Incidence of COVID-19 in the Bolivian Economy: How Much Can We Learn from a Pandemic Shock?

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Abstract

The COVID-19 pandemic has left many questions not only in the field of health, but also in other areas such as economics. Under that precept, I developed a DSGE model that considers the COVID-19 shock with the premise of understand (in quantitative terms) the type of economic recovery that the country could experiment. The results support that the economic growth of Bolivia for 2020 ranges between -5.4%, -5.9% and -6.1% corresponding to 3 different types of scenarios. These scenarios illustrate the behavior of the country's economic recovery and experience the form of the letters U, V and W respectively.

If we consider an economic growth forecast under a scenario that does not consider COVID-19, the model registers a value close to 0% for 2020. In that regard, the incidence of COVID-19 in the country's economy will be approximately 5.8% for 2020.

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Introduction

The appearance of COVID-19 in the world has left up to date an irreparable cost, not only from the population point of view but also in economic terms, leaving the main political agents in the difficult task to ensure the health care of the population but without neglecting to save or cushion the economic shock of the countries given the imminent force of the pandemic shock. For many authors, the aforementioned seems to be more of a “trade off” than a result that is achieved in parallel with the implementation of policies and/or measurements. In that sense, the study seeks to quantify the incidence of COVID-19 for Bolivia´s economy by understanding initially the behavior of worldwide past pandemic shocks, to subsequently find the ideal macroeconomic model that can emulate the COVID-19 shock. It is important to consider that for the case of Bolivia, COVID-19 has not been an exclusive case, and therefore it has also been hit by the pandemic in a particular way as we will see later.

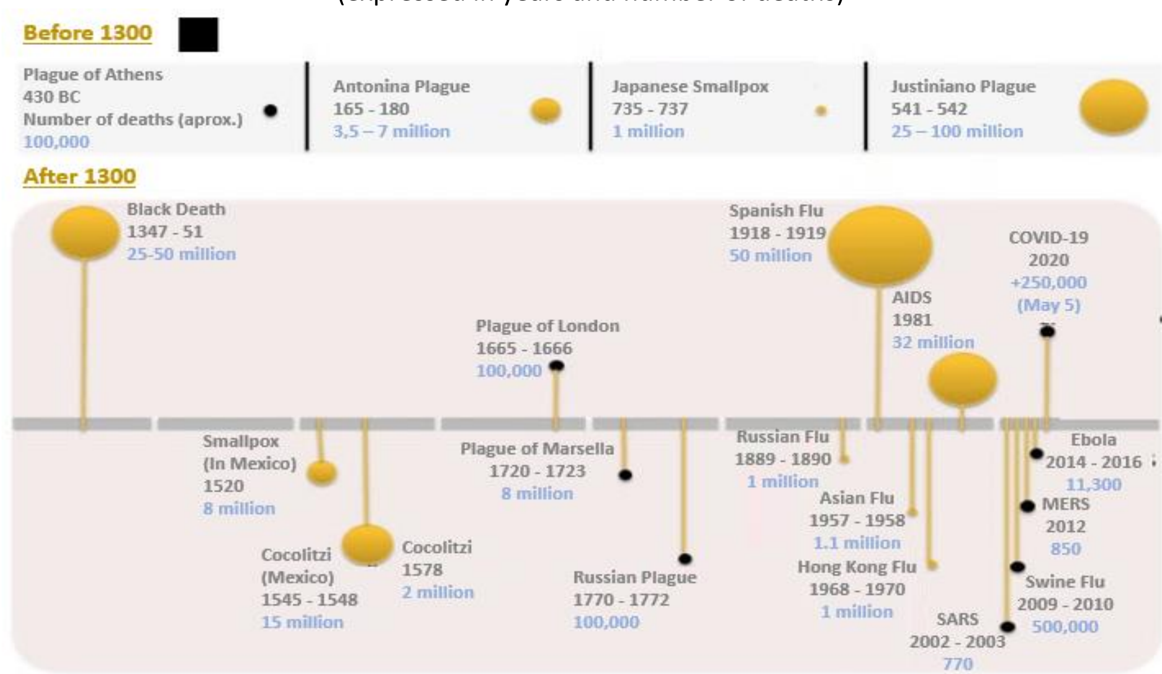
Under this precept the study is divided into 7 sections explained briefly below. Section 1 presents a historical overview of the pandemics in the world and their interaction with the world economy. Section 2, presents previews studies of economic models that consider pandemic shocks. Section 3 explains the main features from a scientific point of view of COVID-19. Section 4 presents in detail the DSGE model that will be used in the study. Section 5 presents evidence of macroeconomic variables in the country that were affected by the quarantine as a result of COVID-19 and consequently the main result of the DSGE model regarding the incidence of COVID-19 on GDP Growth, Inflation and Interest Rate for the period Q2 2020 - Q4 2025. Finally, Section 6 presents the main remarks of the study and Section 7 presents the bibliography of the study.

1. Worldwide Historical Pandemics and their Interaction with the Economy

Throughout history, there have been many epidemics and pandemics[2] that have devastated humanity, with the handicap that all advances that we currently have to date did not exist in the past, meaning that there was a much greater risk to the entire world population back then. Figure 1, presents the main global pandemics in chronological order as well as how they have affected world economies through time.

Figure 1: Historic Major Global Epidemics and Pandemics

(expressed in years and number of deaths)



Source: Own elaboration based on information extracted from Live Science

1.1 The Black Death (1347 - 1351)

One of the first and hardest pandemics occurred in history was the so-called Black Death, which occurred between the period 1347 to 1951 and claimed approximately between 25 to 50 million deaths.

Economically speaking, the Black Death brought about considerable changes in the economy and consequently an imminent setback; it is said that world economy took 100 years to recover. Trade disappeared, population migrated from the field and kings died (all social strata were affected). In

[2] The difference between an epidemic and a pandemic is that the former refers to a disease that spreads in a single territory for some time affecting the inhabitants of that place. While a pandemic expands horizons and thus the disease crosses borders.

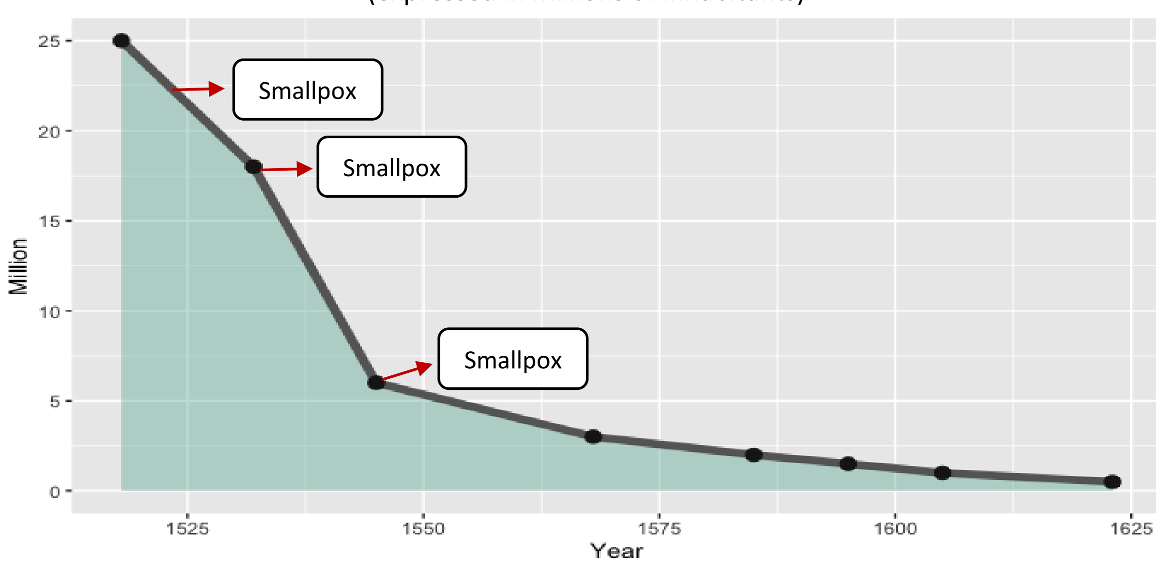
the short term, the most relevant economic consequences were the considerable migration of the population from the fields, leaving almost zero crop activity so many of the crops at the time rotted. This fact, derived a shortage of agricultural products, monopolized only by those who could afford them. Prices rose, generating a hyperinflation and increasing the suffering of the less well off.

1.2 Smallpox (1520)

The disease played an important role in the victory of the Spanish colonizers. Since the year 1529, the city of Tenochtitln (Mexico) was besieged by the Spanish, who could not conquer it, until smallpox appeared. The disease caused a severe impact throughout Mexico, as there were places where mortality was so great that the settlers could not bury their dead.

By 1520, smallpox had spread throughout Mexico. It is estimated that between 7 to 8 million people died from this pandemic according to historians. In economic terms, the post-smallpox effect produced a notorious increase in wages due to the shortage of population (workers). There was also a strong migration from the countryside to the cities, leaving a part of the poor peasants that could access abandoned lands, so that the number of peasants with medium-sized properties grew which gave a new impetus to the rural economy. To get a better idea of the above, Figure 2 is presented, which illustrates an estimate from Cook, Borah, Berkeley (1963), on the demography of Mexico during the smallpox pandemic in 1520 (which is estimated to have wiped out 90% of the Mexican population), as well as for the year 1532 and 1540.

Figure 2: Demography in Mexico during the Smallpox, 1518 - 1623
(expressed in millions of inhabitants)

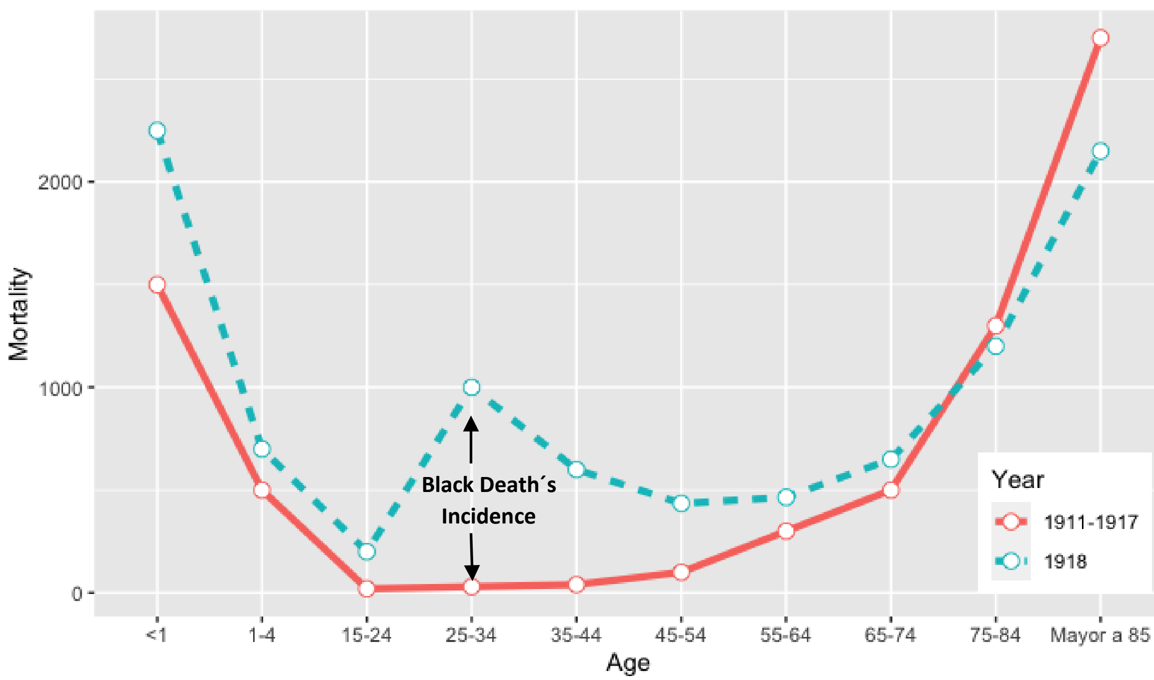


Source: Own elaboration based on information extracted from Cook, Borah, Berkeley (1963)

1.3 Spanish Flu (1918 - 1919)

The Spanish flu, misnamed "Spanish" for being one of the first countries where it was reported have caused more deaths than World War I (about 50 million according to estimates). Although the origin of this flu, many authors claim that it was originated in a town of China from which it would have spread throughout the world. Economically speaking, there were changes in migratory movements, although it is difficult to discern how much of the economic downturn can be linked to each phenomenon mentioned above. Figure 3 illustrates the mortality rate differentiated by age range, for the period 1911-1917 compared to the year when the Spanish flu appeared in 1918. Estimation that is presented in the study of Taubenberger & Morens (2006). The results support that the age of people most affected by the Spanish flu that appeared during the period 1911-1917, were found in the range between ages 5 to 54, specifically in the 25 to 34 age range.

Figure 3: Incidence of Spanish Flu on Mortality Rate according to Age (1911 - 1917 and 1918)
(expressed in millions of inhabitants)

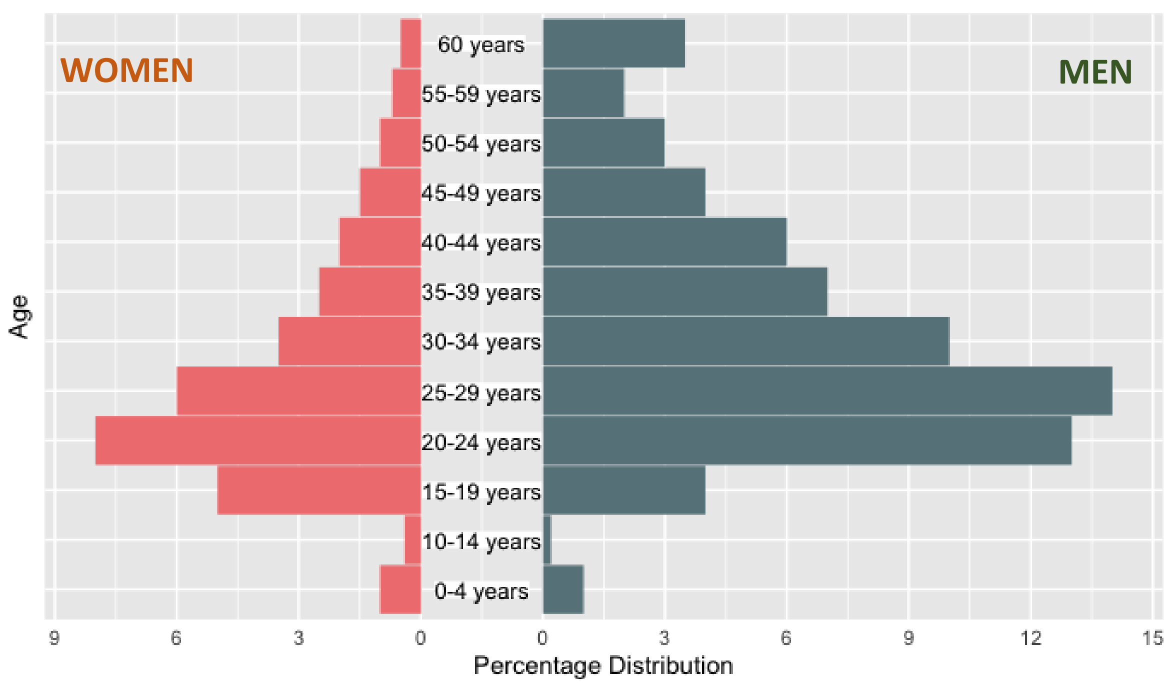


Source: Own elaboration based on information extracted from Taubenberger & Morens (2006)

1.4 HIV (1981 - Current)

HIV/AIDS remains as one of the most serious public health problems in the world especially in low and middle-income countries. In economic terms, according to an International Monetary Fund´s report on epidemics (2004), the expected annual cost of a pandemic flu was estimated to be about 500,000 million dollars (0.6% of world income), supporting also that HIV caused a considerable decrease in the countries' direct foreign investment. If we focus the analysis for the case of Bolivia, Figure 4 presents an illustration of the National Program HIV/AIDS and Viral Hepatitis of Bolivia regarding the number of cases infected with HIV-AIDS during the period 1984 - 2017, according to age and gender. The analysis holds that the age range most vulnerable to contagion in Bolivia, is between 15 to 34 years old, being the age range between 20 and 34 years the most vulnerable in the case of men, while the age range between 15 to 24 years old for women (See Figure 4).

Figure 4: Percentage Distribution by Age and Gender of HIV Infected Cases in Bolivia (1984 - 2017)
(expressed as a percentage)



Source: Own elaboration based on information extracted from the National STI/HIV/AIDS and Viral Hepatitis Program

1.5 Cost and Economic Consequences of Pandemics Appearance

As a final remark to this section, Table 1 presents summary information of the main economic impacts due to the appearance of different epidemics and pandemics worldwide, which were mentioned in detail previously.

Table 1: Economic Consequences of Pandemics Appearance

Pandemic	Period	Economic Consequence
Black Death	1347 - 1351	- Field migration (crop disappeared) - Prices of agricultural products rose (generated hyperinflation) - Trade disappeared - Social inequality grew
Smallpox	1520	- Reduction in labor demand (due to high mortality) - Increase in wages - Migration from the countryside to the cities - New peasants accessed abandoned lands - New boost to the rural economy (due to abandoned lands)
Spanish Flu	1918 - 1919	- Exports and Imports prohibition in European countries - European trade affected - Strong migratory movement
HIV/AIDS	1981 – to date	- Decrease in foreign investment for vulnerable countries - Evidence GDP reduction for vulnerable countries

Source: Author´s main elaboration

In addition, Table 2 presents the total cost of the main worldwide diseases according to WHO data. As a curious fact, only 4 diseases cost a total of $423 billion that represents only 60% of COVID-19's total cost to date.

Table 2: Worldwide Cost of Major Diseases

Year	Disease	Cost in millions of US $
2003	SARS	40.000
2009	H1N1	50.000
2013	Ébola	53.000
2020	COVID-19 (*)	280.000

Source: Own elaboration according to WHO data.
(*): Estimate until July 2020.

2. Economic Models that Considers a Pandemic Shock

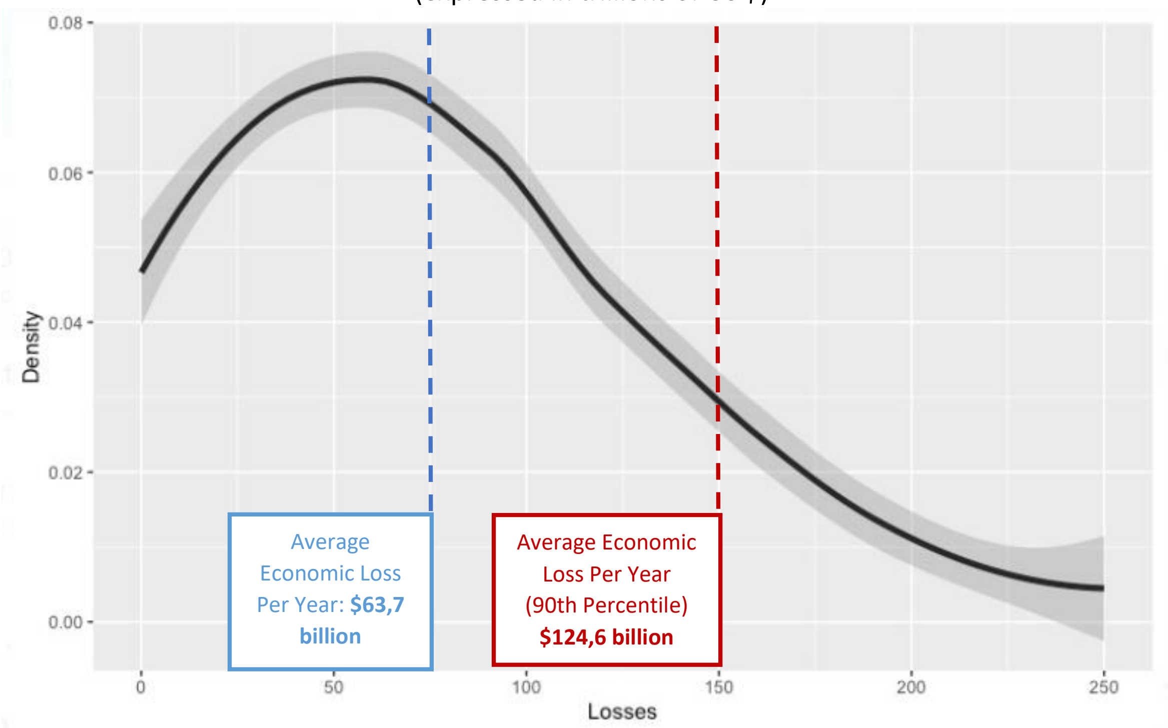
Predicting economic losses associated with pandemics is a challenge since pandemics are rare events with limited data. However, you can use the available limited data to help give an idea of the magnitude of losses through simulations. In that regard, El Turabi & Saynisch (2016), takes this aspect into account (See Figure 5) and concludes that the greater probability occurrence of pandemics during the XXI century is between 2 to 4 pandemics.

Figure 5: Distribution of Expected Number of Pandemics in the XXI Century
(expressed in number of pandemics to occur)

Source: Own elaboration based on information extracted from El Turabi & Saynisch (2016)

Consequently, to estimate the scale of economic losses associated with future pandemics, many studies applied the same strategy of using what was known about previous pandemics, to model the impact of future pandemics. Studies such as McKibben & Sidorenko (2006), estimated an economic loss (that occurred as a result of the pandemics of the 20th Century), between 0.7% and 4.8% of world GDP. Using this approach, El Turabi and Saynisch (2016) estimates the economic losses due to pandemics throughout the 21st century, to obtain a distribution of expected annual economic losses due to pandemics (See Figure 6).

Figure 6: Distribution of Expected Economic Losses Due to Pandemics to Occur in the XXI Century
(expressed in trillions of US $)



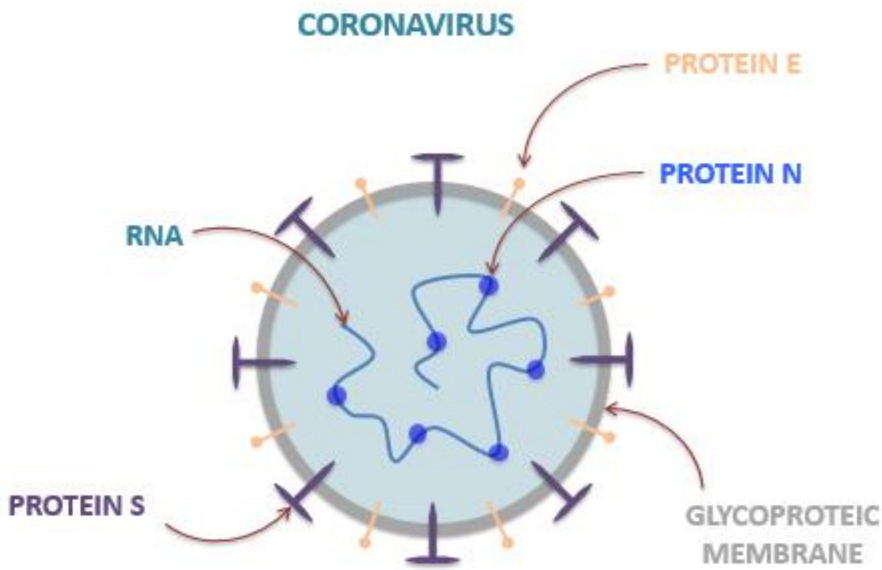
Source: Own elaboration based on information extracted from El Turabi & Saynisch (2016)

The study in turn estimates an average loss for the global economy (at cause of the pandemic), of more than $60 billion per year. An important feature of the distribution of expected economic losses is that it has a long right tail, so there is non-trivial probability of seeing much more extreme losses. For example, the model predicts a 10% probability that this century's average loss will exceed the $120 billion.

3. COVID-19 from a Scientific Point of View

Coronaviruses are a family of viruses that cause infection in humans and some animals, including birds and mammals such as camels, cats and bats. Human coronaviruses (HCoV) can produce clinical pictures ranging from a common cold to others more severe such as those produced by the Severe Acute Respiratory Syndrome viruses (SARS). In 2003, SARS-CoV-1 caused more than 8,000 cases of contagion in 27 countries with a fatality of 10%. The International Taxonomy Committee of Viruses have called the virus as SARS-CoV-2, a family member of other viruses that were earlier detected (SARS-CoV), making it clear that this was a totally new virus. The virus was included in the taxonomic category of Coronaviridae, CoV, or Coronavirus, named for the extensions that it carries above its nucleus that resemble the solar corona (See Figure 7). Their discovery was revealed in the journal Nature in 1968. The so called "Disease X", represented unknown risks that needed to be foreseen and investigated. The recent irruption of the new SARS-CoV-2 coronavirus is a materialization of this type of risk. Finally, in 2014 a scientific blog indicated that a coronavirus could star in the next pandemic.

Figure 7: General Composition of COVID-19

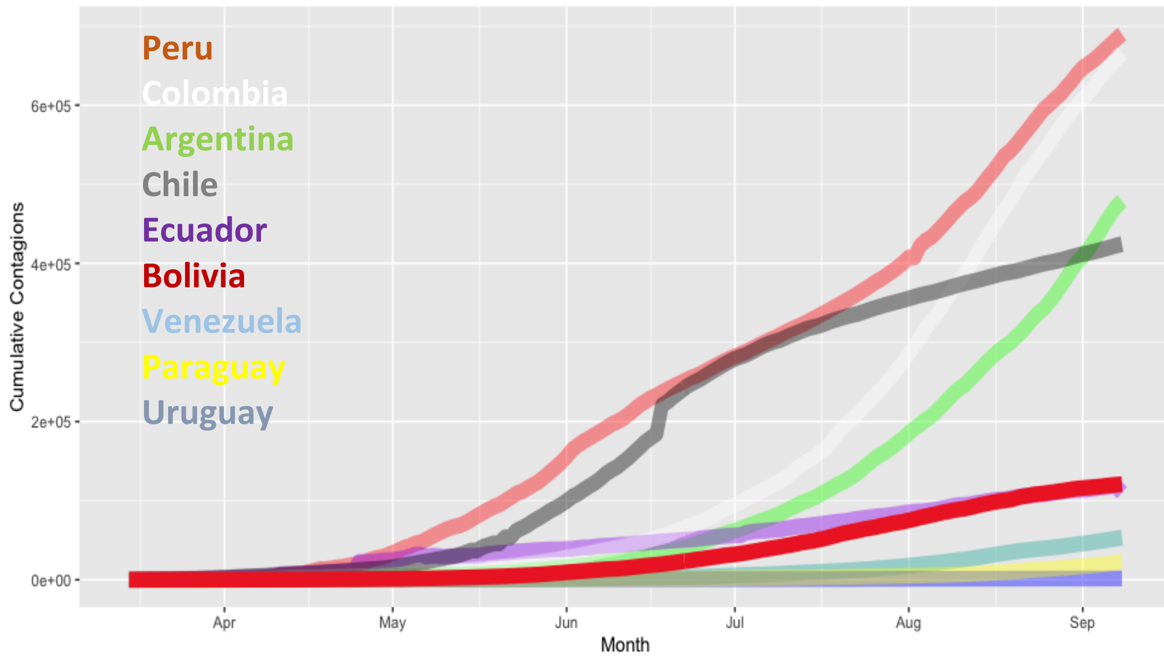


Source: Author´s own elaboration

3.1. COVID-19 Statistics

Considering August 28, 2020 as cut-off, COVID-19 reported around 24.3 million accumulated contagion cases and more than 820,000 accumulated deaths worldwide. If we concentrate the analysis at a regional level, Bolivia registered around 112,000 contagion cases and 4,726 accumulated deaths. Brazil, Peru and Colombia are the countries with a greater number of infections by COVID-19 (See Figure 8).

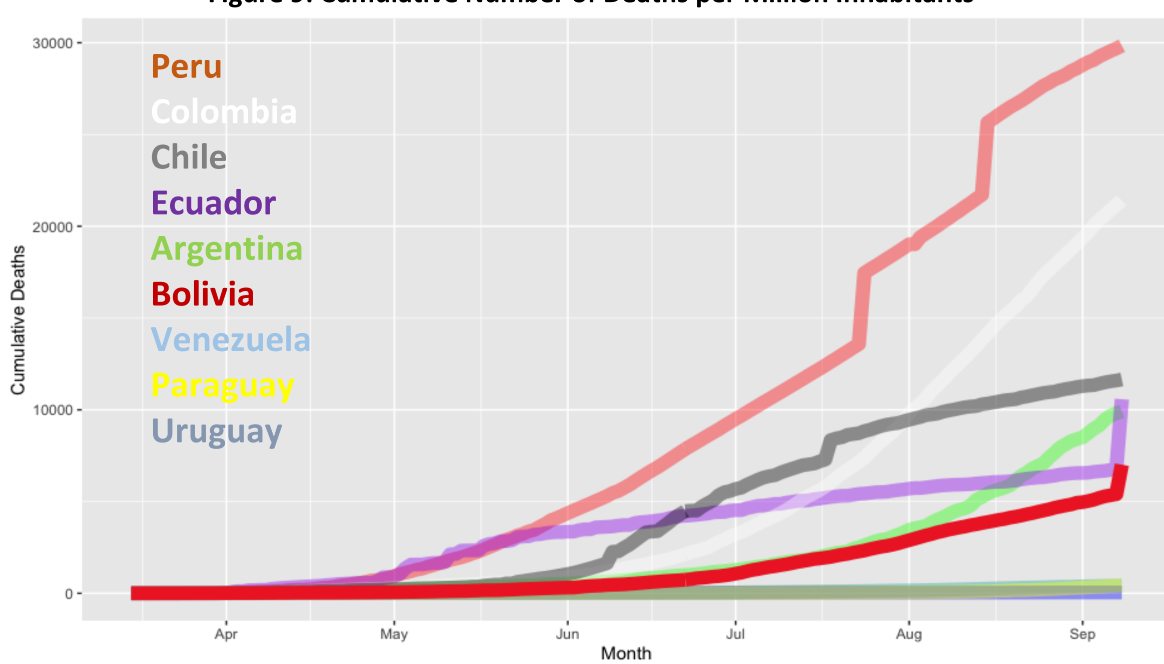
Figure 8: Cumulative Number of Contagions Per Million Inhabitants



Source: Own elaboration according to WHO data.
Note: Since Brazil has a very high number of infections compared to the rest, it was excluded from the graph.

Regarding the number of deaths caused by COVID-19, the list at the South America level does not change that much with Brazil, Peru and Colombia being the countries with the highest number of deaths (See Figure 9).

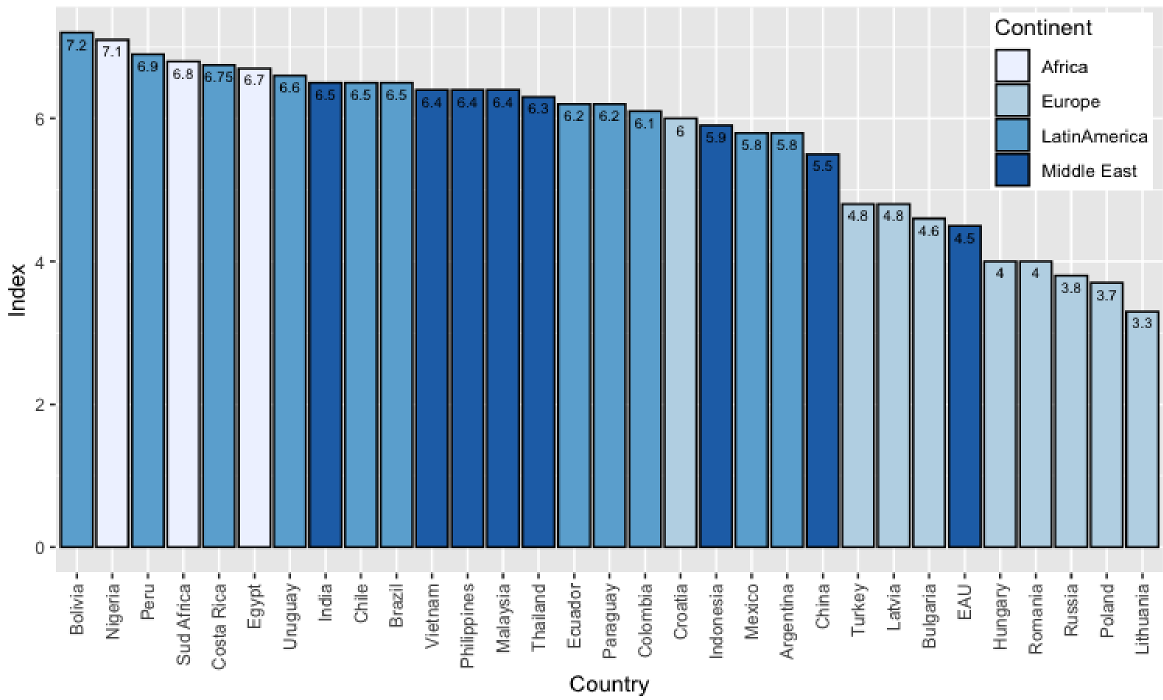
Figure 9: Cumulative Number of Deaths per Million Inhabitants



Source: Own elaboration according to WHO data.
Note: Since Brazil has a very high number of deaths compared to the rest, it was excluded from the graph.

Finally, Figure 10 takes as reference the study of Oxford Economics "Global Coronavirus Rankings - Bad For All, Awful For Some", that presents a list of the main countries vulnerable to COVID-19 according to an index, list that highlights Bolivia as the most vulnerable country on the list (with a vulnerability index of 7.2/10).

Figure 10: Economic and Social Vulnerability to COVID-19



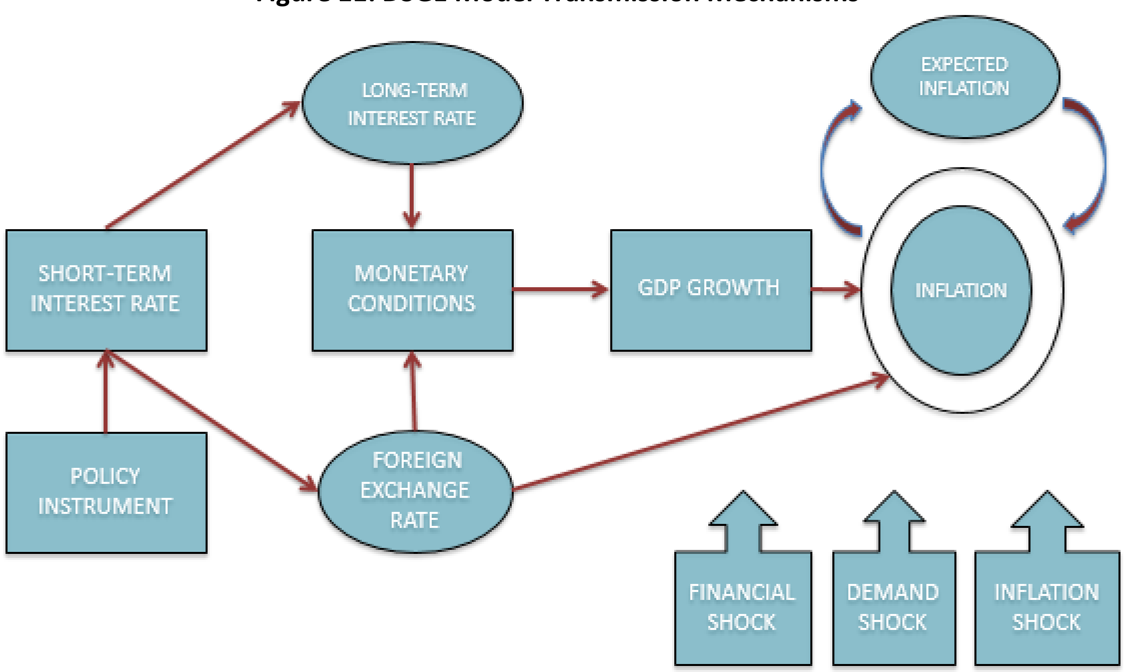
Source: Own elaboration according to Oxford Economics (2020)

4. The DSGE Model for Bolivia

The DSGE model used in the study is a medium scale model that is based on the Neo Keynesian model with financial frictions used in Del Black et al. (2015). The core model is also based on the work of Smets and Wouters (2007) and Christiano et al. (2005), that considers **i)** a neoclassical growth model with nominal prices and wages rigidities, **ii)** the use of capital variability, **iii)** investment adjustment costs and iv) the formation of consumption habits. The model includes credit frictions as in the financial accelerator model developed by Bernanke et al. (1999b) where the actual implementation of credit frictions follows the structure of Christiano et al. (2014), and also considers the future orientation of monetary policy by including shocks from anticipated policy as in Laseen and Svensson (2011).

The DSGE model also considers **i)** the particularities of Bolivia´s economy, such as the fixed exchange rate regime (crawling peg), **ii)** both a deterministic and stochastic trend in productivity and **iii)** it allows exogenous movements in risk premiums; **iv)** the inflation target varies in time following Del Negro and Schorfheide (2012); **v)** households preferences are not separable in consumption and leisure; **vi)** the Dixit-Stiglitz aggregator of intermediate goods has been replaced by the Kimball aggregator (more flexible); and finally considers **vii)** an adjustment indexation of prices and wages. The DSGE model for Bolivia considers eight types of agents: **1)** A set of households, which consume and offer labor; **2)** Aggregate and competitive workforce that considers labor work supplied by individual households; **3)** Companies that produces competitive (intermediate and final) goods; **4)** Monopolistically competitive producers of intermediate goods; **5)** Competitive capital producers that convert final goods into capital; **6)** Entrepreneurs that buys capital to companies that produces intermediate; **7)** A representative bank that collects deposits from households and lends funds to entrepreneurs; and finally **8)** A government, composed of a monetary authority that sets interest rates and a fiscal authority that sets public spending and collect taxes. Figure 11 presents an illustration of the transmission mechanisms of the DSGE model for Bolivia.

Figure 11: DSGE Model Transmission Mechanisms



Source: Author´s own elaboration

4.1.1. DSGE Model Specification: Technological Progress

Economy growth is driven by technological progress with the following features. A technology process Z_t^* is specified, that includes both a deterministic and a stochastic trend as well as a stationary component as follows:

$$Z_t^* = e^{\frac{1}{1-\propto}\widetilde{z_t}} Z_t^p e^{\gamma t} \tag{1}$$

Where γ is the steady-state growth rate of the economy, Z_t^p is a stochastic trend and $\widetilde{z_t}$ is a stationary component. On the other hand, the production function is expressed by:

$$Y_t(i) = \max\{e^{\widetilde{z_t}} K_t(i)^{\propto}(L_t(i)e^{\gamma t}Z_t^p)^{1-\propto} - \Phi Z_t^*, 0\} \tag{2}$$

Where $-\Phi Z_t^*$ is a fixed cost. The trend variables are divided by Z_t^*, to express the equilibrium conditions of the model in terms of stationary variables. Below is a summary of the logarithmic linearized equilibrium conditions where all variables are expressed as logarithmic deviations from its non-stochastic steady state.

4.1.2. DSGE Model Specification: Productivity

The stationary component of productivity $\widetilde{z_t}$ evolves in such a way that:

$$\widetilde{z_t} = \rho_z \widetilde{z_{t-1}} + \sigma_z \epsilon_{z,t} \tag{3}$$

Since Z_t^p is a non-stationary process, its growth rate is defined as $Z_t^p = \log(Z_t^p / Z_{t-1}^p)$, which assumes the following AR(1) process:

$$Z_t^p = \rho_z Z_{t-1}^p + \sigma_{zp}\epsilon_{zp,t,}\ \epsilon_{zp,t} \sim N\,(0,1) \tag{4}$$

Which follows the following formula:

$$z_t = \log\left(\frac{Z_t^*}{Z_{t-1}^*}\right) - \gamma = \frac{1}{1-\propto}(\rho_z - 1)z_{t-1} + \frac{1}{1-\propto}\sigma_z\epsilon_{z,t} + Z_t^p \tag{5}$$

where γ is the steady-state growth rate of the economy.

Note: All steady state values are expressed by the subscript (*). All steady state formulas used in the model are indicated in the appendix of Del Negro and Schorfheide (2012).

4.1.3. DSGE Model Specification: Consumption

The optimal consumption allocation satisfies the following Euler equation:

$$c_t = -\frac{(1-he^{-\gamma})}{\sigma_c(1+he^{-\gamma})}(R_t - E_t[\pi_{t+1}] + b_t) + \frac{he^{-\gamma}}{(1+he^{-\gamma})}(c_{t-1} - z_t) + \frac{1}{(1+he^{-\gamma})}E_t[c_{t+1} + z_{t+1}] + \frac{(\sigma_c - 1)}{\sigma_c(1+he^{-\gamma})}\frac{w_* L_*}{C_*}(L_t - E_t[L_{t+1}]) \quad (6)$$

where c_t is defined as consumption, L_t is expressed as labor offer, R_t is the nominal interest rate and π_t is inflation. The exogenous process b_t drives a gap between the utility marginal consumption and the real risk-free return $R_t - E_t[\pi_{t+1}]$, and is intended to capture risk premium shocks. This shock follows an AR(1) process with parameters ρ_μ and σ_μ. The parameters $\overline{\sigma_c}$ and h capture the degree of risk aversion and the degree of habit persistence in the utility function, respectively.

4.1.4. DSGE Model Specification: Investment

The optimal investment decision satisfies the following relationship between investment i_t (measured in terms of consumer goods), and capital value (measured in terms of consumption q_t^k).

$$i_t = \frac{q_t^k}{S'' e^{2\gamma}(1+\bar{\beta})} + \frac{1}{1+\bar{\beta}}(i_{t-1} - z_t) + \frac{1}{1+\bar{\beta}}E_t[i_{t+1} + z_{t+1}] + \mu_t \quad (7)$$

This relationship shows that investment is affected by adjustment costs of investment (S'' is the second derivative of the adjustment cost function) and by a exogenous process μ_t, which is called "marginal efficiency of investment", which alters the transformation rate between consumption and capital (see Greenwood et al. 1998). The shock μ_t follows an AR (1) process with parameters ρ_μ and σ_μ. Finally, the parameter $\bar{\beta}$ depends on **i)** the intertemporal discount rate of household utility function, β, **ii)** the degree of risk aversion σ_c, and **iii)** the steady state growth rate γ: $\bar{\beta} = \beta e^{(1-\sigma_c)}$.

4.1.5. DSGE Model Specification: Capital

Capital $\bar{k}_t$, which it is also referred as "installed capital", evolves as follows:

$$\bar{k}_t = \left(1 - \frac{i_*}{\bar{k}_*}\right)(\bar{k}_{t-1} - z_t) + \frac{i_*}{\bar{k}_*}i_t + \frac{i_*}{\bar{k}_*}S'' e^{2\gamma}(1+\bar{\beta})\mu_t \quad (8)$$

where $i_*/\bar{k}_*$ is the steady state investment/capital ratio. Capital is subject to the use of capital u_t and effective capital rented to companies k_t, which is related to $\bar{k}_t$ by:

$$k_t = u_t - z_t + \bar{k}_{t-1} \quad (9)$$

The optimal condition that determines capital utilization rate is given by

$$\frac{1-\psi}{\psi} r_t^k = u_t \tag{10}$$

where r_t^k is rental rate of capital and ψ captures utilization costs in terms of lost consumption. The real marginal costs for businesses are given by

$$mc_t = w_t - \alpha L_t + \alpha K_t \tag{11}$$

where w_t is the real wage and α is the share of capital income (after paying fixed costs) of the production function. From the optimal conditions of producer goods it follows that all firms have the same capital-labor ratio:

$$k_t = w_t - r_t^k + L_t \tag{12}$$

4.1.6. DSGE Model Specification: Financial Frictions

The model also considers financial frictions, based mainly on Bernanke et al. (1999a) and Christiano et al. (2003). The general idea raises with banks that receives deposits from households and lend to entrepreneurs that uses these funds to acquire physical capital that is rented out from producers of intermediate goods. Entrepreneurs are subject to an idiosyncratic disruption that affect their ability to manage capital. Therefore, their income may be not enough to repay loans received by banks. Banks protect themselves against the risk default by charging a margin (spread) over the deposit rate.

4.1.7. Model Specification: Return on Capital and Equity

The return on capital is given by:

$$\tilde{R}_t^k - \pi_t = \frac{r_*^k}{r_*^k+(1-\delta)} r_t^k + \frac{1-\delta}{r_*^k+(1-\delta)} q_t^k - q_{t-1}^k \tag{13}$$

where $\tilde{R}_t^k$ is expressed as the gross nominal return on capital for entrepreneurs, r_*^k is the steady state value of capital rental rate r_t^k, and δ is the rate of depreciation. The excess of return on capital can be expressed as a function of: **i)** entrepreneurs leverage and **ii)** exogenous fluctuations in the volatility of entrepreneurs' productivity:

$$E_t[\tilde{R}_{t+1}^k - R_t] = b_t + \zeta_{sp,b}(q_t^k + \bar{k}_t - n_t) + \tilde{\sigma}_{w,t} \tag{14}$$

Where n_t is the net worth of entrepreneurs, $\zeta_{sp,b}$ is the elasticity of credit spread in relation to entrepreneurs' leverage ($q_t^k + \bar{k}_t - n_t$) and $\tilde{\sigma}_{w,t}$, where t captures changes in the capacity of financial dispersion among entrepreneurs (see Christiano et al. (2014)). $\tilde{\sigma}_{w,t}$ follow an AR(1) process with parameters ρ_{σ_w} and σ_{σ_w}. The net worth of entrepreneurs n_t evolves based on the following:

$$n_t = \zeta_{n,\tilde{R}_t^k} (\tilde{R}_t^k - \pi_t) - \zeta_{n,R} (R_{t-1} - \pi_t + b_{t-1}) + \zeta_{n,qK} \left(q_{t-1}^k + \bar{k}_{t-1}\right) + \zeta_{n,n} n_{t-1} - \gamma_* \frac{u_*}{n_*} z_t - \frac{\zeta_{n,\sigma_w}}{\zeta_{sp,\sigma_w}} \tilde{\sigma}_{w,t-1} \quad (15)$$

where ζ denote elasticities, which depend, among other things, on the probability default $F(\bar{w})$ of entrepreneurs, where γ_* is the fraction of entrepreneurs who survive and continue to operate for another period, and where u_* is real capital divided by Z_t^* in steady state. The function of production is given by:

$$y_t = \Phi_p(\alpha k_t + (1 - \alpha) L_t) \quad (16)$$

where $\Phi_p = \frac{y_* + \Phi}{y_*}$ and the resource constraint is given by:

$$y_t = g_* g_t + \frac{C_*}{y_*} c_t + \frac{i_*}{y_*} i_t + \frac{r_*^k k_*}{y_*} u_t \quad (17)$$

where $g_t = log(\frac{G_t}{Z_t^* y_* g_*})$ and $g_* = 1 - \frac{C_* + i_*}{y_*}$

Likewise, it is assumed that public spending g_t follows the following exogenous process:

$$g_t = \rho_g g_{t-1} + \sigma_g \varepsilon_{g,t} + \eta_{g,z} \sigma_z \varepsilon_{z,t} \quad (17.1)$$

The Phillips curve of prices and wages is expressed by:

$$\pi_t = \kappa\, mc_t + \frac{\iota_p}{1+\iota_p \bar{\beta}} \pi_{t-1} + \frac{\bar{\beta}}{1+\iota_p \bar{\beta}} E_t[\pi_{t+1}] + \lambda_{f,t} \quad (18)$$

$$w_t = \frac{(1-\zeta_w \bar{\beta})(1-\zeta_w)}{(1+\bar{\beta})\zeta_w((\lambda_w - 1)\varepsilon_w + 1)} \left(w_t^h - w_t\right) - \frac{1+\iota_w \bar{\beta}}{1+\bar{\beta}} \pi_t + \frac{1}{1+\bar{\beta}} (w_{t-1} - z_t + \iota_w \pi_{t-1}) + \frac{\bar{\beta}}{1+\bar{\beta}} E_t [w_{t+1} + z_{t+1} + \pi_{t+1}] + \lambda_{w,t} \quad (19)$$

where $\kappa = \frac{(1-\zeta_p \bar{\beta})(1-\zeta_p)}{(1+\iota_p \bar{\beta})\zeta_p((\Phi_p - 1)\varepsilon_p + 1)}$, the parameters ζ_p, ι_p and ε_p follows the: **i)** Calvo parameter, **ii)** degree of indexing and iii) parameter curvature of Kimball´s aggregator for prices, and ζ_w, ι_w. Finally,

ε_w is expressed as a parameter corresponding to wages, w_t^h measures the household's marginal rate of substitution between consumption and work and is given by:

$$w_t^h = \frac{1}{1-he^{-\gamma}} \left(c_t - he^{-\gamma} c_{t-1} + he^{-\gamma} z_t\right) + v_l L_t \quad (20)$$

Where v_l characterizes the disutility function of work curvature (and would be equal to the Frisch elasticity inverse in the absence of wage rigidity). The margins $\lambda_{f,t}$, and $\lambda_{w,t}$ follows the following exogenous ARMA (1,1) processes:

$$\lambda_{f,t} = \rho_{\lambda_f} \lambda_{f,t-1} + \sigma_{\lambda_f} \varepsilon_{\lambda_f,t} - \eta_{\lambda_f} \sigma_{\lambda_f} \varepsilon_{\lambda_f,t-1}$$

$$\lambda_{w,t} = \rho_{\lambda_w} \lambda_{w,t-1} + \sigma_{\lambda_w} \varepsilon_{\lambda_w,t} - \eta_{\lambda_w} \sigma_{\lambda_w} \varepsilon_{\lambda_w,t-1}$$

4.1.8. Specification of the DSGE Model: Monetary Policy

The monetary authority follows a generalized feedback rule from policies, which is expressed by:

$$R_t = \rho_R R_{t-1} + (1 - \rho_R)\left(\psi_1(\pi_t - \pi_t^*) + \psi_2(y_t - y_t^f)\right) + \psi_3\left((y_t - y_t^f) - (y_{t-1} - y_{t-1}^f)\right) + r_t^m \quad (21)$$

where y_t^f is given by the result between price/salary flexibility, obtained by solving the DSGE model without considering nominal marginal shocks (that is, equations (6) to (20) with $\zeta_p = \zeta_w = 0$, y $\lambda_{f,t} = \lambda_{w,t} = 0$). The remainder r_t^m follows an AR (1) process with parameters ρ_{r^m} and σ_{r^m}. The DSGE model used for Bolivia, considers replacing a constant inflation target with an inflation target that varies over time π_t^*, in order to capture the rise and fall of inflation and interest rates in the estimation of the model. In that sense, the model follows the Aruoba and Schorfheide (2008) and Del Negro and Eusepi (2011) approach, which includes data on inflation expectations. Inflation expectations at long-term determine the level of inflation rate target. Inflation target evolves in time according to the following formula:

$$\pi_t^* = \rho_\pi * \pi_{t-1}^* + \sigma_{\pi^*} \varepsilon_{\pi^*,t} \quad (22)$$

where $0 < \rho_{\pi^*} < 1$ y $\varepsilon_{\pi^*,t}$ is a shock iid. π_t^* it is also considered as a stationary process although the parameter ρ_{π^*} will force the process to be persistent.

4.1.9. DSGE Model Specification: Policy Shocks

The specification of anticipated policy shocks in the model follows Laseen and Svensson (2011). In this sense, the exogenous component of the rule was modified from (21) as follows:

$$r_t^m = \rho_{r^m} r_{t-1}^m + \varepsilon_t^R + \sum_{k=1}^{K} \varepsilon_{k,t-k}^R \qquad (23)$$

where ε_t^R is a contemporary policy shock, and $\varepsilon_{k,t-k}^R$ is also a policy shock at time t - k, which in turn affects the monetary policy rule *k* subsequent periods, that is, at time *t*. On the other hand it is assumed that $\varepsilon_{k,t-k}^R \sim N(0, \sigma_{k,r}^2)$, i.i.d. k, i.i.d. To solve the model, it is necessary to express recursively anticipated shocks. For this purpose, the model increases the vector state s_t with *K* additional states $v_t^R, \ldots, v_{t-K}^R$, which It is expressed by:

$$v_{1,t}^R = v_{2,t-1}^R + \varepsilon_{1,t}^R$$

$$v_{2,t}^R = v_{3,t-1}^R + \varepsilon_{2,t}^R$$

.

.

$$v_{K,t}^R = \varepsilon_{K,t}^R$$

Therefore, rewriting the exogenous component of the monetary policy rule (23):

$$r_t^m = \rho_{r^m} r_{t-1}^m + \varepsilon_t^R + v_{1,t-1}^R$$

4.2. Including COVID-19 in the DSGE Model

Without major modifications, the DSGE model would not adequately capture the impact of the COVID-19 pandemic on the Bolivian economy. In that sense, the modifications of the model are expressed by the aggregation of shocks i.i.d. These types of shocks are i.i.d. because they relate economic events with COVID-19 (impossibility in production capacity and consumption of goods and/or services). However, it is important to consider that even temporary shocks can have more persistence in the economy due to the dynamic nature of the model per se. In that regard, it will be assumed that some shocks are anticipated. For example, agents expect a much larger set of shocks than those affecting the economy in the current quarter. The model introduces two new shocks: The so-called "factor shock discount" $\bar{\beta}_t$ and a "job offer" shock $\hat{\varphi}_t$. The first describes a stochastic addition to the discount rate β, and the second represents a displacer of the (un)usefulness of work. These shocks modify the Euler equation and the intertemporal condition as follows:

$$\hat{c}_t = -\frac{\left(1-he^{-z_*^*}\right)}{\sigma_c\left(1-he^{-z_*^*}\right)}\left(\hat{R}_t - E_t[\hat{\pi}_{t+1}]\right) + \frac{he^{-z_*^*}}{\left(1-he^{-z_*^*}\right)}\left(\hat{c}_{t-1} - \hat{z}_t^*\right) + \hat{b}_t + \hat{\beta}_t + \frac{1}{\left(1-he^{-z_*^*}\right)} E_t[\hat{c}_{t+1} + \hat{z}_{t+1}^*] + \frac{(\sigma_c - 1)}{\sigma_c\left(1+he^{-z_*^*}\right)}\frac{w_* L_*}{c_*}\left(\hat{L}_t - E_t[\hat{L}_{t+1}]\right) + \frac{(\sigma_c - 1)}{\sigma_c\left(1+he^{-z_*^*}\right)}\frac{w_* L_*}{c_*}\left(\hat{\varphi}_t - E_t[\hat{\varphi}_{t+1}]\right) \quad (24)$$

And

$$\frac{1}{1-he^{-z_*^*}}\left(\hat{c}_t - he^{-z_*^*}\hat{c}_{t-1} + he^{-z_*^*}\hat{z}_t^*\right) + \mathrm{v}_l\hat{L}_t + \mathrm{v}_l\hat{\varphi}_t = \hat{w}_t^h \quad (25)$$

The model also considers that labor supply shock φ_t, enters the Phillips curve salary in the same way as a salary shock through $\hat{w}_t^h$. However, to difference $\hat{\lambda}_{w,t}$, it also considers the Euler equation. Finally, the model also considers a stationary productivity disturbance $\hat{z}_t$ of the type i.i.d. On the other hand, total growth productivity is expressed as follows:

$$\hat{z}_t^* = \frac{1}{1-\alpha}\left(\hat{z}_t - \hat{z}_{t-1}\right) + z_t^p + \frac{1}{1-\alpha}\left(\hat{z}_t - \hat{z}_{t-1}\right) \quad (26)$$

It is important to consider that all shocks are i.i.d. (that is, $\rho_\beta = \rho_\varphi = \rho_{\hat{z}} = 0$). Therefore, to describe the economic impact of the COVID-19 pandemic, the model considers multiple possible scenarios that present the following anticipated shocks:

$$\hat{z}_t = \rho_{\hat{z}}\hat{z}_{t-1} + \sigma_{\hat{z}}\varepsilon_{\hat{z},t} + \sum_{k=1}^{K}\sigma_{\hat{z},k}\varepsilon_{k,t-k}^{\hat{z}}$$

$$\hat{\beta}_t = \rho_\beta\hat{\beta}_{t-1} + \sigma_\beta\varepsilon_{\beta,t} + \sum_{k=1}^{K}\sigma_{\beta,k}\varepsilon_{k,t-k}^{\beta}$$

$$\hat{\varphi}_t = \rho_\varphi\hat{\varphi}_{t-1} + \sigma_\varphi\varepsilon_{\varphi,t} + \sum_{k=1}^{K}\sigma_{\varphi,k}\varepsilon_{k,t-k}^{\varphi}$$

In that sense, parameter K=1 is considered only for an anticipated shock, and in turn, the anticipated shock is established as a proportion ϕ of the current shock, for example: $\sigma_{\hat{z},1}\varepsilon_{1,t}^{\hat{z}} = \phi\sigma_{\hat{z}}\varepsilon_{\hat{z},t}$

4.3. Seasonality of the DSGE Model for Bolivia

To estimate the model´s seasonality, the method of Sims (2002) was used to solve the system equilibrium conditions of the loglinear type and thus obtain the transition equation, which summarizes the evolution of the states s_t:

$$s_t = \mathcal{T}(\theta)s_{t-1} + \mathcal{R}(\theta)\varepsilon_t \qquad (27)$$

where θ is a vector that collects all parameters and ε_t is a vector with all structural shocks. The representation of seasonality y_t, is composed of the transition equation (27) and the following system of measurement equations:

$$y_t = \mathcal{D}(\theta) + \mathcal{Z}(\theta)s_t \qquad (28)$$

Finally, the model follows the assumption that some variables are measured considering an additional component, that is, the observed value is equal to the implicit value of the model plus an exogenous process, which evolves as an AR (1). Therefore, this exogenous process is added to the vector of states s_t.

4.4. DSGE Model Database for Bolivia

The estimation of the model database for Bolivia is based mainly in the following observable variables:

GDP growth $= 100\gamma + (y_t - y_{t-1} + z_t) + e_t^{pib} - C_{me}\varepsilon_{t-1}^{pib}$

Gross Domestic Income Growth $= 100\gamma + (y_t - y_{t-1} + z_t) + e_t^{iib} - C_{me}\varepsilon_{t-1}^{iib}$

Consumption Growth $= 100\gamma + (c_t - c_{t-1} + z_t)$

Investment Growth $= 100\gamma + (i_t - i_{t-1} + z_t)$

Real Salary Growth $= 100\gamma + (w_t - w_{t-1} + z_t)$

Work Hours $= \bar{L} + L_t$

Inflation $= \pi_* + \pi_t + e_t^{pce}$

GDP deflator (with inflation) $= \pi_* + \delta_{defpib} + \gamma_{defpib} * \pi_t + e_t^{defpib}$

Monetary Policy Interest Rate $= R_* + R_t$

$$\text{Nominal Yield 10} - \text{year Bonds} \quad = R_* + E_t\left[\frac{1}{40}\sum_{k=1}^{K} R_{t+k}\right] + e_t^{10n}$$

$$\text{Inflation Expectation} \quad = \pi_* + E_t\left[\frac{1}{40}\sum_{k=1}^{K} \pi_{t+k}\right]$$

$$\text{Spread} \quad = SP_* + E_t\left[\tilde{R}_{t+1}^{k} - R_t\right]$$

$$\text{Productivity Growth} \quad = z_t + \frac{\alpha}{1-\alpha}(u_t - u_{t-1}) + e_t^{tfp}$$

(29)

4.5. Inference Estimates and Model Parameters

The model uses Bayesian techniques to estimate parameters that require the specification of a prior distribution. For the calculation of some parameters, I use the same a priori marginal distributions as Smets and Wouters (2007) with two important exceptions. The model uses values that has a greater influence on the forecast performance of the model per se, since data specifically from Bolivia was used. Second, for the financial friction mechanism, I estimated an *a priori* estimation for the parameters SP_*, $\zeta_{sp,b}$, ρ_{σ_w} and $\sigma_{\sigma_w,}$while they were other fixed parameters corresponding to the default probability in state stationary. It is important to consider that these parameters also imply values for the parameters of equation (15).

5. Impact of COVID-19 on the Bolivian Economy

5.1. Main Affected Macroeconomic Variables

Although COVID-19 dates from December 2019, where it is presumed to appear for the first time in Wuhan-China, it was not until March 2020 that it appeared on Bolivia, damaging not only the population´s health, but also the country´s economy and its main sectors (Monetary, Financial, External, Fiscal). Below is evidence of the main macroeconomic variables of Bolivia affected directly or indirectly by the pandemic.

5.1.1 Evidence 1: Gross Domestic Product - GDP

According to INE data, the country registered an economic growth of 0.6% for the first quarter of 2020, which represents 2.5 percentage points less than the value recorded for the first quarter of 2019 (3.1%). First evidence of COVID-19 effect on the Bolivian economy. Another interesting point is that from 2013 and so on, a decreasing trend can be noted (See Figure 12).

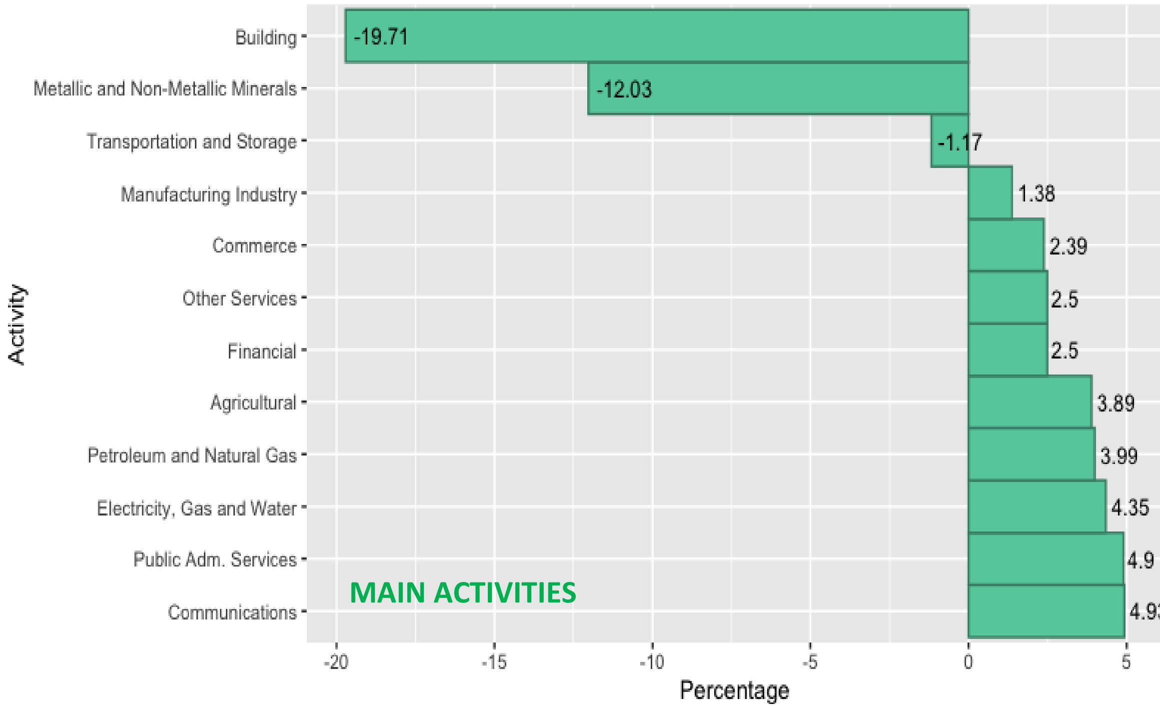
Figure 12: Real GDP Growth Rate
First Quarter 2000 - 2020
(In percentage)

Source: Own elaboration based on data from INE

5.1.2 Evidence 2: Economic Growth by Economic Activity

The most affected economic activities of the country due to the pandemic, during the first quarter of 2020, were Transportation and Storage, Metallic and Non-Metallic Minerals and Construction with negative growth of 1.2%, 12.1% and 19.7% respectively (See Figure 13). Second evidence that illustrates the impact of COVID19 on the Bolivian economy.

Figure 13: GDP Growth Rate by Economic Activity
First Quarter 2020
(In percentage)

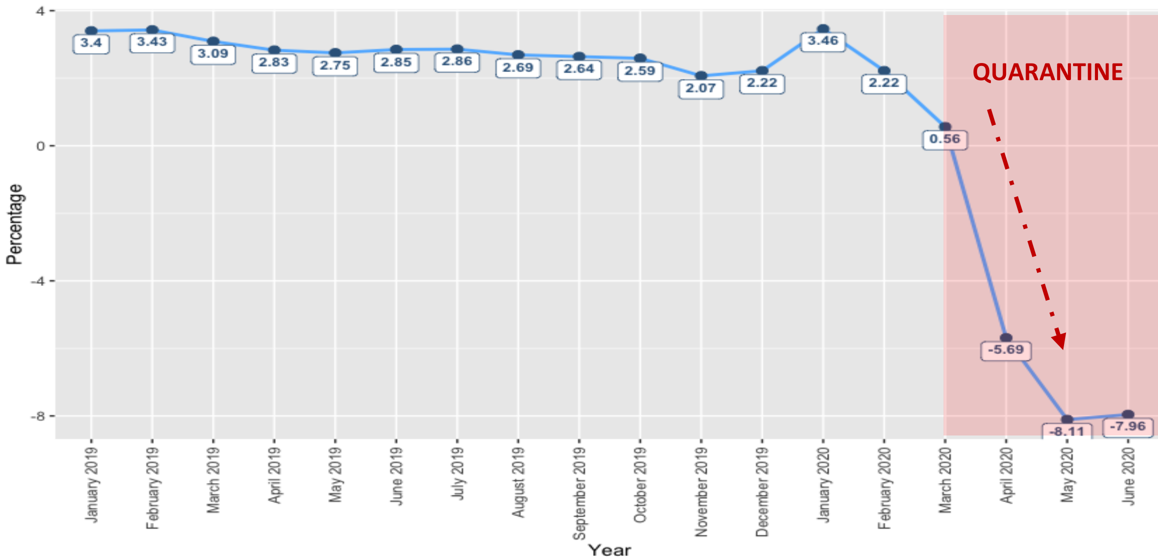


Source: Own elaboration based on data from INE

5.1.3 Evidence 3: Global Economic Activity Index – IGAE

Regarding the IGAE Index (indicator that shows the economic activity evolution of the country), we see that the mentioned index falls sharply from March 2020 (0.6%) to June 2020 (-7.9%) respectively. This being the third evidence of economic impact of COVID-19 in Bolivia, and in fact one of the most significant evidences of the analysis (See Figure 14).

Figure 14: Variation of Global Economic Activity Index - IGAE
(In percentage)

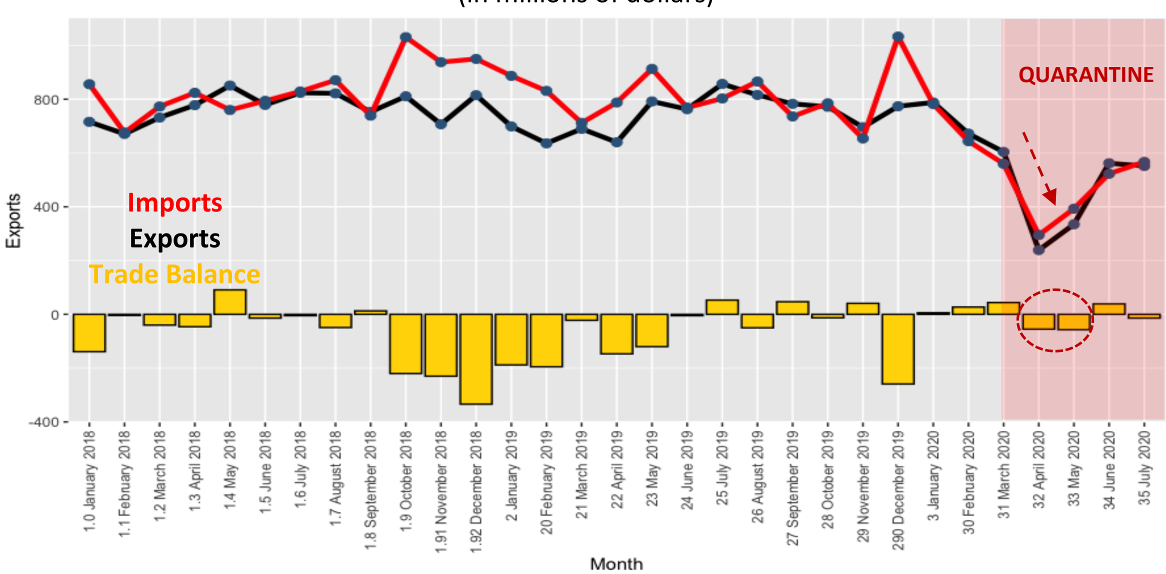


Source: Own elaboration based on data from INE.
Note: The shaded area represents the quarantine period due to COVID-19.

5.1.4 Evidence 4: Foreign Trade

Regarding the External Sector, it stands out that during the period January-April 2020, there was a considerable drop in both exports and imports, registering the lowest value for the month on April 2020 (Fourth evidence of the economic impact of COVID-19 in the country). Also, during the period April-May 2020, a negative trade balance was registered (See Figure 15).

Figure 15: Bolivia´s Foreign Trade 2018 - 2020
(in millions of dollars)

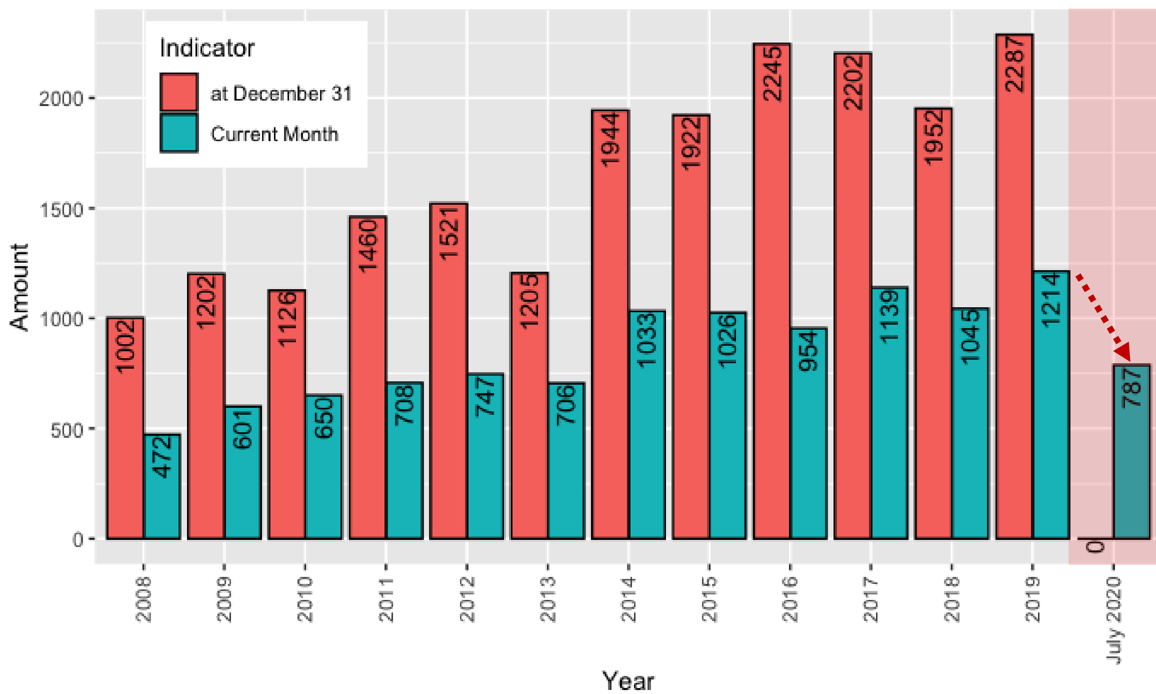


Source: Own elaboration based on data from INE.
Note: The shaded area represents the quarantine period due to COVID-19.

5.1.5 Evidence 5: Financial Sector

If we analyze banks' profits, it highlights that in July 2020 banks registered a value of Bs787 million, which represents Bs427 million less than the registered value in July 2019 (Bs1,214 million) and also represents the minimum value of profits that banks registered in the last 7 years for the month of July. Fifth evidence of economic impact of COVID-19 in the country (See Figure 16).

Figure 16: Banks Profits
(in millions of bolivianos)

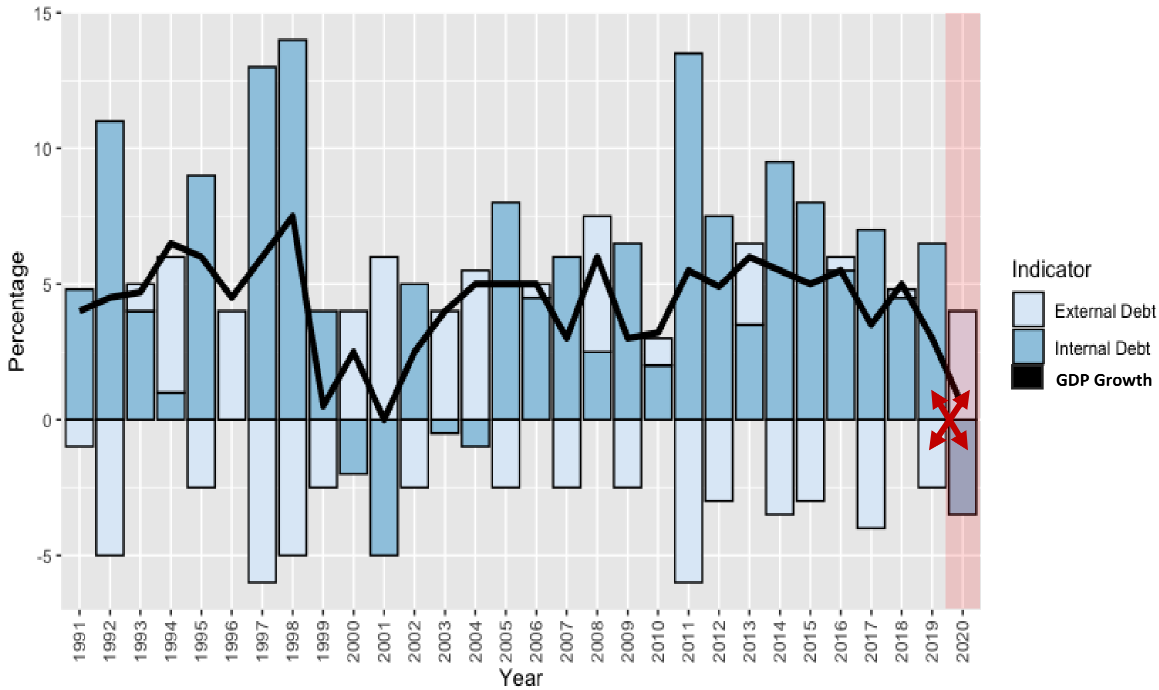


Source: Own elaboration based on data from INE.
Note: The shaded area represents the quarantine period due to COVID-19.

5.1.6 Evidence 6: Internal and External Debt

Figure 17 illustrates that Internal and External Debt´s behavior in the first quarter of 2020, is exactly opposite to the behavior of these variables in the first quarter of 2019. On the other hand, there is a notorious External Debt growth (main source of resources for bonds granted by Government to economic sectors), as well as a notorious contraction of Internal Debt for the first quarter of 2020. Sixth evidence of the economic impact of COVID-19 in the country.

Figure 17: Internal and External Demand Incidence on Real GDP Growth
First Quarter 1991 - 2020 (p)
(Growth in % and incidence in PPs)

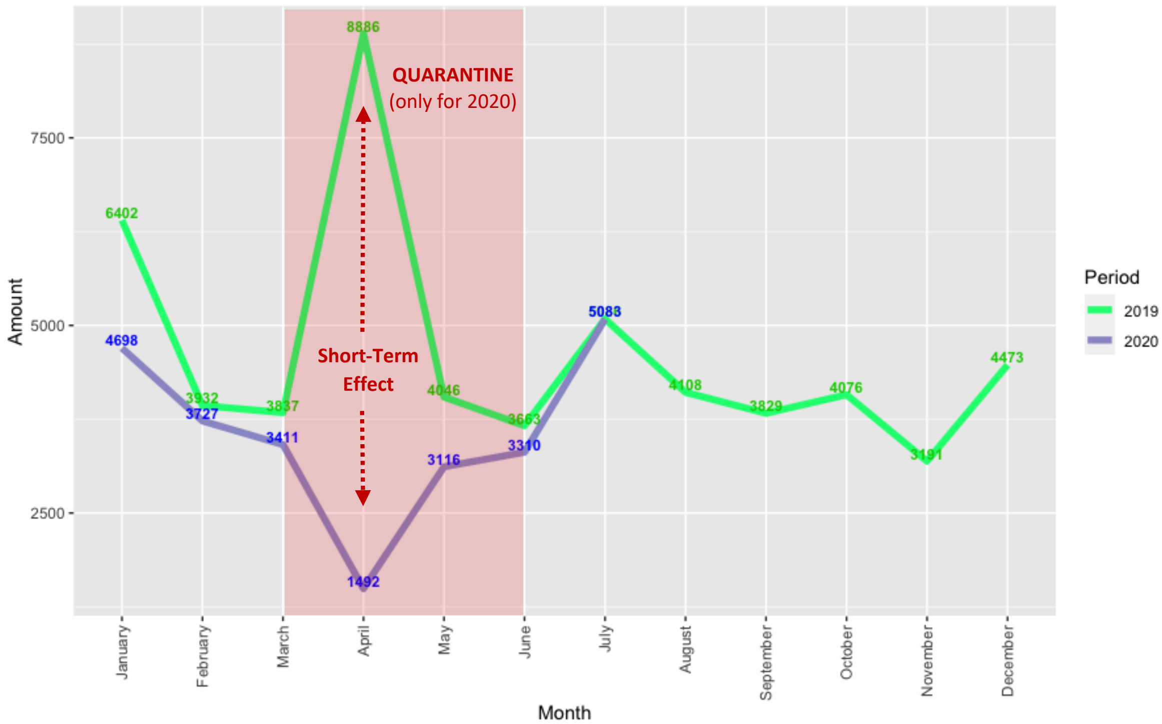


Source: Own elaboration based on data from INE.
Note: The shaded area represents the quarantine period due to COVID-19.
(p): Preliminary

5.1.7 Evidence 7: Tax Collection

Figure 18 presents a 2019-2020 comparison of monthly tax collections of the country. Although April 2019, was the month with the highest tax collection of 2019, April 2020 registered the lowest tax collection of 2019 and 2020. Seventh evidence of the economic impact of COVID-19. Also, in the May - July 2020 period, tax collection stabilized, reaching (July 2019 and July 2020) the same level of tax collection, which could be a hypothesis that the effect of COVID-19 on tax collection was short-term.

Figure 18: Monthly Tax Collection, 2019 - 2020 (p)
(in millions of bolivianos)



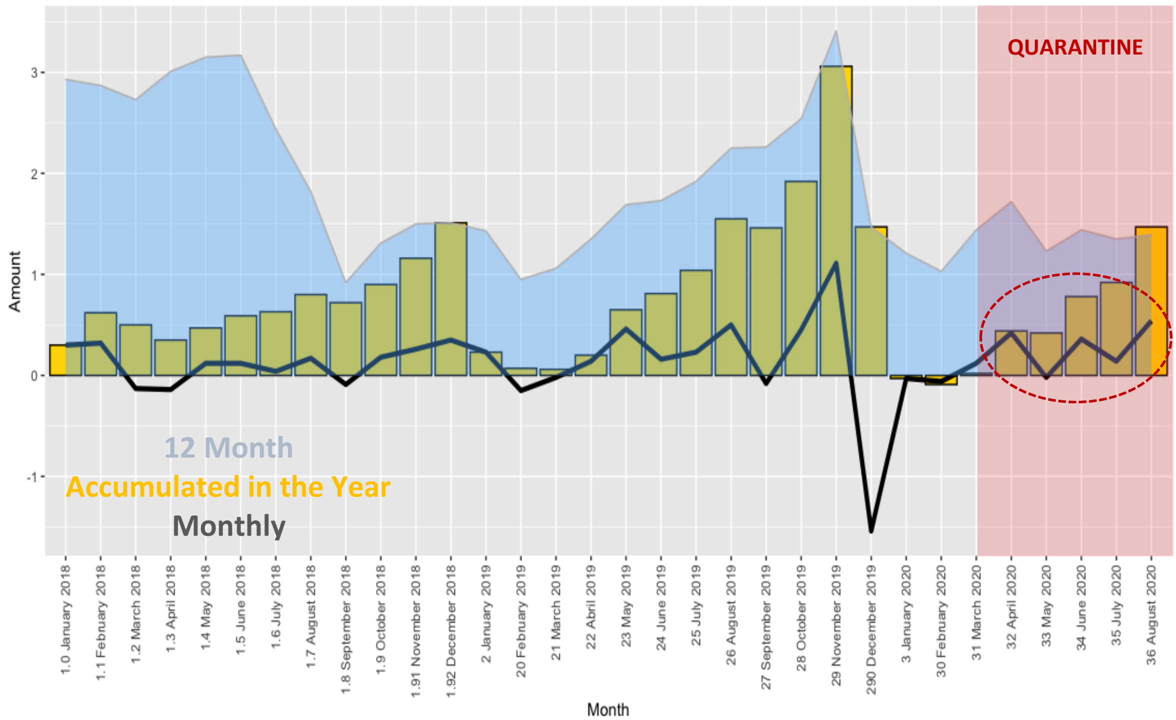
Source: Own elaboration based on data from INE.
Note: The shaded area represents the quarantine period due to COVID-19 (only for 2020).
(p): Preliminary

5.1.8 Evidence 8: Consumer Price Index - CPI

One could expect that the pandemic generates an increase on inflation, however, although there was a fluctuation in prices, it was less than expected. Figure 19 illustrates the percentage change on CPI 2019 - July 2020. Regarding 2020, April was the month with the greater percentage change on CPI (+0.42%), month when the country was in a rigid quarantine period due to COVID-19. On the other hand, during the quarantine period there was a significant volatility of CPI compared to past periods. Eighth evidence of the economic impact of COVID-19 in the country.

Figure 19: Monthly Percentage Variation of the Consumer Price Index 2018 - August 2020

(in percentage)

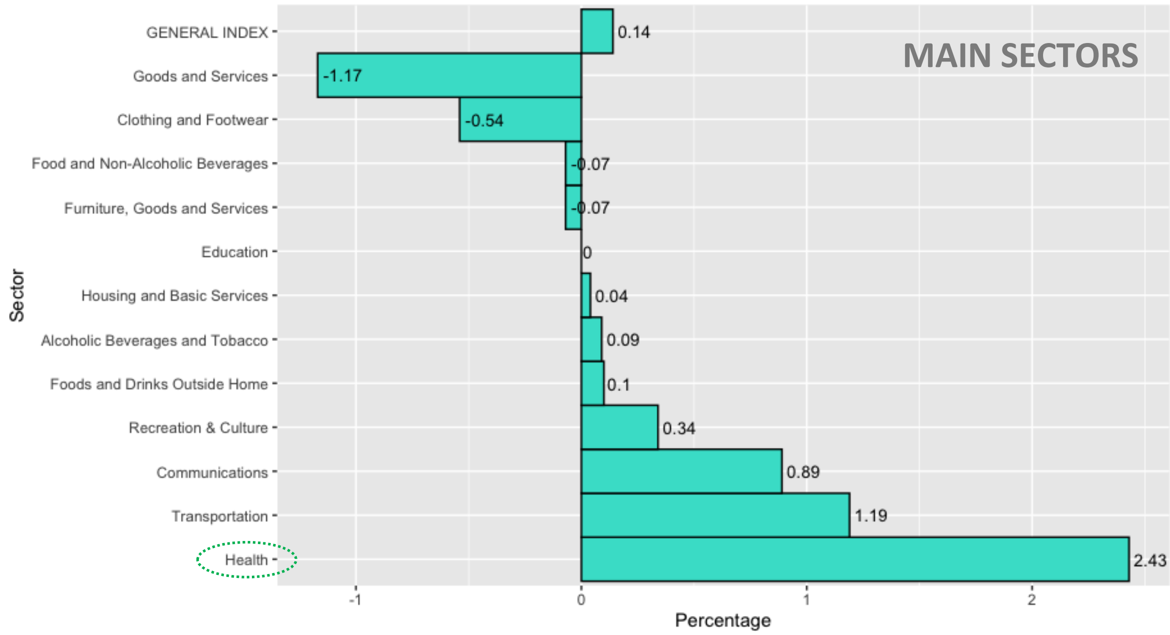


Source: Own elaboration based on data from INE.
Note: The shaded area represents the quarantine period due to COVID-19.

5.1.9 Evidence 9: CPI According to Economic Sector

Figure 20 illustrates CPI´s composition according to main economic sectors. In July 2020, health stands out as the main contributor to the percentage change of CPI, which is logical taking into account that a pandemic increases the demand of the sector. Ninth evidence of the economic impact of COVID-19 in the country. It also stands out that Goods and Services (-0.54%), as well as Clothing and Footwear (-1.17%), were the activities that generated the least percentage change in the Bolivian CPI in July 2020.

Figure 20: Percentage Variation of CPI by Economic Sector, July 2020
(in percentage)

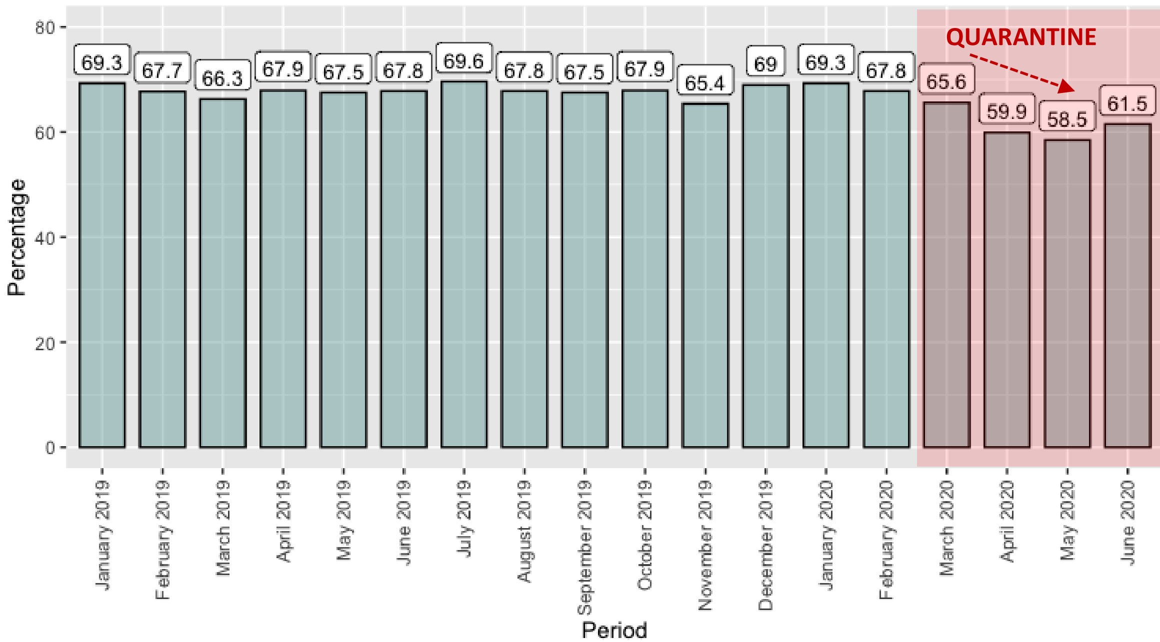


Source: Own elaboration based on data from INE.

5.1.10 Evidence 10: Global Participation Rate - TGP

Finally, the tenth evidence of the impact of COVID-19 in the country, comes represented by the TGP, defined as labor force (employed + unemployed) on the working age population. Figure 21 illustrates the behavior of TGP during the period January 2019-June 2020. It stands out that the rate registered a considerable drop for the period April-May 2020 (rigid quarantine period for COVID-19 in the country), with a participation rate of 59.9% and 58.5% respectively. Finally, on June 2020 this rate experienced an increasing value of 61.5%. The above could be considered as possible evidence that the impact of COVID-19 for this indicator was short-term, due to the economic reactivation and employment measures imposed by the current government.

Figure 21: Global Participation Rate - TGP
January 2019 - June 2020
(in percentage)



Source: Own elaboration based on data from INE.
Note: The shaded area represents the quarantine period due to COVID-19.

5.2. Bolivia´s Economy Forecasting according to the DSGE Model

5.2.1. What Can We Learn from A Pandemic Shock?

Although there is a trend difference for countries that imposed lockdown restrictions, COVID-19 has already hit the world economy. In that regard, there is a premise for countries to tackle the magnitude of this pandemic shock, so countries can economically recover the sooner. The answer to the mentioned, can be answered by the use of one of the following letters: *V*, *U* and *W*. These letters come as the typically seen shape during these recovery periods.

- ✓ *V*-shaped Economic Recovery: Considered as the best scenario, this type of recession begins with a sharp decline, but then bottoms out and rapidly recover. This would mean that the recession would last only a few quarters before a rapid return to growth, which would take the economy to where it was before the pandemic of coronavirus.
- ✓ *U*-shaped Economic Recovery: This is similar to a recession V-shaped but lasts longer. In this scenario, GDP normally contracts for several quarters in a row and only slowly returns to observed growth level before the recession.

- ✓ *W*-shaped Economic Recovery: This is when a recession starts with the appearance that it will be a V-shaped recession, but then falls back after what turns out to be a false sign of recovery. It is also known as a double dip recession, since the economy falls twice before recovering to its rate of previous growth. This is the worst of the cases already mentioned.

5.2.2. Incidence of COVID-19 in the Bolivian Economy

To incorporate a substantial uncertainty surrounding economic activity due to COVID-19, the model presents three possible scenarios, that differs primarily in the severity of the pandemic and consequently its effects on economic behavior. The three scenarios that the model considers are: **i)** A "temporary lockdown" (Scenario 1 - V-shaped Economic Recovery), **ii)** A "blockade with dynamics of the economic cycle "(Scenario 2 - U-shaped Economic Recovery) and a "blockage with persistent demand deficit" (Scenario 3 - W-shaped Economic Recovery).

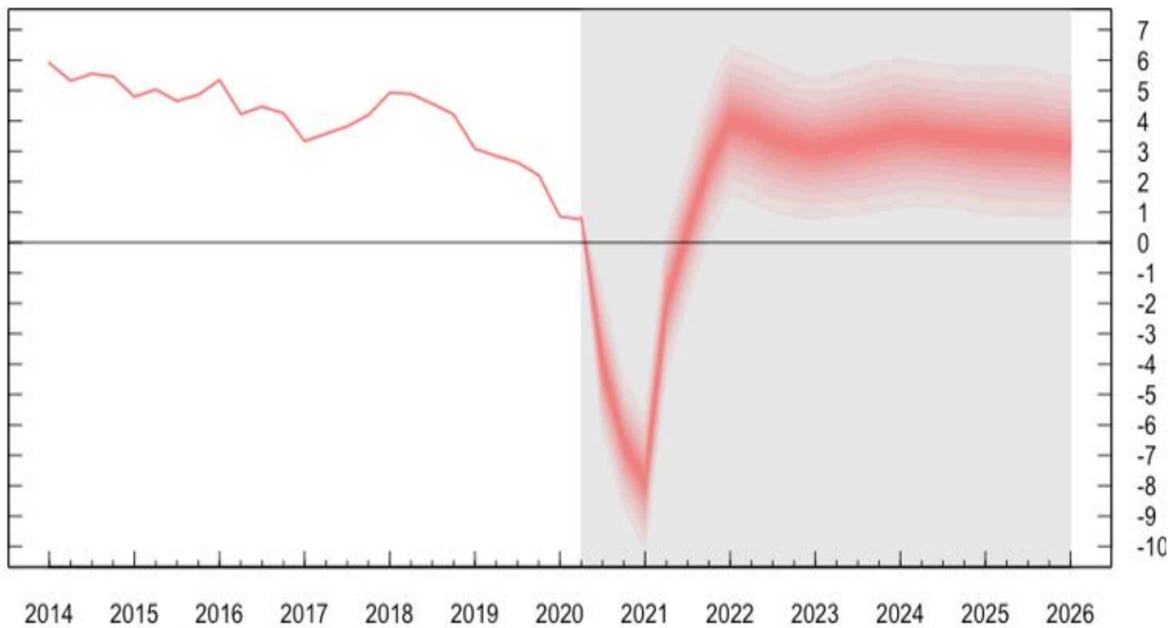
5.2.2.1. Model Results: Economic Growth Forecast

This section answers the main question of the study: How will Bolivia's economy be during and after the COVID-19 pandemic? In this sense, it presents the results of the DSGE model for Bolivia regarding economic growth forecast (2020 - 2025), considering 3 different scenarios that the model assumes in order to include the COVID-19 pandemic shock.

5.2.2.1.1. DSGE Model Results: GDP Growth Forecast under Scenario 1 - V

Scenario 1 considers a temporary blocking of the economy due to the pandemic, characterized by transitory supply and demand shocks, and intentionally restrict the role of standard shocks of the model, which is why this scenario is considered as optimistic. This produces a recovery relatively V-shaped, with a negative economic growth of (-6.1%) for 2020. Consistent with the theory of cycles, the economy will experience from 2021 a rise until the beginning of 2022, with a 3.7% growth that represents the maximum growth for the period of analysis (Q2-2020, Q4-2025). Later, economic growth will stabilize, with an average economic growth of 3.3% (See Figure 22).

Figure 22: Bolivia´s GDP Forecast
Scenario 1 (V), 2014 - 2026
(in percentage)

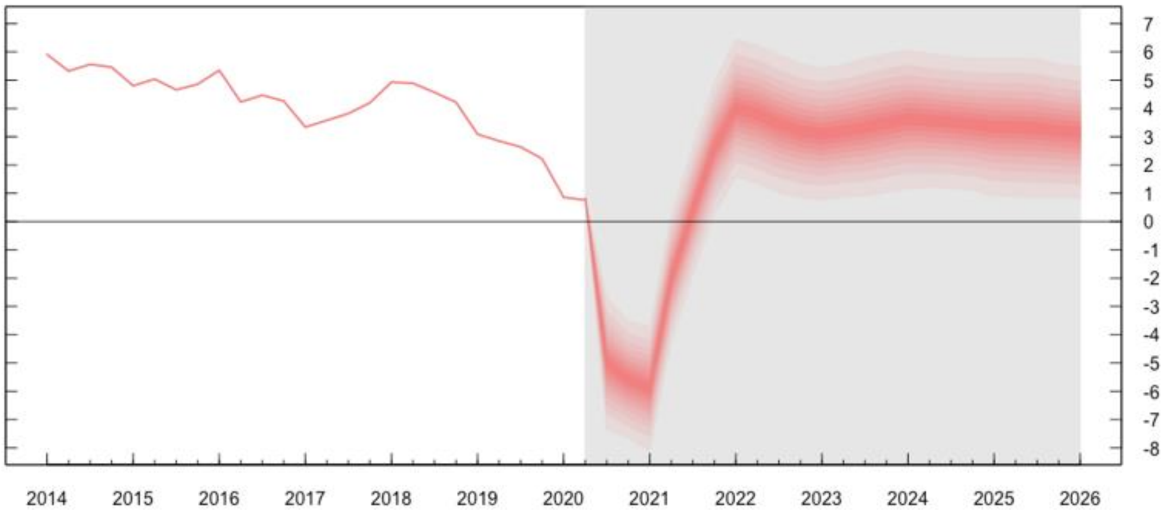


Source: Own elaboration based on data from INE and DSGE model for Bolivia (forecast)
Note 1: The shaded area corresponds to the DSGE model for Bolivia forecast that considers the shock of COVID19
Note 2: The forecast graph considers confidence probability intervals of 50%, 60%, 70%, 80% and 90%

5.2.2.1.2. DSGE Model Results: GDP Growth Forecast under Scenario 2 - U

For Scenario 2, the higher weigh on the set standard shocks plays a more important role in the Bolivian economy, producing more persistent effects. Although the country under this scenario registers a negative growth of (-5.8%) for 2020, the shock anticipates compared to Scenario 1 and therefore is more durable. This is why this scenario, presents a U-shaped form of economic recovery characterized by a greater persistence of the COVID-19 shock in the country's economy. After the pandemic shock, it is expected that the economy will get up and behave in a similar manner to that explained for Scenario 1 with respect to subsequent periods of analysis (See Figure 23).

Figure 22: Bolivia´s GDP Forecast
Scenario 1 (U), 2014 - 2026
(in percentage)

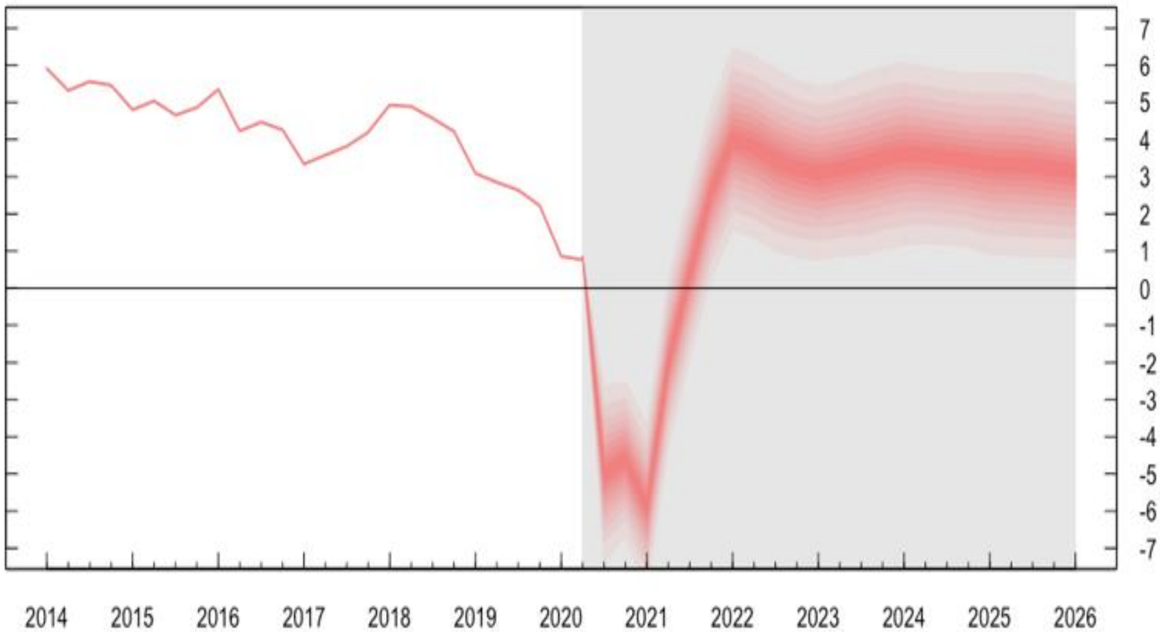


Source: Own elaboration based on data from INE and DSGE model for Bolivia (forecast)
Note 1: The shaded area corresponds to the DSGE model for Bolivia forecast that considers the shock of COVID19
Note 2: The forecast graph considers confidence probability intervals of 50%, 60%, 70%, 80% and 90%

5.2.2.1.3. DSGE Model Results: GDP Growth Forecast under Scenario 3 - W

Scenario 3, which considers a pessimistic scenario, assume that deficit demand will persist during the third quarter of 2020, which reflects a prolonged weakness in the Bolivian economy demand, due mainly to the W-shaped economic recovery. This type of economic recovery is characterized by experiencing two consecutive shocks with an apparent recovery in between. This situation is one of those that leaves the greatest damage to the economy of a country, so it will be important to take the necessary policy measures to avoid this type of threat to the country's economic recovery. In quantitative terms, this scenario registers a negative economic growth of (-4.4%) for the period Q2-2020, which can be interpreted as the COVID-19 shock per se and a negative growth of -6.3% for the period Q4-2020, interpreted as the post shock COVID-19 effect (See Figure 24).

Figure 22: Bolivia´s GDP Forecast
Scenario 1 (W), 2014 - 2026
(in percentage)



Source: Own elaboration based on data from INE and DSGE model for Bolivia (forecast)
Note 1: The shaded area corresponds to the DSGE model for Bolivia forecast that considers the shock of COVID19
Note 2: The forecast graph considers confidence probability intervals of 50%, 60%, 70%, 80% and 90%

5.2.2.1.4. DSGE Model Results: Quarterly GDP Growth Forecast

If we analyze economic growth of the country in quarterly terms under a Scenario A that considers the COVID-19 shock and a Scenario B that does not, we can visualize and understand the impact of this pandemic shock. There is two important time periods according to the comparison of both scenarios: **i)** Q2-Q42020 stands out as a period with a notorious negative impact of COVID-19. **ii)** Q2-2021 and Q4-2022 stands out as periods with greater economic recovery of Scenario A that considers a pandemic shock, mainly explained by the sharp drop in previous periods (See Figure 25).

Figure 25: Quarterly GDP Growth Forecast for Bolivia
Scenario 2 (U), 2014 - 2026
(in percentage)

Source: Own elaboration based on data from INE and DSGE model for Bolivia (forecast)
Note 1: The shaded area corresponds to the DSGE model for Bolivia forecast period
Note 2: The green line represents the DSGE model for Bolivia´s result that considers COVID-19 shock.
Note 3: The interlined red line represents the DSGE model for Bolivia´s result that does not consider COVID-19 shock.

5.2.2.1.5. Summary Results of the DSGE Model: GDP Growth Forecast 2020–2025

Table 3 shows summary results of annual economic growth forecast in Bolivia for the period Q2-2020, Q4-2025, with its corresponding maximum and minimum confidence intervals. Regarding the results of the model for each of the scenarios, the following points stand out: **i)** 2020-2021 represents the period with the highest volatility with respect to the results of each scenario. Subsequently, growth is similar in terms of value and trend (2022-2025). **ii)** There is strong evidence that Scenario 1 would be the best option for the Bolivian economy, since it would experience a fall not so strong (2020), which allows it subsequently (2021) to grow at a rate of higher economic growth compared to growth behavior of other scenarios. iii) Scenario 3 is equivalent to the worst situation, represented mainly by a considerable drop in growth for 2020 (the lowest in relation to other scenarios), and subsequently (2021) a growth rate that does not reach growth level of others scenarios, mainly explained by the lower economic recovery in the form of W.

Table 3. Bolivian´s Annual GDP Growth Forecast, 2020 - 2025
(in percentage)

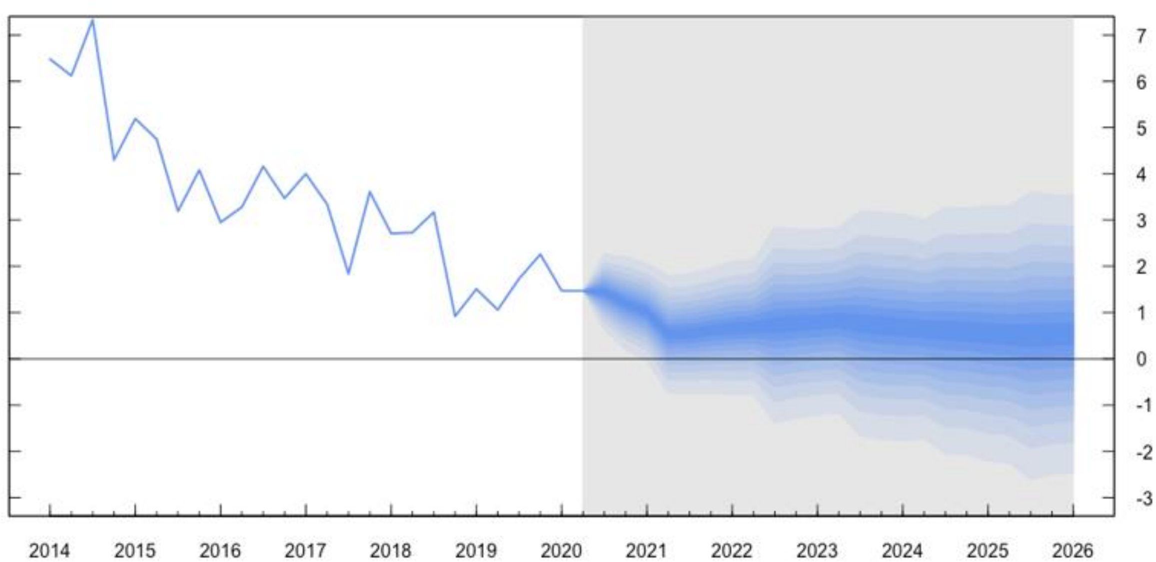
	2020	2021	2022	2023	2024	2025
Scenario 1 – V	-5,4	2,7	3,1	3,6	3,3	3,2
	(-6,6 -5,7)	(0,9 3,2)	(0,8 5,6)	(0,9 5,8)	(1,1 5,7)	(0,8 5,8)
Scenario 2 – U	-5,9	2,1	3,2	3,3	3,2	3,1
	(-7,5 -3,8)	(0,5 4,1)	(0,9 5,8)	(1,1 5,7)	(1,2 5,8)	(0,9 5,7)
Scenario 3 – W	-6,1	1,5	3,2	3,7	3,4	3,3
	(-5,1 -2,9)	(1,2 4,8)	(0,8 5,7)	(0,9 5,8)	(1,1 5,7)	(0,9 5,8)

Source: Own elaboration based on the DSGE model for Bolivia forecast that considers COVID-19 shock

5.2.2.2. DSGE Model Results: Inflation Forecast

According to the results of the DSGE model, inflation is expected to oscillate below inflation target level of 4% for the period 2020-2023. However, from 2024 onwards it is possible to experienced a "post-pandemic shock" effect, explained by an excessive injection of production that allows a speedy recovery economic, however as a consequence it is accompanied by an increase also in inflation, due to household consumption incentives. Finally, as can be seen in Figure 26, the degree of uncertainty associated with these forecast, represented by confidence bands, begins to stand out from the post-pandemic shock period, since the behavior of inflation will depend a lot on monetary policy policies that Central Bank of Bolivia chooses to implement.

Figure 26: 12 Month Bolivian Inflation Forecast, 2014-2026
(in percentage)



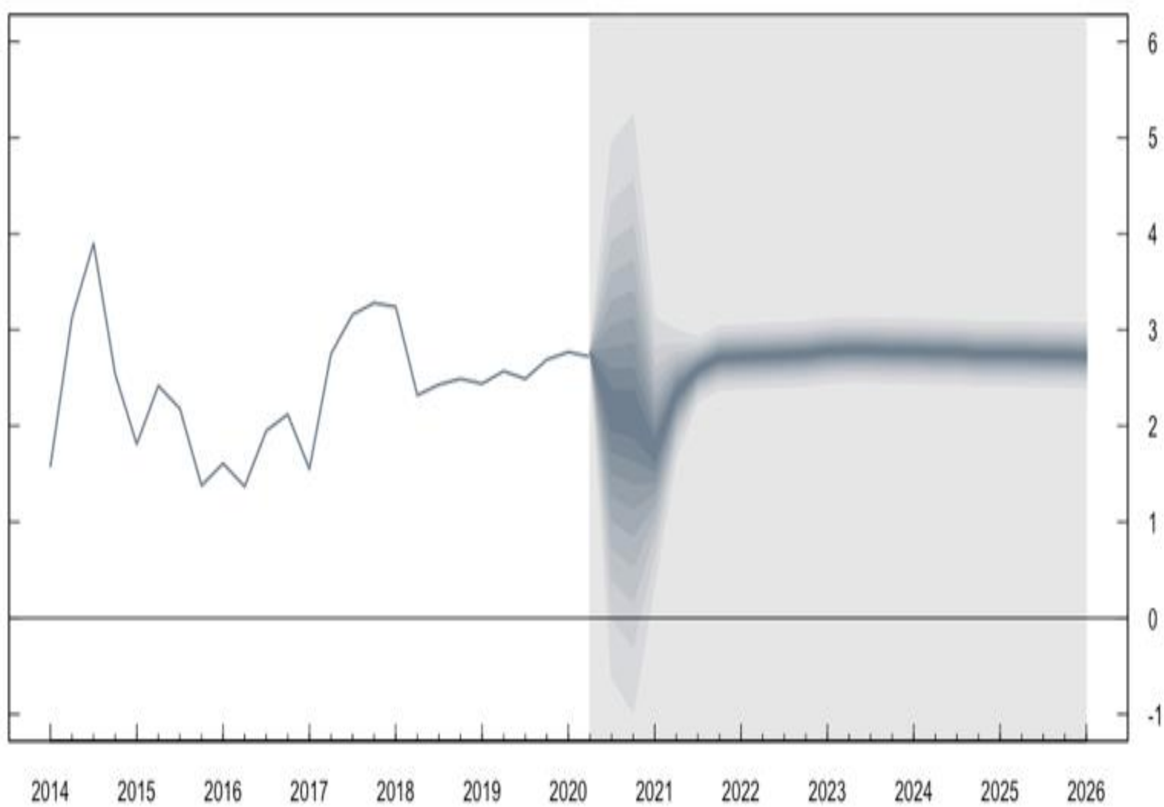
Source: Own elaboration based on data from INE and DSGE model for Bolivia (forecast)
Note 1: The shaded area corresponds to the DSGE model for Bolivia forecast that considers the shock of COVID19
Note 2: The forecast graph considers confidence probability intervals of 50%, 60%, 70%, 80% and 90%

5.2.2.3. DSGE Model Results: Interest Rate Forecast

The transmission mechanism of interest rate forecast goes as follows: Interest rate is expected to fall during Q2-Q4 2020, so in order to incentivize demand, it is expected that the country experienced an increase on consumption as a tackle policy to the pandemic shock effect. This trade off will cause an increase on inflation from period Q2-2023 (period also known as post-pandemic shock previously).

To keep inflation at the right level, it is expected that monetary authority would increase interest rate during Q1-Q4 2021, so once controlled inflation can maintain a constant interest rate level (which can be seen from Q4-2021 onwards). Finally, it is important to note that this forecast is subject to a considerable uncertainty during period Q2-Q4 2020, since empirical evidence has shown us that not all monetary authorities reacts the same way (See Figure 27).

Figure 27: Projection of the Bolivian Nominal Interest Rate, 2014 - 2026
(in percentage)



Source: Own elaboration based on data from INE and DSGE model for Bolivia (forecast)
Note 1: The shaded area corresponds to the DSGE model for Bolivia forecast that considers the shock of COVID19
Note 2: The forecast graph considers confidence probability intervals of 50%, 60%, 70%, 80% and 90%

5.2.2.4. Summary Results of the DSGE Model

Below is a quarterly forecast summary of the main macroeconomic variables during the period of analysis 2020-2025. The main results are the following: **i)** GDP growth is the only variable that registers negative values during the forecast period, **ii)** GDP growth is the most volatile variable among the others, **iii)** Interest rate is the least volatile variable, with a maximum and minimum value of 2.9% and 2.2% respectively and finally **iv)** with regard to confidence intervals, interest rate presents the greater uncertainty variable, since behavior of this variable will also depend of central bank measures. On the other hand, during the period Q2-2022 Q4-2025, inflation presents a broader confidence band, explained by a possible appearance of a post-pandemic shock as a result of excessive stimulation on the economy (See Table 4).

Table 4. GDP Growth, Inflation and Interest Rate Quarterly Forecast for Bolivia 2020 - 2015

(in percentage)

	2020		2021		2022		2023		2024		2025	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
ΔGDP (Scenario 2 - U)	0,6*	-4,1	-3,1	-0,2	3,7	3,2	3,1	3,4	3,8	3,4	3,3	3,2
		(-4,9 -4,2)	(-3 -3,4)	(-1,2 0,4)	(1,1 6,1)	(0,9 5,9)	(1,1 5,2)	(1,1 5,7)	(1,2 5,8)	(1,1 5,9)	(1,1 5,8)	(0,8 5,8)
Inflation	1,4*	1,4	0,8	0,9	1,1	1,1	1,2	1,2	1,8	1,9	2,6	2,9
		(1,1 2,0)	(-0,9 2,3)	(-0,9 2,4)	(-1,1 2,6)	(-1,3 2,6)	(-1,4 3,1)	(-1,5 3,4)	(-0,8 3,9)	(-0,9 4,3)	(-0,2 5,1)	(-0,3 5,9)
Interest Rate	2,77*	2,4	2,2	2,8	2,9	2,9	2,8	2,7	2,6	2,6	2,5	2,4
		(-0,7 4,8)	(0,8 3,3)	(2,2 3,1)	(2,3 3,1)	(2,4 3,1)	(2,6 3,1)	(2,7 3,1)	(2,8 3,1)	(2,8 3,1)	(2,8 3,1)	(2,8 3,1)

Source: Own elaboration based on the DSGE model for Bolivia forecast that considers COVID-19 shock
Note: Q1 and Q2 correspond to Quarter 1 and 2 respectively.
(*) Corresponds to registered data extracted from INE and BCB.

6. Conclusions

Throughout the study, numerous questions are presented and answered regarding the behavior and impact of a pandemic shock on the economy. Empirical evidence shows that there are three types of recovery from a pandemic shock and that are shaped like the letters *U*, *V* and *W*, with *U* and *W* being the most and least favorable scenario for the economy recovery respectively.

To understand in quantitative terms what kind of economic recovery could Bolivia experience, a DSGE model has been developed that considers the COVID-19 shock and that was built for particular case of Bolivia. The main results of the DSGE model forecast, maintains that GDP growth of Bolivia for 2020, will range between -5.4%, -5.9% and -6.1% according to Scenarios 1, 2 and 3 respectively. Following the analysis, if we consider GDP growth under a scenario that does not consider COVID-19, the DSGE model registers a value close to 0% for 2020. In that regard, it can be inferred that the incidence of COVID-19 will be approximately 5.8%. Regarding inflation, it is expected to register a value of 1.8% in 2020, evidence that COVID-19 will not greatly affect purchasing power of the main products and services of consumer prices.

Finally, the study presents three scenarios that leave an important lesson for the current government to consider. In other words, the form of recovery that the country could experience (*U*, *V* or *W*), will depend to a large extent on the measures that the government has to alleviate the shock of COVID-19. This is why the importance of economic measures to be implemented, since they will play a decisive role in the economic recovery of Bolivia for the coming years.

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