July and have been recovering since then[1] (Figure 1, left panel). Exports declined only slightly more than last year despite an overall increase in lockdown stringency in trading partner economies (Figure 1, middle panel). The average, however, masks stark differences in export destinations. Exports to the US and Argentina, Brazilian exports' second and third largest destination, plummeted in early 2020, in line with lockdowns in these countries, while exports to China increased from April onwards as China began to reopen its economy (see Figure 1, right panel). Consequently, export shares to China increased by almost 5 percent of total exports, with most other destinations seeing their shares decline.

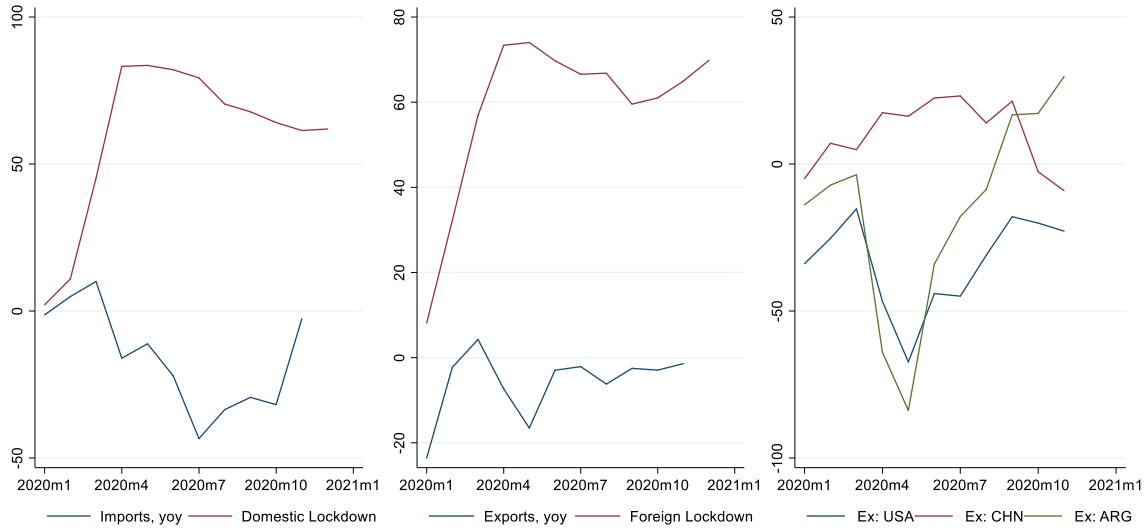






[1] Domestic lockdown measures are taken from the Oxford University stringency index. Monthly bilateral trade data are from the IMF Direction Of Trade Statistics (DOTS) database. COVID-19 case numbers and deaths seem less related to trade growth.

Figure 1. COVID Lockdown Stringency and Brazil's Trade In 2020



Notes: Monthly, year-on-year growth in imports and exports. "Domestic Lockdown" and "Foreign Lockdown" represent the COVID-10 lockdown stringency, taken from Oxford University, on a scale of 0-100, with 100 being most stringent. "Foreign lockdown" is the trade weighted average of Brazil's export destination countries. Right panel: "Ex:" denotes bilateral exports from Brazil to USA/China/Argentina.

B. Putting 2020 into Global Perspective: CA Adjustments During Past Recessions

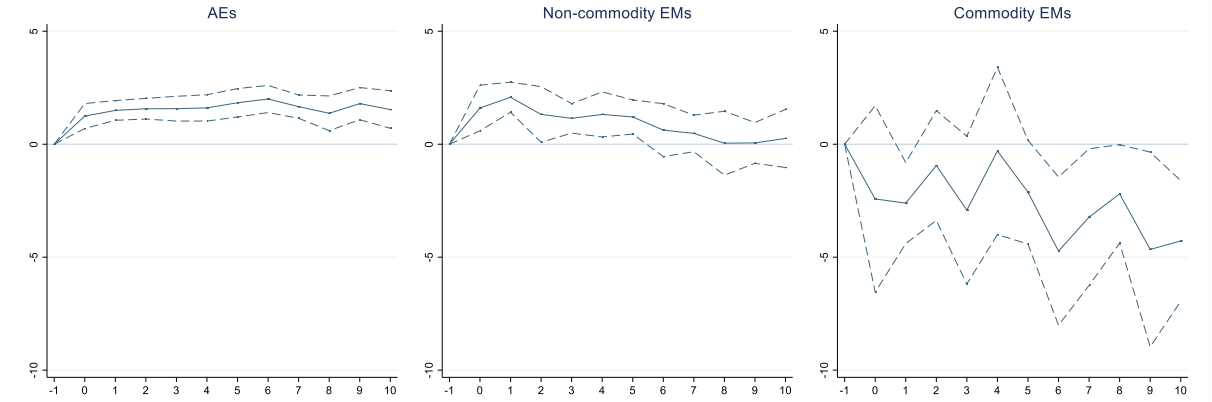
3. Historical evidence shows that CA balances typically rise by 1-2 percent of GDP during recessions in non-commodity exporting economies[2]. While the increase is highly persistent in advanced economies (AEs) for up to 8-10 years, non-commodity exporting emerging market (EM) CA balances react more strongly in the short term but return to pre-crisis levels more quickly (4-6 years). No significant CA improvement can be found in the group of commodity exporters as recessions tend to be closely associated with terms of trade shocks and subsequent decline in commodity exports (Figure 2.1). Brazil's CA response to its seven past recessions since the 1970s[3] averaged 2-3 percent of GDP and are thus mostly in line with the EM non-commodity average, despite a substantial share of commodities in Brazil's export basket (49 percent of total exports in 2020). Unlike most commodity exporters, Brazil's commodities are diversified, with food, oil and metals making up roughly one third each, rendering the external position less prone to terms of trade shocks in specific commodities.

[2] Derived from regression analyses of 456 recessions episodes in 38 AEs and 90 recession episodes in 20 non-commodity exporting EMs over the time span of 1967 to 2019 (based on Kolerus, Christina, 2021. "What Shapes Current Account Adjustment During Recessions?", IMF Working Paper 2021/198). Recessions are defined as negative real GDP growth years.

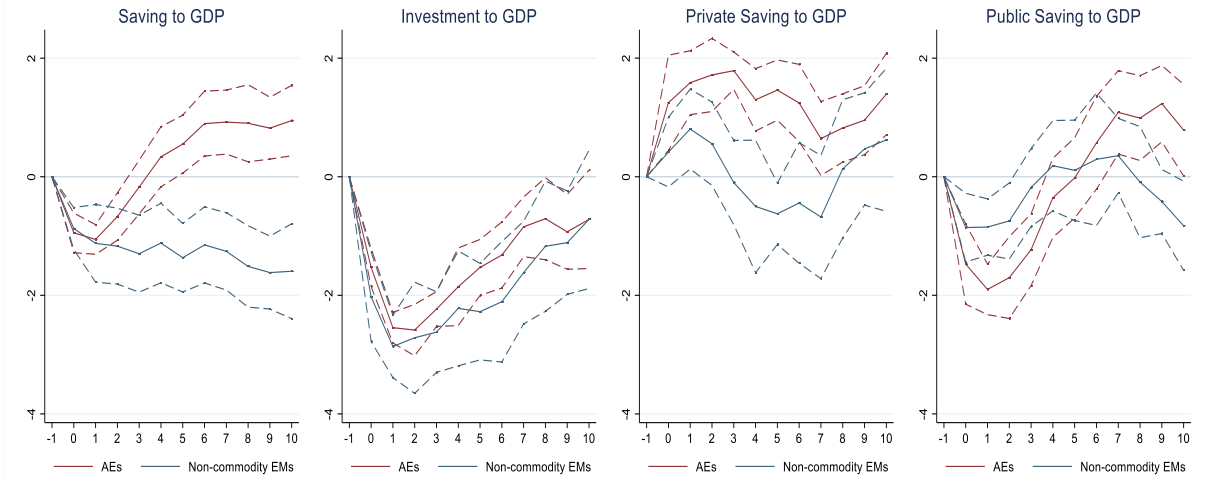
[3] Recession years for Brazil are: 1981, 1983, 1990, 1992, 2009, 2015, 2016.

Figure 2. CA and Components' Response to Recessions by Income Group

Current Account Response: AEs, Non-commodity EMs and Commodity EMs



Saving and Investment Response: AEs and Non-commodity EMs



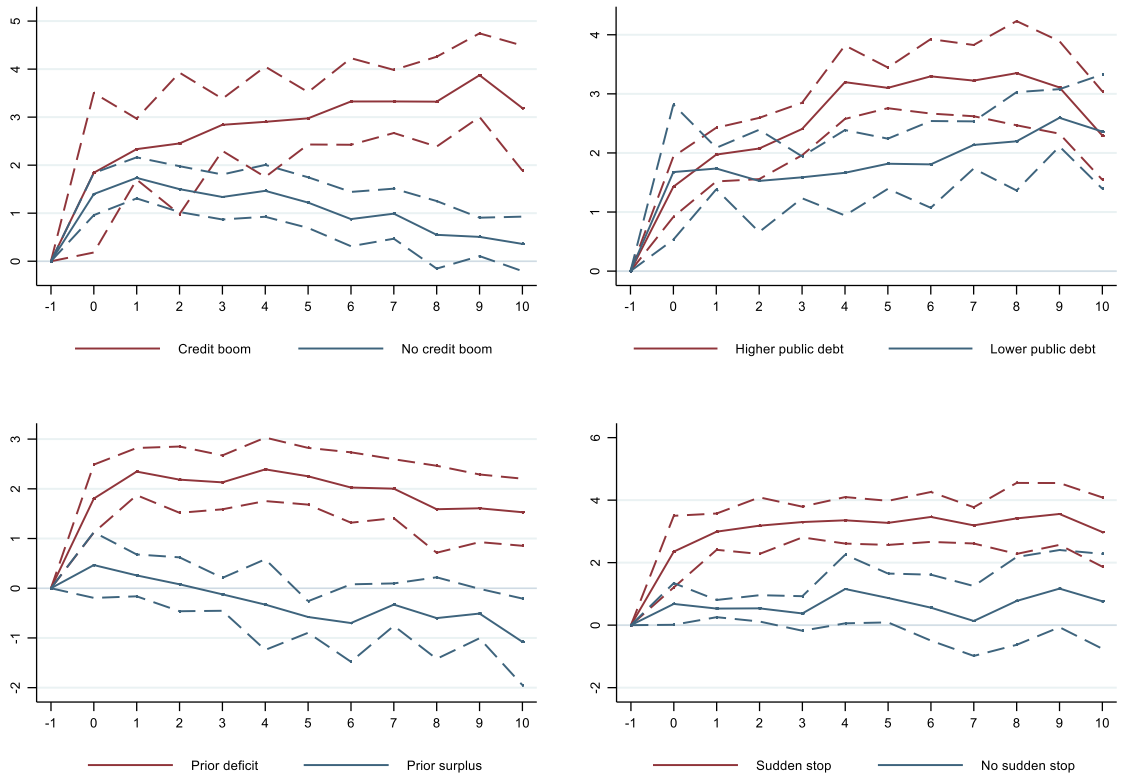
Notes: Recession defined as negative real GDP growth. Estimated using Jorda (2005) local projections with Driscoll Kraay standard errors. Regressions include time and country fixed effects and two lags of the dependent variable and recession dummy. Cumulative response of CA balances and components in percent of GDP over a 10-year horizon. Dashed lines represent 90 percent confidence interval.

4. The CA adjustment is typically driven by a sharp decline in imports, which reflects persistently lower investment (on average 2-3 percent of GDP) and somewhat higher private savings, based on a broad sample of AEs and EMs (Figure 2.2.). Public dissaving—i.e. countercyclical policy—more than offsets the increase in private savings, leaving the overall saving response at around -1 percent of GDP, on average. EMs also see their currency depreciate strongly, by around 60 percent for the NEER, on average, helping the CA to adjust faster.

5. Internal and external imbalances are associated with a stronger and more persistent CA response. Countries entering a recession with prevailing internal imbalances, as reflected in excessive private and public borrowing for instance, experience stronger deleveraging during economic downturns and thus a stronger CA improvement than countries where these imbalances are not present. Recessions associated with credit booms (or banking crises) trigger CA increases of

up to 3½ percent of GDP over 10 years (Figure 3, upper left panel). Higher public debt (above the 75th percentile) is associated with less short-term countercyclical policy and somewhat more saving in the medium term[4] (Figure 3, upper right panel). External imbalances, such as sustained CA deficits or higher external debt, as well as recessions associated with sudden stops are also associated with stronger and more persistent increases in CAs (Figure 3, lower panels).

Figure 3. Internal and External Imbalances Shape the CA Response to Recessions



Notes: Cumulative response of CA balances in percent of GDP over a 10-year horizon. Dashed lines represent 90 percent confidence interval. Credit booms are taken from Dell'Arriccia et al. 2020. Recessions associated with credit booms are defined as recessions which occur up to 3 years after the end of a credit boom. Higher public debt is defined as debt above the 75th percentile, lower public debt as debt below the 75th percentile within income group (AEs and EMs). Prior deficit (surplus) is defined as running a CA deficit (surplus), on average, over 5 years preceding the recession. Following the literature (e.g. Catão, Luis, 2006. "Sudden Stops and Currency Drops: A Historical Look", IMF Working Paper No. 06/133), sudden stop episodes occur where net private capital inflows are either: (i) 1½ standard deviations below their mean and the annual decline is ¾ standard deviations from a year earlier (defined in real U.S. dollars); or (ii) have declined by at least 3 percentage points of GDP relative to the previous year and 2 percentage points from two years earlier. Recessions associated with sudden stops are defined as such if a sudden stop occurs two years prior or two years after the recession.

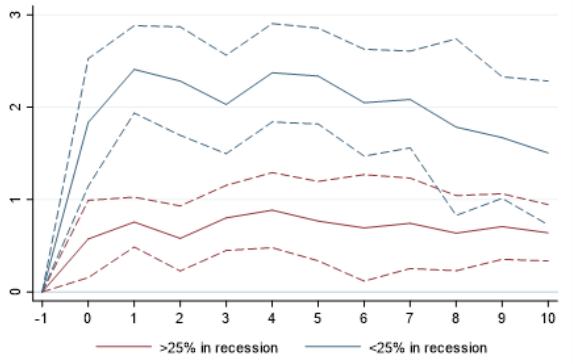
6. However, global crises and epidemics would tend to dampen the CA improvement. Global crises, characterized by a synchronized slowdown in activity, are associated with a smaller increase in the CA balance, of around 1 percent of GDP, compared with a more than 2 percent improvement during "idiosyncratic" crises (Figure 4, left panels). As global and domestic demand

[4] Brazil seems to be an outlier as past recessions were associated with a somewhat stronger countercyclical response than other EMs.

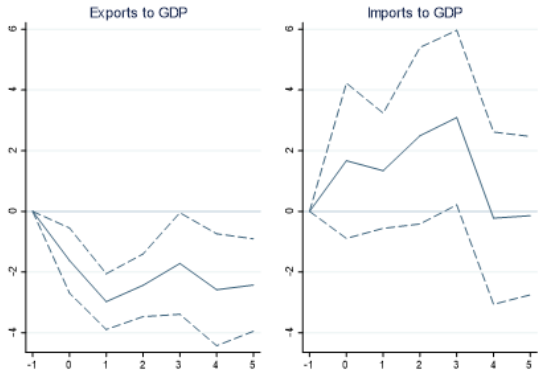
slow down during synchronzied recessions, both exports and imports decline leading to an overall more muted CA response. A dampening effect on the CA balance can also be observed for health emergencies and natural disasters, but through different channels than for globally synchronized recessions. Indeed, historical evidence points towards an even more negative CA response: high-impact (90th percentile mortality) epidemics are associated with increasing imports in the short term (see Figure 4, right panels), as more foreign goods are needed to substitute for the fallout in domestic production due to a sick, quarantined, or deceased share of the labor force[5] (this would also explain a temporary drop in exports)[6]. Possible shifts in consumption, e.g. towards medical goods, and away from services or travel, could also fuel demand for imports.

Figure 4. Global Recessions and Historic Epidemics

Global recessions, CA to GDP



Severe epidemics (90th percentile), 1900-2018



Notes: Left panel: Cumulative response of the CA balance in percent of GDP over a 10-year horizon. Dashed lines represent 90 percent confidence interval. Threshold of 25 percent defined as at least (most) 25 percent of countries in recession, GDP-weighted. Right panel: Cumulative response of exports and imports to GDP to severe epidemics and pandemics which includes epidemics at the 90th percentile of mortality rates and above. The cutoff is equivalent to about 1 death per 10 000 inhabitants. COVID-19 was about 10-20 times as lethal in most countries.

C. The COVID-19 Shock: Is This Time Different?

7. Brazil's 2020 CA improvement of 1.8 percent was broadly in line with its historical average despite multiple factors that would suggest a more muted response. The COVID-19 crisis has been one of the most global and synchronized recessions recorded so far, and on balance, EM economies entered the 2020 crisis with fewer prior imbalances, including Brazil[7], with the notable exception of high public debt. In addition, fiscal stimulus turned out much stronger in 2020

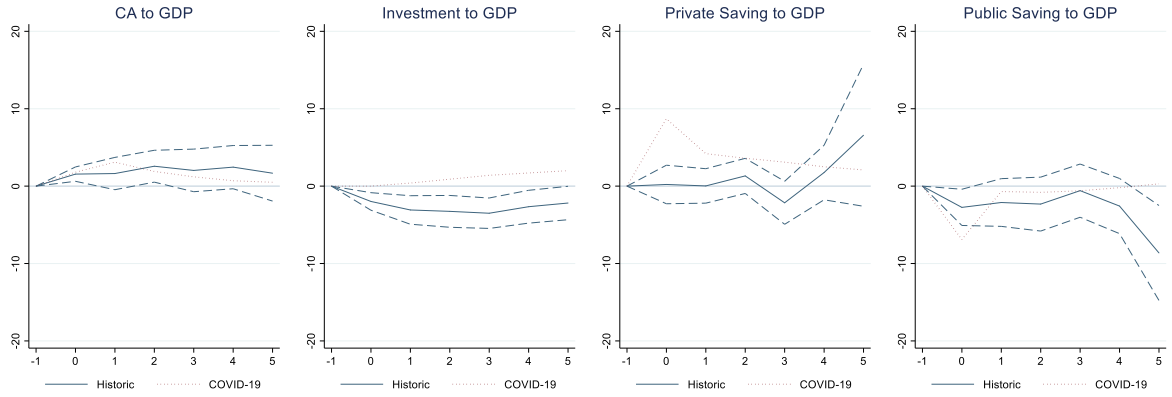
[5] In the case of natural disasters, damages to production and transportation capacity negatively affect exports. Rebuilding the economy, which is often boosted by disaster relief, insurance payments, and international aid and remittances in lower/middle income economies pushes up imports as well as financial inflows.

[6] Restrictions to transport and travel could hamper exports more than imports, as domestic border controls would favor (essential) imports while destination country border controls would restrict origin country exports.

[7] While Brazil's CA deficit has proven highly persistent over the past decades, the pre-crisis 5-year average of the CA deficit was about 1.2 percent of GDP larger prior to the 2015-16 crisis and about three times larger in the 1980s.

than in the past, leading to massive public dissaving, notably in Brazil[8]. Finally, epidemics tend to be associated with increases in imports, which also dampen recessionary CA improvements. These factors would point towards a smaller-than average adjustment to the recession. However, with an almost 2 percent increase in the CA balance during the first recession year, the COVID-19 impact is surprisingly close to past CA responses to recessions (Figure 5, first panel), including the 2015-16 crisis. What is different this time to cause a higher CA improvement than expected given international and past experiences?

Figure 5. Brazil's Past Recession Responses Compared with COVID-19



Notes: Red dotted line depicts the COVID-19 outturn (2020 corresponds to "0") and IMF staff forecasts from 2021 onwards.

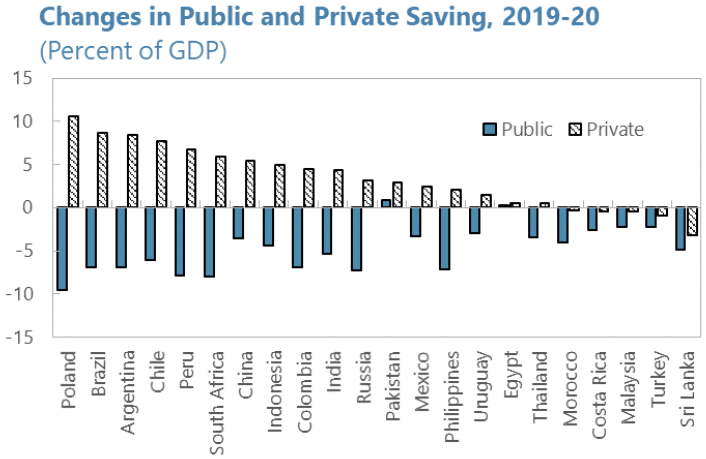
8. The underlying drivers of the 2020 CA adjustment differ strongly from past responses to recessions:

- **Investment**. Past CA adjustments in Brazil as well as in AEs and non-commodity EMs were driven by falling investment of around 3 percent of GDP (see Figure 5, 2nd panel, for Brazil and Figure 2 for other economies). Investment declined further during Brazil's past recessions reaching almost -4 percent of GDP, cumulatively one year into the crisis, followed by a relatively fast recovery compared with peers.[9] This time, however, investment to GDP remained surprisingly stable across most countries and particularly in Brazil. Corporates were able to easily access liquidity to support their operations during the COVID-19 crisis; the tightening of financial conditions in the very early phase of the pandemic was quickly met with massive liquidity injections, by central banks as well as governments, while corporate balance sheets proved, on average, healthier than in past recessions, allowing companies to invest at a cheaper cost. In Brazil, the authorities pressed ahead with institutional reforms, including passing new laws on sanitation, startups, natural gas, and bankruptcy to attract new investment.

[8] Public dissaving during past recessions has been relatively strong in Brazil in the short term (around 3 percent) compared with other EMs, yet the 2020 fiscal impulse of 7 percent of GDP by far exceed historical values.

[9] The average decline in investment proves highly persistent, returning to precrisis levels after around 9 years, and is similar in AEs and EMs.

- **Private saving.** The most important driver supporting higher CA improvement during COVID-19 in Brazil and other major economies is a substantial surge in private saving. Recession responses in private saving to GDP have usually been muted in Brazil (Figure 5, 3rd panel), particularly compared with other countries, suggesting less need or scope for deleveraging by households or firms in past recessions (due to lower initial indebtedness or higher obstacles to restructure for instance). This time, the response in private saving of almost 9 percent of GDP is unprecedented. Although private saving increased across countries, particularly in AEs, Brazil's increase is among the highest across major EMs.



9. Three factors contributed to Brazil's private saving surge: substantial government transfers, forced household saving due to a lack of consumption opportunities, and precautionary motives. Brazil's emergency support was large (at around 4 percent of GDP) and relatively broad-based, more than offsetting the income losses of the bottom four deciles[10] and boosting disposable income. Stringent lockdowns (early in the pandemic) severely affected activity and mobility[11] and thus restricted opportunities to consume, notably in the services and leisure industries which are more likely to be frequented by middle to upper class households[12]. This observation is not specific to Brazil: across major AEs and EMs, household saving is positively associated with lockdown stringency[13]. The relationship is weakening over time, consistent with the notion of "lockdown fatigue"[14]. Precautionary motives may also help explain the rise in private saving by households; with substantial job losses in the services and retail sector in the early phase

[10] Al Masri, Diala, Valentina Flamini, Frederic Toscani, 2021. "The Short-Term Impact of COVID-19 on Labor Markets, Poverty and Inequality in Brazil", IMF Working Paper No. 2021/066

[11] IMF 2021. "World Economic Outlook: Managing Divergent Recoveries" Washington DC, April

[12] Due to the lack of data, the distribution of saving cannot be assessed at the current juncture. Recent analyses based on credit card data in selected AEs show a likely concentration of saving at the top of the income distribution (Bachas, Natalie, Peter Ganong, Pascal J. Noel, Joseph S. Vavra, Arlene Wong, Diana Farrell, and Fiona E. Greig. 2020. "Initial Impacts of the Pandemic on Consumer Behavior: Evidence from Linked Income, Spending, and Savings Data." NBER Working Paper 27617, National Bureau of Economic Research, Cambridge, MA)

[13] Recent studies for selected AEs have shown that the weight of the two large factors contributing to the increase in household saving, government support and decline in consumption proxying forced saving, differs across countries. Using detailed quarterly data, a decomposition of household saving shows that for the US, the contribution of government support (taxes and transfers) was larger than the decline in consumption, while for the EU and other AEs, the decline in consumption was larger than government support. (IMF 2021. "External Sector Report 2021: Divergent Recoveries and Global Imbalances". IMF, Washington DC)

[14] IMF 2021. "External Sector Report 2021: Divergent Recoveries and Global Imbalances". IMF, Washington DC

of the crisis, and high uncertainty about the evolution of the COVID-19 virus, households were likely to have increased their savings to guard against possible job insecurity.[15]

10. A temporary household liquidity trap and pent-up demand. While liquidity was (made) available during the pandemic, many households could not spend or were reluctant to do so out of precaution. Such an environment imposes important limits on fiscal or monetary policies unless stronger policies are taken to end the pandemic through wide-spread vaccination drives. As consumption opportunities are restored and confidence returns, accumulated household savings are expected to boost aggregate private demand. Finally, countries with high public debt will typically increase public saving over the medium term leading to a sustained increase in the CA balance up to 6-8 years after the recession. Building back fiscal buffers could therefore more than offset expected private dissaving and support the CA adjustment.

[15] While it is difficult to disentangle precautionary from forced saving, preliminary analysis in EU countries suggests that most of the early increase in saving was due to forced saving (Dossche, Maarten, and Stylianos Zlatanos, 2020. "COVID-19 and the Increase in Household Savings: Precautionary or Forced?" European Central Bank Economic Bulletin Boxes 6 (5)).

AN EXTENDED SEIRD MODEL TO ASSESS THE IMPACT OF VACCINATION ON MOBILITY[1]

As in many countries. the pandemic has caused a large economic and health toll in Brazil. As vaccination progresses, voluntary and mandated social distancing measures, aimed at lowering virus transmission, are being gradually reduced. However, the spread of a new, more infectious, virus variant would pose risks to the baseline scenario. This annex calibrates a simple epidemiological model to Brazil to assess how mobility and death numbers would change in this risk scenario under alternative vaccination profiles. It is shown that a 6 months delay in vaccination could require mobility to be 13 percent lower than the baseline to maintain the same number of fatalities in the country. Given the large economic impact that mobility has, especially on high contact sectors, the economic return to vaccination remains very high.

1. The COVID-19 pandemic keeps unfolding and new more infectious variants are spreading while the vaccination campaign builds further population immunity. In the economic front, government mandated lockdowns and voluntary social distancing reduce the virus spread but also lower economic activity in the near term.

2. To examine how the vaccine rollout can affect economic activity, we make use of the extended SEIRD model developed by Dizioli and Radzikowski (2021). We show in this annex that a speedier 3 months vaccination conclusion could allow mobility to be 3 percent higher in 2022 while keeping the number of deaths the same even if a more infectious new variant arises in June 2021. On the other hand, we show that if vaccination is delayed by 6 months, then mobility would need to fall by 13 percent in 2022 to keep the deaths level the same. This shows the importance of a speedier delivery of vaccination in the coming months.

3. Our basic framework divides the population (*N*) into susceptible (*S*), infectious (*I*), recovered (*R*), quarantined (*Q*), vaccinated (V) and dead (*D*). The "quarantined" category is adopted to accommodate both asymptomatic and pre-symptomatic transmission and to allow for random testing in the model. The difference between people who are infectious and people who are quarantined is that those in quarantine no longer transmit COVID-19 because they do not have contact with others.

4. At each point in time, the population can be partitioned into the five categories mentioned above, so that $N = S_t + I_t + R_t + Q_t + V_t + D_t$. When a share q of the population is tested each day, the laws of motion are:

$$\frac{dS_t}{dt} = \underbrace{-\beta_t S_t I_t / N}_{new\ infections} \underbrace{-\rho_t S_t / N}_{vaccinations};$$

[1] The authors of this annex are Allan Dizioli and Daniel Greenwood (RES)

$$\frac{dI_t}{dt} = \beta_t S_t I_t/N + \underbrace{(\beta_t V_t I_t/N)\omega_t}_{Infected\ after\ vaccination} - \underbrace{\frac{\gamma}{1-q} I_t}_{discover\ infection};$$

$$\frac{dV_t}{dt} = \rho_t S_t/N - (\beta_t V_t I_t/N)\omega_t;$$

$$\frac{dQ_t}{dt} = \underbrace{-\theta Q_t}_{resolving\ infections} + \frac{\gamma}{1-q} I_t;$$

$$\frac{dR_t}{dt} = \underbrace{(1-\delta)\theta Q_t}_{recovered};$$

$$\frac{dD_t}{dt} = \underbrace{\delta\theta Q_t}_{dead}.$$

5. The time varying β measures the rate of infection, γ is the rate at which symptoms develop, θ is the time it takes to recover from an infection, ω is how efficient the vaccine is in cutting transmission and δ is the probability of death. The expression $\gamma/(1-q)$ is the rate at which an infected individual discovers that he/she is infected. The reasoning is as follows: once a person is infected, symptoms develop at Poisson rate γ, which means that the average number of days until the first symptoms appear is $1/\gamma$. When a fraction q of the population is tested each day, the average number of days until a person either develops symptoms or receives a positive result is $q \times 0 + (1-q) \times (1/\gamma)$ – inverting this expression gives the rate at which infections are discovered.

The link between mobility and infections is the one that drives the economic impacts of the pandemic. Its derivation is defined as follows:

6. Endogenous rate of infection. The rate of infection can change based on behavioral patterns:

$$\beta_t = n_t \times inf_t \times \mu_t,$$

where n_t is the average number of substantive contacts with other people per day (affected by lockdowns and social distancing), inf_t is the probability of infection conditional on having a substantive contact (which can be reduced by wearing masks, keeping distance, washing hands, etc.) and μ_t that adjusts the scale and controls for seasonal differences in the rate of infections. The number of contacts per day is defined as:

$$ln(n_t) = ln(n_0) - m_t$$

where n_0 is the initial number of contacts and m_t is relative mobility in day t, measured in relation to the pre-pandemic baseline. We use google transportation mobility data to proxy the changes in the

number of contacts that someone has. Moreover, we assume that people learn with time how to avoid infection, and the probability of contagion evolves according to:

$$inf_t = \beta_0 e^{-\lambda t} + \beta_s\left(1 - e^{-\lambda t}\right)$$

where β_0 is the initial rate of infection, β_s is the rate of infection when safety precautions are taken, and λ measures the time to make that transition.

7. Population subgroups, mutant strains, and ICU capacity. The model also allows for the population to be subdivided into vulnerable and non-vulnerable (young), who differ in their probabilities of death if infected. This is done by differentiating between the vulnerable and the young in each of the six categories of the population. Importantly, the categories remain related. For example, a susceptible vulnerable person can still be infected by a young person. The differentiation between the vulnerable and young is relevant to capture the dynamics of the pandemics, especially when policies that prioritize one of these groups are implemented (e.g., vaccines).

8. Equally important to capture the dynamics of COVID-19 is the introduction of mutant strains, which are potentially more infectious to humans than the wild virus. Including this into the model requires accounting for infections from both types of the virus, which is reflected by including extra terms for the mutant variant in the law of motion of each category in the population. For example, the law of motion for the susceptible becomes:

$$\frac{dS_t^v}{dt} = -\beta_t\, S_t^v\left(I_t^v + I_t^y\right)/N - \beta_t^n S_t^v\left(I_t^{v,n} + I_t^{y,n}\right)/N$$

where I_t^v is the number of infectious vulnerable people that are infected with the wild virus and $I_t^{v,n}$ is the number of infectious vulnerable people that are infected with the new (mutant) strain of the virus. Thus, β_t^n is the rate of infection for the new strain, defined as

$$\beta_t^n = \sigma \times \beta_s \times n_t \times \mu_t \quad ,$$

where β_s, n_t and μ_t are as defined above, and σ is a constant that captures how much more infectious the new strain is, relative to the original one.

9. Finally, the model also incorporates a non-linear increase in the probability of death due to hospital congestion. This increase is calibrated based on estimates of the number of deaths in the United Kingdom when ICU occupation was high.

10. Vaccines. Vaccination can benefit a susceptible person by generating an immune response that prevents illness/death if they are infect with the virus. It also reduces the probability that this person, if infected, transmits the virus to other susceptible persons. In the model, we assume that vaccinated people do not die if they get infected, and the rate of transmission is cut by around 50

percent.[2] We also only count fully vaccinated people. While this assumption is conservative, it offsets the fact that in reality people in the recovered category also gets vaccinated.

11. Calibration. The parameters in the model are calibrated to capture the evolution of the pandemic in Brazil. The path of vaccinations, number of deaths, and other daily data on the COVID-19 pandemic can be found on the datasets compiled by Our World in Data. In addition, the pre-pandemic number of daily contacts is calibrated using results from the American Community Survey, and relative mobility is available through Google's Community Mobility Reports. It is important to highlight some degree of parameter uncertainty in SEIR models. More complicated models tend to increase this uncertainty given the nonlinear nature of these models. Having this in mind, several out-of-sample exercises were conducted to validate our parameters choice.

12. The top panel of table 1 shows the values of the parameters mentioned above. We also include the probability of death (once infected) of the vulnerable (δ^v) and the young (δ^y), as well as their population shares (s^v and s^y). Those parameters are calibrated by defining the vulnerable population as those aged 65 and over. The bottom panel of table 1 shows the share of the population that is tested in each of the 500 days between February 29th, 2020 and July 12th, 2021.

Table 1. Brazil: Parameter Values

Parameter	β_0	β_s	λ	γ	θ	μ	ωi	δ^v	δ^y	s^v	s^y
Value	0.15	0.067	0.028	0.17	0.12	1.47	0.5	0.02473	0.00069	0.18	0.82

Days	1-14	15-27	28-40	41-60	61-101	102-500
q	0	0.05	0.25	0.28	0.3	0.3

A. Assumptions Guiding Projections on Behavior and Vaccination

13. The projections depend on assumptions related to behavior and vaccination. We assume that people would remain careful in their daily interactions until infections drop considerably. Thus, the variable inf_t remains low throughout the pandemic. As for the daily contacts, we assume that people gradually increase their mobility as more people get vaccinated and infections start to drop. The mobility path is consistent with staff's baseline macro projections. Finally, the baseline vaccination projections follow actual data through August 1st, 2021.

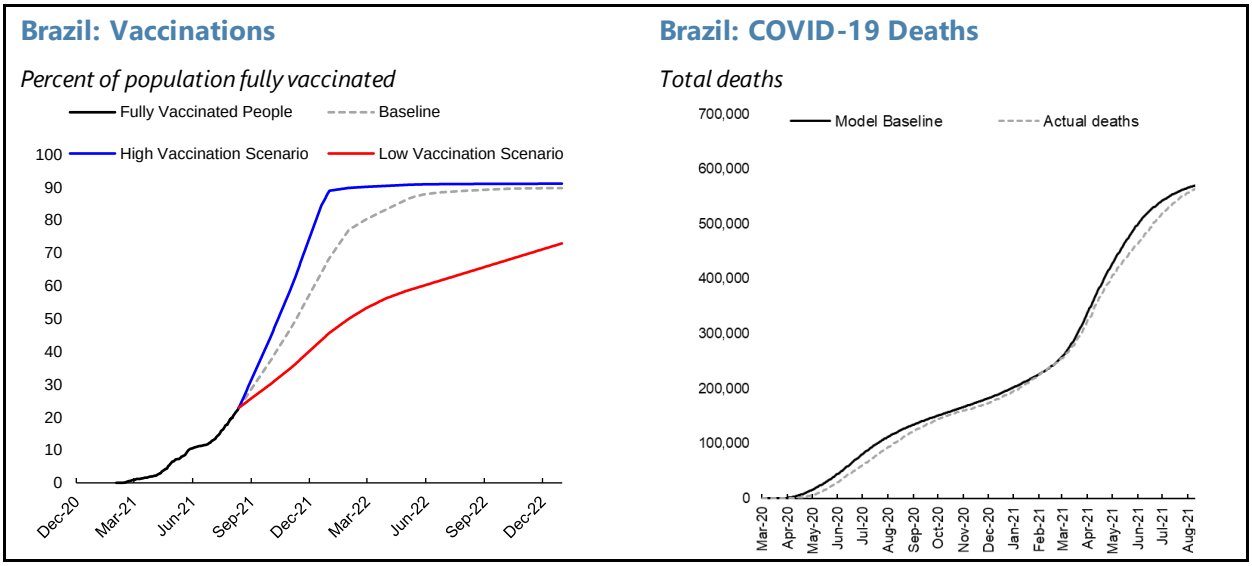
Vaccination Path

14. The vaccination path incorporates actual vaccination rates for fully vaccinated individuals (19.5 percent of the population on August 1st, 2021). Additionally, as the current vaccination campaign focuses on individuals at risk, we expect vulnerable groups to be vaccinated

[2] While this number is still highly uncertain, there is increasing evidence that vaccines can substantially cut the rates of transmission for infected individuals. A recent study by Levine-Tiefenbrun et al. (2021) shows that vaccines can significantly reduce the viral load if an infection occurs, which has been shown to affect the probability of transmission. A *Daily Briefing* by the Advisory Board published on March 4th also discusses the issue (available at: https://www.advisory.com/en/daily-briefing/2021/03/04/vaccine-transmission).

first, with vaccinations for the general population following afterwards. The model assumes that the fully vaccinated population will continually increase until 88 percent of the population are fully vaccinated, following a COVID-19 vaccination willingness poll by Ipsos/World Economic Forum (February 2021)[3].

15. In our baseline scenario, 75 percent of the population will be vaccinated by the end of January 2022, with the vulnerable population already vaccinated (75% coverage in July 2021) while the non-vulnerable population will reach this threshold in February 2022. The first alternative scenario accelerates the vaccination pace by 1 month, with the population reaching 75 percent of fully vaccinated coverage in December 2021. Lastly, the third scenario implies a slower rollout and vaccination pace, with the population reaching 75 percent coverage in early 2023. The vaccination paths are illustrated in the figure below:



B. Alternative Scenario with COVID Variant

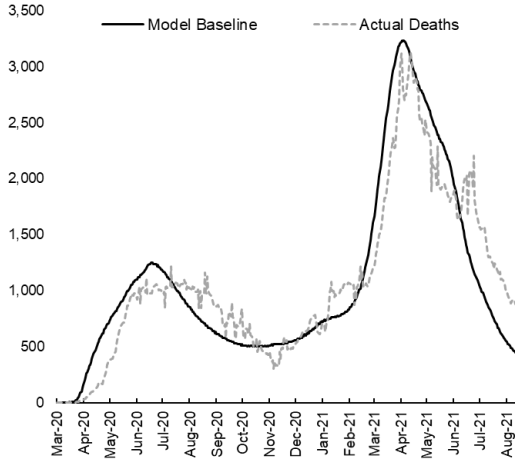
16. In our central scenario, we assume that people can be re-infected after 6 months, but that once sufficient immunity is built, either through previous infection or vaccination, deaths fall, and the pandemic is over. However, another variant could arise and prolong the pandemic into 2022, just as the COVID-19 variant that originated in Manaus. In order to investigate that, we build a risk scenario in which a new variant, 50 percent more infectious than the P.1 variant, arises in June 2021. Moreover, we assume that reinfection becomes more likely with this new variant and people could get re-infected on average after 4 months. Under this scenario, we investigate what is the impact of the different vaccination profiles that we discussed in the previous section.

[3] "Global Attitudes: COVID-19 Vaccines", Ipsos/World Economic Forum Survey, February 9, 2021. https://www.ipsos.com/en-ro/global-attitudes-covid-19-vaccine-january-2021

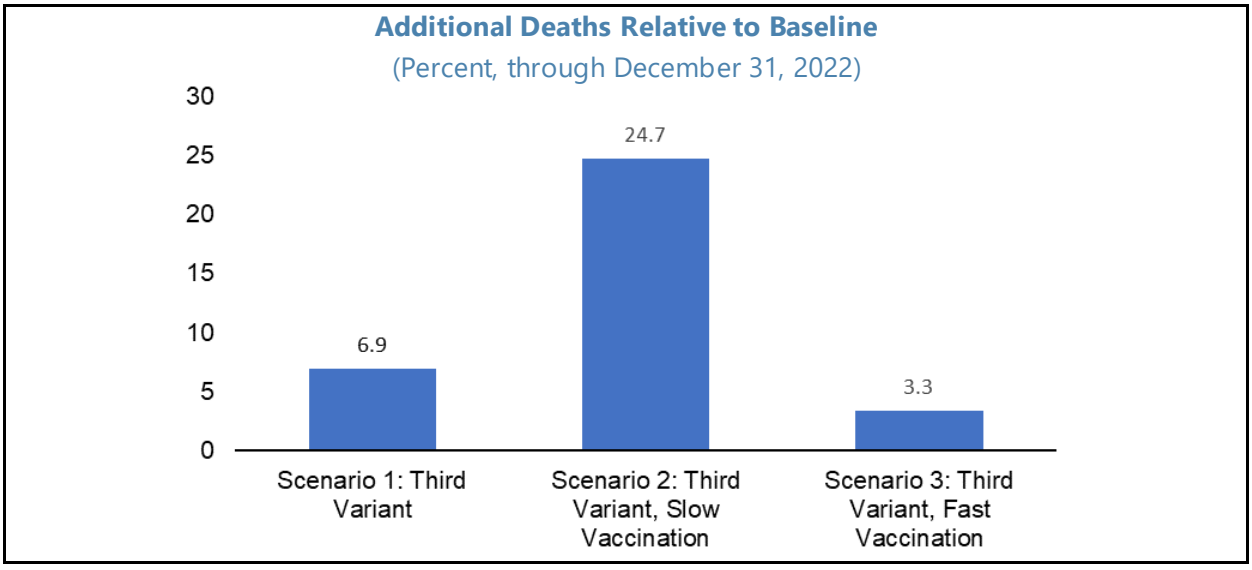
17. If the baseline vaccination scenario is maintained even with the third more infectious variant, we would observe 6.9 percent more deaths through December 31st, 2022. In the scenario in which vaccination is expedited by 1 months, we would record 3.3 percent more deaths than the baseline (through December 2022). On the other hand, in the scenario in which vaccination is delayed by 12 months, deaths increase by 24.7 percent compared to the baseline through the end of 2022. The pandemic effect is prolonged into 2022 and a large number of deaths are still recorded next year.

Brazil: COVID-19 Deaths.

7-day moving average



18. If the pandemic is controlled, then the need for social distancing, either voluntary or government mandated, is lower. Higher mobility benefits high contact sectors and spillover positively to the rest of the economy. This model cannot directly estimate the economic effects from these vaccination scenarios. In order to do that, the model would have to predict people's behavior in response to vaccination, chance of death and increase probability of infection. For example, mobility could be even higher in the faster roll-out vaccination scenario because of an additional optimist. Thus, the model does not try to forecast economic activity in these different scenarios. However, we can predict what mobility would have to be in the different scenarios to maintain the same number of deaths by 2022.



19. In the baseline vaccination scenario with the third more infectious variant, mobility would have to be around 1 percent lower through December 2022 to keep the same death count as if there were no third variant. In the scenario in which vaccination is expedited by 1 month, mobility could be relaxed and be on average around 2 percent higher than under the

baseline vaccination scenario. On the other hand, in the scenario in which vaccination is delayed by 12 months, mobility would need to be tighter again even for this year and next by around 11 percent[4] on average, so as the death count is kept the same as the baseline. Clearly, the investment in vaccines would have a large positive economic effect this year and next if a third variant were going to hit the country again this year.

[4] Qualitatively, mobility is reduced dramatically when cases peak and then recover to values close to baseline in periods where infection is low. This result in the daily average reduction in mobility described in the text.