**Impact of COVID-19 Pandemic on Business Start-ups, Money Supply, Lending Interest Rate, International Trade, Savings, Investments, and Economic Growth: VAR Model for Rwanda**

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## Abstract

*COVID-19 continues to cause severe economic negative effects in the whole world and particularly in developing economies in Africa. Rwanda has not been spared of the pandemic. These negative impacts are worsened by the lack of enough vaccines. In Rwanda, the pandemic impact on business start-ups, money supply, interest rates, credits, international trade, savings, investments, and economic growth comes on top of already declining trend with slow recovery noticeable with the release in set virus countermeasures which include the halt of some non-essential economic activities. In this paper, we have analyzed business start-ups, money supply, interest rates, credits, international trade, savings, investments, and economic growth using monthly and quarterly series to show and interpret the analysis of the impact of COVID-19 on the above key macroeconomic variables in Rwanda. We have carried out the analysis by expressing the COVID-19 categorical variable as a dummy variable taking the value of zero (0) before the outbreak of the COVID-19 pandemic, that is before 2020, and the value of one (1) from when it started being felt, that is from January 2020. The results reveal that COVID-19 has contributed significantly on the contraction of the economy even though some internet- based businesses have gained ground.*

***Key words***: *Business start-ups,* *money supply, interest rates, credits, trade, import, export, savings, investments, economic growth, Rwanda*

# Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It was first identified in December 2019 in Wuhan, Hubei, China, and has resulted in an ongoing pandemic (Page J et al., 2021). The first confirmed case has been traced back to 17 November 2019 in Hubei. As of 13 July 2020, more than 12.9 million cases have been reported across 188 countries and territories, resulting in more than 571,000 deaths. More than 7 million people have recovered. The disease has since spread worldwide, leading to an ongoing pandemic (Zimmer C, 2021).

In fact, school have temporarily closured, enterprises have been finically devastated and many jobs have been lost. In addition, the social and economic costs of the pandemic are heavy for the world economies. Furthermore, COVID-19 has threatened with inequalities everywhere, and therefore leading to the undermined progress on global poverty and clean energy, among others. The solutions are tests, treatments, and vaccines.

Therefore, there is a need to measure the impact that this pandemic is causing on different angles of people’s life. This is why in this paper we have attempted to measure the impact that COVID-19 is causing on Rwanda’s economy including the evolution of Rwanda’s international trade by the use of econometric technique. Rwanda is a land-locked country and the Member State of the East African Community (EAC) which is an intergovernmental organization composed of six countries in the African Great Lakes region in eastern Africa: Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda (EAC, 2020).

To sum, the main objective of this study is to assess the impact that COVID-19 has caused on Rwanda’s economy by analyzing the pre-COVID-19 period data and the current data of key macroeconomic variables by the use of vector autoregressive modelling. This paper is structured into five sections. The first section is about the introduction followed by the literature review. The third section goes though the research methodology while empirical results are presented in section four. Finally, the conclusions and recommendations are developed in section five.

# Literature review

The COVID-19 pandemic is far more than a health crisis: it is affecting societies and economies at their core. While the impact of the pandemic will vary from country to country, it will most likely increase poverty and inequalities at a global scale, making achievement of the Sustainable Development Goals (SDGs) even more urgent. The Sustainable Development Goals (SDGs) or Global Goals are a collection of 17 interlinked global goals designed to be a "blueprint to achieve a better and more sustainable future for all" (United Nations, 2017). The SDGs were set in 2015 by the United Nations General Assembly and are intended to be achieved by the year 2030. They are included in a UN Resolution called the 2030 Agenda or what is colloquially known as Agenda 2030 (United Nations, 2015). The 17 SDGs are: no poverty; zero hunger; good health and well-being; quality education; gender equality; clean water and sanitation; affordable and clean energy; decent work and economic growth; industry, innovation, and infrastructure; reducing inequality; sustainable cities and communities; responsible consumption and production; climate action; life below water; life on land; peace, justice, and strong institutions; and partnerships for the goals.

Therefore, without urgent socio-economic responses, global suffering will escalate, jeopardizing lives and livelihoods for years to come. Immediate development responses in this crisis must be undertaken with an eye to the future. Development trajectories in the long-term will be affected by the choices countries make now and the support they receive. Over the next 12 to 18 months, the socio-economic response will be one of three critical components of the UN’s COVID-19 response, alongside the health response, led by WHO, and the Global Humanitarian Response Plan (UNDP, 2020).

Stock markets collapsed in March 2020. Most stock indices around the world have registered their biggest one-day falls on record. For example, the Dow Jones Index registered the worst ever one-day fall (2,977 points on March 16, 2020). And several well-known companies have seen their share prices fall by more than 80% in a few days (Nuno, 2020).

The outbreak came surprisingly and as an emergency case. Unusually negative effects are also expected. But it is also a testing parameter of the extent to which African economies are robust and resilient to such pandemic. Response to this crisis does not require only financial resources or the level of economic resilience but also prevailing leadership to effectively drive the population and their economic behaviors throughout the pandemic (Bizoza et al., 2020).

Therefore, COVID-19 is changing the way people used to live and to interact by pushing them to have a certain length of distance or working from home or even not visiting vulnerable persons, including old age ones. This is the cause of closure for some economic activities or contraction for the others. However, some new economic activities have emerged that have new ICT technology as their basis and online video-conferencing has increased.

According to the Rwanda’s economic outlook by the African Development Group (AfDB) mainly on the Rwanda’s recent macroeconomic and financial developments, real GDP in Rwanda was estimated to contract by 0.4% in 2020 due to the COVID–19 pandemic, after growing 9.4% in 2019. Trade, transportation, and tourism services have been the sectors most affected by the global pandemic. COVID–19 also hurt investment and exports. Rising food prices, stoked by disruptions to regional and domestic supply chains, contributed to a 6.6% increase in inflation in 2020. That was far higher than the 2.4% in 2019 and breached the central bank’s 5% policy target. The National Bank of Rwanda (NBR) has reduced the key policy rate to 4.5% in April 2020 from 5.0% in 2019 to stimulate growth, but private sector credit remained subdued, expanding by 10.2% in 2020, compared with 12.6% in 2019. Low tax yield and elevated health and social protection spending caused the fiscal deficit to grow to 8.3% of GDP in 2020, compared with 7.3% in 2019. The deficit was financed by COVID–19 budget support loans and grants from cooperating partners (AfDB, 2021).

Furthermore, low exports and reduced foreign direct investment resulted in a current account deficit equivalent to 16.5% of GDP in 2020, compared with 9.3% in 2019. Gross reserves shrank. In 2020 they could cover 2.4 months of imports, compared with 4.5 months in 2019. Low external inflows contributed to a 4.6% depreciation of the Rwandan franc against the US dollar. The financial sector remains stable and well capitalized, with a capital adequacy ratio of 23.7% in June 2020, above the 15% regulatory threshold. The latest available data show an unemployment rate of 22.1% in May 2020, compared with 15% a year earlier. Unemployment growth reflects the virtual shutdown of such major industries as transport, food, and hospitality during the lockdown and is like to increase the poverty rate —which was 38.2% in 2017, the most recent data available (AfDB, 2021).

As observed in the above literature, COVID-19 is a new negative factor that need more attention by all countries in order to contain it as early as possible. However, as this pandemic was felt worldwide in early 2020, as of now there are few empirical research that have been conducted in Rwanda to assess its empirical impact on economic health of the country and particularly on business start-ups, money supply, interest rates, credits, international trade, savings, investments, and economic growth. The following sections are going through the impact of COVID-19 on these key macroeconomic variables.

# Research methodology

Using econometric techniques and in order to achieve the objective of this research the unrestricted vector autoregressive model (VAR) results have been analyzed as well as the impulse-responses. The impulse-response function has led to the production of the response of certain variables made to take into account the shock produced by the studied model variables. In fact, the aftermath of impulse or innovation or shock of the independent variable with one standard deviation on the dependent variable has been analyzed. The following variables have been used in the econometric model: *lending interest rate (lr), exports (x), imports (m), business start-ups (b), economic growth (y\_gr), savings growth (s\_gr), investments growth (i\_gr)* and *money supply growth (m2\_gr).* As Daniela has pointed out, these variables are recognized as endogenous because they determine the level of economic activity at national level unlike the exogenous variables used by Keynes in his works, which characterize the behavior of economic entities (Daniela V.A, et all, 2019).

In order to detect the impact of COVID-19 on Rwanda’s economy the dummy variable has been introduced into our regression. According to Draper and Smith (1998), in statistics and econometrics, particularly in regression analysis, a dummy variable is one that takes only the value 0 or 1 to indicate the absence or presence of some categorical effect that may be expected to shift the outcome (Draper, N. R. et al, 1998). Therefore, for the case of Rwanda, the COVID-19 variable takes the value of 0 from quarter one of 2006 up to the last quarter of 2019 when this pandemic has emerged with one case being detected precisely in March even though from January the pandemic was foreseeable based on news that were circulating in media.

Other variables that have been used in this research include total exports of goods and services in billions Rwf, total imports of goods and services in billions Rwf, the number of domestic new business start-ups, economic growth measured by current quarterly GDP growth, total gross savings growth, investment growth measured by the growth of the gross capital formation, and M2 money supply that represents the money supply. In fact, M2 measures money supply by adding up cash, checking deposits, and easily convertible near money. Finally, the Rwanda’s financial sector is represented, in this econometric model, by the lending interest rate variable.

Quarterly data have been used for the vector autoregressive model for the period that runs from 2006 quarter one to 2021 quarter one. The National Institute of Statistics of Rwanda (NISR) and NBR make the source of the used data. The augmented dickey fuller test and Engle-Granger Co-integration technique have been used to test the stationarity of the time series and the relationship between them respectively.

As a matter of fact, the ADF test resembles the Dickey–Fuller test but it is applied to the model . α is a constant, β is the coefficient on a time trend and ρ is the lag order of the autoregressive process. By imposing the constraints and seems like modeling a random walk. Furthermore, using the constraint equals modeling a random walk with a drift. Finally, included lags of order ρ in the ADF formulation have given room to the higher-order autoregressive processes. Therefore, the lag length ρ has been determined.

The unit root test has then been carried out under the null hypothesis against the alternative hypothesis of . . The computed test statistic has been compared to the relevant critical value for the Dickey-Fuller Test. The rule is that, if the test statistic is less than the critical value, then the null hypothesis of is rejected and no unit root is present. The intuition behind the test is that if the series is integrated then the lagged level of the series will provide no relevant information in predicting the change in besides the one obtained in the lagged changes. In that case the null hypothesis is not rejected.

To sum, the following four types of econometric tests have been carried out in order to assess the validity of the model and help have better interpretation of the model both in the short run and the long run: ADF and Phillips-Perron (PP) tests, Johansen cointegration test, the VAR model stability test, and multicollinearity test.

## Multicollinearity test

At this point, the check for the relative importance of the independent variables is done by testing the statistical significance of the regression coefficients. Before those tests are conducted, however, there is a need to assess multicollinearity between independent variables. If multicollinearity is high, the significance tests on regression coefficient can be misleading. But if multicollinearity is low, the same tests can be informative.

This has been evaluated through the multicollinearity test which consisted of extracting the variance inflation factors (VIF) of independent variables from Eviews. The rule of thumb is that if any of the VIF values are greater than five but less than ten, independent variables might be highly correlated while if these values are greater than ten, independent variables are highly correlated. The results are presented in the following two tables. In fact, VIFs start at 1 and have no upper limit. A value of 1 indicates that there is no correlation between this independent variable and any others. VIFs between 1 and 5 suggest that there is a moderate correlation, but it is not severe enough to warrant corrective measures. VIFs greater than 5 represent critical levels of multicollinearity where the coefficients are poorly estimated, and the p-values are questionable (Jim F., 2022).

Table 3.2 illustrates that overall the model consisting of detecting the impact of Rwanda’s macroeconomic variables on the financial sector through the lending rate as the dependent variable is statistically significant as the probability of the F-statistic is less than 5 percent and the R-squared in greater than 60 percent. However, the multicollinearity test must be done to check if we can go ahead and interpret the regression coefficients.

Table 3.1: Least Squares regression results to help detect multicollinearity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | 16.62947 | 0.250149 | 66.47833 | 0.0000 |
| B | 0.000197 | 9.65E-05 | 2.039051 | 0.0470 |
| X | -0.005193 | 0.001640 | -3.165858 | 0.0027 |
| M | 0.002929 | 0.001260 | 2.324501 | 0.0244 |
| Y\_GR | -0.009031 | 0.011118 | -0.812302 | 0.4206 |
| S\_GR | 0.001431 | 0.000766 | 1.868974 | 0.0677 |
| I\_GR | -0.006864 | 0.003123 | -2.197977 | 0.0328 |
| M2\_GR | -0.691092 | 1.256463 | -0.550030 | 0.5848 |
| COVID19 | -1.259414 | 0.188858 | -6.668590 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.621433 | Mean dependent var | | 16.79930 |
| Adjusted R-squared | 0.558339 | S.D. dependent var | | 0.502377 |
| S.E. of regression | 0.333868 | Akaike info criterion | | 0.787794 |
| Sum squared resid | 5.350442 | Schwarz criterion | | 1.110381 |
| Log likelihood | -13.45214 | Hannan-Quinn criter. | | 0.913163 |
| F-statistic | 9.849252 | Durbin-Watson stat | | 1.955789 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

*Note: Dependent Variable: LR, Sample (adjusted): 2007Q1 2021Q1, Included observations: 57 after adjustments.*

Source: Own data processing in Eviews

Table 3.2 displays the variance inflation factors when LR is the dependent variable. The results reveal that import and export variables are each one highly correlated with the other variables in the model as their centered VIFs are greater than five (5) at a high extent, 47 and 33 respectfully; while the business startup variable is somehow correlated with other variables with the VIF of 7.

Table 3.2: Variance inflation factors when LR is the dependent variable

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |
|  | Coefficient | Uncentered | Centered |
| Variable | Variance | VIF | VIF |
|  |  |  |  |
|  |  |  |  |
| C | 0.062574 | 31.99800 | NA |
| B | 9.31E-09 | 26.27553 | 7.136667 |
| X | 2.69E-06 | 108.8313 | 32.79645 |
| M | 1.59E-06 | 215.0466 | 46.94075 |
| Y\_GR | 0.000124 | 13.08054 | 2.924117 |
| S\_GR | 5.86E-07 | 1.794832 | 1.571182 |
| I\_GR | 9.75E-06 | 4.022730 | 2.407814 |
| M2\_GR | 1.578700 | 2.385864 | 1.129458 |
| COVID19 | 0.035667 | 1.599891 | 1.459549 |
|  |  |  |  |
|  |  |  |  |

*Note: Sample: 2006Q1 2021Q1, Included observations: 57 after adjustments.*  
Source: Own data processing in Eviews

The import variable can be dropped as a solution to get rid of multicollinearity and be able to interpret the regression coefficients. Table 3.3 summarizes the centered VIFs when the import variable has been dropped.

Table 3.3: Summarized VIFs when the import variable has been dropped

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Independent/Dependent | LR | B | X | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
| LR |  | 1.8 | 2.0 | 2.3 | 2.3 | 2.3 | 2.3 | 1.3 |
| B | 4.9 |  | 2.4 | 5.7 | 6.2 | 6.2 | 6.4 | 5.0 |
| X | 3.6 | 1.6 |  | 4.0 | 3.8 | 3.8 | 4.1 | 4.0 |
| Y\_GR | 2.8 | 2.6 | 2.8 |  | 2.8 | 2.1 | 2.9 | 2.7 |
| S\_GR | 1.3 | 1.2 | 1.2 | 1.2 |  | 1.0 | 1.3 | 1.3 |
| I\_GR | 2.2 | 2.3 | 2.2 | 1.8 | 1.9 |  | 2.2 | 2.4 |
| M2\_GR | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |  | 1.1 |
| COVID19 | 1.4 | 2.0 | 2.5 | 2.4 | 2.6 | 2.6 | 2.6 |  |

The results show that all VIF values are less than ten (10). For most of authors, a VIF value of above ten (10) indicates a high correlation and is cause for concern. Given these results, we can proceed with the statistical analysis of our independent variables. In fact, the results illustrate well that economic growth, savings, investment and money supply are highly correlated with starting new businesses as their respective VIF values are greater than five (5). This is in conformity economic theories because starting any new business depends on money availability (savings, money supply), investment, and obviously having a new running business contributes to value addition therefore contributing to economic growth.

## Stationarity test

The ADF and Phillips-Perron (PP) tests have been executed and the results were depicted in *Table 3.4*. Three out of seven variables used in the model are not stationary at level, however their first order differences are stationary, which means that they are integrated of order one I(1) according to ADF test; while, PP test results show that two out of seven variables used in the model are non-stationary at level, but their first order differences are stationary, similarly which means that they are integrated of order one I(1).

# Table 3.4: Summary results of the Augmented Dickey - Fuller and Phillips-Perron tests for the initial variables and the first order differences

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Prob.\* at level | Rejection H0  up to 95% | Prob.\* at the first difference | Rejection  H0 up to 95% |
| Augmented Dickey-Fuller test - H0: Variable has a unit root | | | | |
| LR | 0.0908 | No | 0.0000 | Yes |
| X | 0.4831 | No | 0.0000 | Yes |
| B | 0.9925 | No | 0.0000 | Yes |
| Y\_GR | 0.0376 | Yes | - | - |
| S\_GR | 0.0000 | Yes | - | - |
| I\_GR | 0.0019 | Yes | - | - |
| M2\_GR | 0.0000 | Yes | - | - |
| Phillips-Perron test - H0: Variable has a unit root | | | | |
| LR | 0.0235 | Yes | - | - |
| X | 0.7284 | No | 0.0001 | Yes |
| B | 0.9137 | No | 0.0000 | Yes |
| Y\_GR | 0.0291 | Yes | - | - |
| S\_GR | 0.0000 | Yes | - | - |
| I\_GR | 0.0014 | Yes | - | - |
| M2\_GR | 0.0000 | Yes | - | - |

\*MacKinnon (1996) one-sided p-values.

Source: Own data processing in Eviews

## The cointegration test

The identification of the long-run equilibrium relationship between the model variables has been achieved through the Johansen cointegration test using the Trace and Max-Eigenvalue test results. The test was applied after the optimal number of lags has been identified. According to the criteria values presented in *Table 3.4*; they all agree with using one lag. Therefore, one lag will be used because of being suggested by the all criteria.

In order to move to the next stage in the econometric analysis, it must be taken into account that both the integration order I(1) of the time series and the existence of cointegration relationships make it possible to fulfill the conditions of running the Vector Error Correction Model (VECM). Coefficients of the VECM provide the short-run relationship between variables. The VECM’s VAR was designed by choosing a number of 1 lags without imposing any restriction on the coefficients.

# Table 3.4: Appropriate number of lags for the Johansen co-integration test

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Lag | LogL | LR sequential modified LR test statistic (each test at 5% level) | Final prediction error (FPE) | Akaike information criterion (AIC) | Schwarz information criterion (SC) | Hannan-Quinn information criterion (HQ) |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 1 | -1215.668 | NA | 9.89e+09\* | 45.70244\* | 48.01713\* | 46.59984\* |
|  |  |  |  |  |  |  |

\* indicates lag order selected by the criterion

Sample: 2006Q1 2021Q1, Included observations: 55

Source: Own data processed in Eviews

Furthermore, the Trace and Max-Eigenvalue tests for the Johansen cointegration test are presented in *Table 3.5.* The existence of a cointegration relationship between the model variables has been demonstrated as the p-value is less than the 0.05 significance level for the existence of at least one cointegrating equation. Therefore, the null hypothesis is rejected. In this regard, the existence of a short-run relationship between the model variables has been confirmed.

# Table 3.5: Johansen cointegration test

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Date: 05/19/22 Time: 11:07 | | |  |  |
| Sample (adjusted): 2007Q3 2021Q1 | | |  |  |
| Included observations: 55 after adjustments | | | |  |
| Trend assumption: Linear deterministic trend | | | |  |
| Series: LR X B Y\_GR S\_GR I\_GR M2\_GR COVID19 | | | |  |
| Lags interval (in first differences): 1 to 1 | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Unrestricted Cointegration Rank Test (Trace) | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Hypothesized |  | Trace | 0.05 |  |
| No. of CE(s) | Eigenvalue | Statistic | Critical Value | Prob.\*\* |
|  |  |  |  |  |
|  |  |  |  |  |
| None \* | 0.658044 | 202.6818 | 159.5297 | 0.0000 |
| At most 1 \* | 0.593966 | 143.6628 | 125.6154 | 0.0025 |
| At most 2 | 0.446002 | 94.09025 | 95.75366 | 0.0647 |
| At most 3 | 0.332430 | 61.60759 | 69.81889 | 0.1893 |
| At most 4 | 0.286201 | 39.38147 | 47.85613 | 0.2454 |
| At most 5 | 0.262836 | 20.83799 | 29.79707 | 0.3678 |
| At most 6 | 0.060128 | 4.066013 | 15.49471 | 0.8981 |
| At most 7 | 0.011845 | 0.655356 | 3.841466 | 0.4182 |
|  |  |  |  |  |
|  |  |  |  |  |
| Trace test indicates 2 cointegrating eqn(s) at the 0.05 level | | | | |
| \* denotes rejection of the hypothesis at the 0.05 level | | | | |
| \*\*MacKinnon-Haug-Michelis (1999) p-values  Source: Own data processed in Eviews | | | |  |
|  |  |  |  |  |
| Unrestricted Cointegration Rank Test (Maximum Eigenvalue) | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| Hypothesized |  | Max-Eigen | 0.05 |  |
| No. of CE(s) | Eigenvalue | Statistic | Critical Value | Prob.\*\* |
|  |  |  |  |  |
|  |  |  |  |  |
| None \* | 0.658044 | 59.01906 | 52.36261 | 0.0091 |
| At most 1 \* | 0.593966 | 49.57253 | 46.23142 | 0.0212 |
| At most 2 | 0.446002 | 32.48266 | 40.07757 | 0.2773 |
| At most 3 | 0.332430 | 22.22612 | 33.87687 | 0.5901 |
| At most 4 | 0.286201 | 18.54349 | 27.58434 | 0.4506 |
| At most 5 | 0.262836 | 16.77198 | 21.13162 | 0.1830 |
| At most 6 | 0.060128 | 3.410657 | 14.26460 | 0.9157 |
| At most 7 | 0.011845 | 0.655356 | 3.841466 | 0.4182 |
|  |  |  |  |  |
|  |  |  |  |  |
| Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level | | | | |
| \* denotes rejection of the hypothesis at the 0.05 level | | | | |
| \*\*MacKinnon-Haug-Michelis (1999) p-values | | | |  |

Source: Own data processed in Eviews

## VAR model stability test

In order to supplement the determination of the optimal number of lags, the stability of the VAR model has also been considered. *Figure 1* shows the inverse roots of the autoregressive characteristic polynomial. The figure’s results are also confirmed by what is displayed in *Table 3.6*. The condition that must be satisfied in order for a model to be dynamically stable is that the roots of the autoregressive model equation have to be found within the circle. The characteristic equation has three real roots and two complex pairs of conjugated roots, the inverse roots are distributed only within the unit circle. The AR process is stationary, since all the roots of the equation are within the unit circle.

# Figure 1: Inverse Roots of AR Characteristic Polynomial



# Source: Own data processing in Eviews

*Table 3.6* demonstrates that there is no root that lies outside the unit circle. Therefore, the VAR satisfies the stability condition as depicted in *Figure 1.* In facts all roots of the characteristic polynomial are less than one. As highlighted by Kevin Kotzé in 2019, this implies that forecasting with a stable VAR model will converge towards the unconditional mean of the variables in the model, and the MSE matrix of the forecast errors will converge towards the unconditional variance of the variables in the model. Density forecasts and forecast intervals could then be constructed based on the normality assumptions of the errors. Then lastly, we could use Granger causality test, which involve testing whether or not lagged values of a given variable in the VAR system help predict one of the other endogenous variables in the system. Such a test can simply be conducted using F-test procedure, where the null hypothesis is no Granger causality (Kotzé K., 2019). Therefore, this model can be used to forecast future behavior of the endogenous variables.

# Table 3.6: Roots of Characteristic Polynomial

|  |  |
| --- | --- |
| Roots of Characteristic Polynomial | |
| Endogenous variables: LR X B Y\_GR S\_GR | |
| I\_GR M2\_GR COVID19 | |
| Exogenous variables: | |
| Lag specification: 1 1 | |
| Date: 05/19/22 Time: 11:10 | |
|  |  |
|  |  |
| Root | Modulus |
|  |  |
|  |  |
| 0.997935 | 0.997935 |
| 0.958903 | 0.958903 |
| 0.870426 - 0.133508i | 0.880605 |
| 0.870426 + 0.133508i | 0.880605 |
| 0.483681 - 0.066975i | 0.488296 |
| 0.483681 + 0.066975i | 0.488296 |
| 0.276965 | 0.276965 |
| 0.072116 | 0.072116 |
|  |  |
|  |  |
| No root lies outside the unit circle. | |
| VAR satisfies the stability condition. | |

Source: Own data processing in Eviews

According to *Table 3.7*, no heteroskedasticity or autocorrelation of residuals was found in the model under study. Autocorrelation LM Test has allowed to accept the null hypothesis of no serial correlation at lag *3* at a significance level of less than 0.05; however, at lag 1 this test has rejected the null hypothesis. The White Heteroskedasticity Test (No Cross Terms) uses elements similar to those of the Autocorrelation LM Test in determining the absence of heteroskedasticity, it has led to the acceptance of the null hypothesis that states that there is no heteroskedasticity at a significance level of less than 0.05. Normality Test - Cholesky (Lutkepohl) was not applied to check the normal distribution of the residuals. According to the central limit theorem, (a) if the sample data are approximately normal then the sampling distribution too will be normal; (b) in large samples (> 30 or 40), the sampling distribution tends to be normal, regardless of the shape of the data; and (c) means of random samples from any distribution will themselves have normal distribution” (Ghasemi et al. 2005). Taking into account the hypotheses of the theorem, the specific residuals of the analyzed model fulfill the normal distribution condition.

Table 3.7: Diagnostic tests applied to VAR residuals

|  |  |  |
| --- | --- | --- |
| Lag order | Prob.: Autocorrelation LM Test | Prob.: White Heteroskedasticity Test (No Cross Terms) |
| Null hypothesis: No serial correlation at lag h | Null hypothesis: No heteroskedasticity |
| 1 | 0.0275 |  |
| 2 | 0.5606 |  |
| 3 | 0.5282 | 0.4858 |

Source: Own data processed in Eviews

The diagnostic tests applied to VAR residuals in Table 3.7 show that the regressed model has no serial correlation from two lags and more. If the serial correlation was detected, this would cause the estimated variances of the regression coefficients to be biased, leading to unreliable hypothesis testing. The t-statistics would actually appear to be more significant than they really are. Therefore, the estimated model can be used predict probable future values if need be.

Furthermore, Table 3.7 displays the results of the White Heteroskedasticity Test with no cross terms that is a test of pure heteroscedasticity. In fact, in statistics, the White test results prove whether the variance of the errors in a regression model is constant: that is for homoscedasticity, which is the case for the studied model regression. In fact, homoscedastic or homoscedastic is about a condition in which the variance of the residual, or error term, in a regression model does not change over time, meaning that the error term remains almost constant as the value of the predictor variable changes.

# Empirical results

In this section, the empirical results are discussed, and conclusions drawn. In fact, the macroeconomic interdependence between variables are analyzed by evaluating the impact that COVID-19 is having on the Rwanda’s economy from its detection in March 2020. The future behavior of the impact of COVID-19 is also studied in depth.

# Empirical estimation of the cointegration relation

As specified in the methodology, the ECM empirical estimation is done in two steps. The first step consists of carrying out the OLS estimation of the long-term relationship while the other is concerned with estimating the ECM using OLS. The long run relationship estimation results are presented in *Table 3.8*.

Table 3.8: ARDL Long Run Form

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dependent Variable: D(LR) | | |  |  |
| Selected Model: ARDL(1, 0, 1, 0, 1, 1, 0, 1) | | | |  |
| Case 2: Restricted Constant and No Trend | | | |  |
| Date: 05/19/22 Time: 13:57 | | |  |  |
| Sample: 2006Q1 2021Q1 | | |  |  |
| Included observations: 56 | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Conditional Error Correction Regression | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | 11.48537 | 2.326572 | 4.936608 | 0.0000 |
| LR(-1)\* | -0.668308 | 0.134913 | -4.953615 | 0.0000 |
| B\*\* | 0.000242 | 7.82E-05 | 3.100903 | 0.0034 |
| X(-1) | -0.001798 | 0.000504 | -3.565371 | 0.0009 |
| S\_GR\*\* | 0.000883 | 0.000602 | 1.466141 | 0.1499 |
| I\_GR(-1) | -0.006507 | 0.003238 | -2.009883 | 0.0507 |
| M2\_GR(-1) | -2.982916 | 1.447953 | -2.060092 | 0.0455 |
| Y\_GR\*\* | -0.005106 | 0.010972 | -0.465418 | 0.6440 |
| COVID19(-1) | -0.845150 | 0.280512 | -3.012881 | 0.0043 |
| D(X) | 0.000692 | 0.000953 | 0.726828 | 0.4713 |
| D(I\_GR) | -0.002459 | 0.002692 | -0.913251 | 0.3662 |
| D(M2\_GR) | -0.684676 | 1.149498 | -0.595631 | 0.5545 |
| D(COVID19) | 0.505528 | 0.348876 | 1.449021 | 0.1546 |
|  |  |  |  |  |
|  |  |  |  |  |
| \* p-value incompatible with t-Bounds distribution. | | | | |
| \*\* Variable interpreted as Z = Z(-1) + D(Z). | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Levels Equation | | | | |
| Case 2: Restricted Constant and No Trend | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| B | 0.000363 | 0.000105 | 3.459935 | 0.0012 |
| X | -0.002690 | 0.000761 | -3.537352 | 0.0010 |
| S\_GR | 0.001322 | 0.000902 | 1.465579 | 0.1500 |
| I\_GR | -0.009737 | 0.004930 | -1.975176 | 0.0547 |
| M2\_GR | -4.463389 | 2.203001 | -2.026050 | 0.0490 |
| Y\_GR | -0.007641 | 0.015918 | -0.480004 | 0.6337 |
| COVID19 | -1.264612 | 0.287011 | -4.406137 | 0.0001 |
| C | 17.18576 | 0.283009 | 60.72520 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| EC = LR - (0.0004\*B -0.0027\*X + 0.0013\*S\_GR -0.0097\*I\_GR -4.4634 | | | | |
| \*M2\_GR -0.0076\*Y\_GR -1.2646\*COVID19 + 17.1858 )  Source: Study data processed in Eviews  The results for the autoregressive distributed lag (ARDL) of the long run form reveal that the long run relationship is noticeable as confirmed by the F-bound test for the long run relationship in Table 3.9. The null hypothesis of no levels relationship has to be rejected at 5 percent level of significance because the calculated probability is less than 5 percent.  Table 3.9: F-Bounds Test for the long run relationship | | | | |
|  |  |  |  |  |
|  |  |  |  |  |
| F-Bounds Test | | Null Hypothesis: No levels relationship | | |
|  |  |  |  |  |
| Test Statistic | Value | Signif. | I(0) | I(1) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  | Asymptotic: n=1000 |  |
| F-statistic | 3.492574 | 10% | 1.92 | 2.89 |
| k | 7 | 5% | 2.17 | 3.21 |
|  |  | 2.5% | 2.43 | 3.51 |
|  |  | 1% | 2.73 | 3.9 |
|  |  |  |  |  |
| Actual Sample Size | 56 |  | Finite Sample: n=60 |  |
|  |  | 10% | 2.044 | 3.104 |
|  |  | 5% | 2.373 | 3.54 |
|  |  | 1% | 3.129 | 4.507 |
|  |  |  |  |  |
|  |  |  | Finite Sample: n=55 |  |
|  |  | 10% | 2.069 | 3.148 |
|  |  | 5% | 2.414 | 3.608 |
|  |  | 1% | 3.194 | 4.562 |
|  |  |  |  |  |
|  |  |  |  |  |

Source: Study data processed in Eviews

# Empirical estimation of the error correction model

Table 3.10: ARDL Error Correction Regression

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dependent Variable: D(LR) | | |  |  |
| Selected Model: ARDL(1, 0, 1, 0, 1, 1, 0, 1) | | | |  |
| Case 2: Restricted Constant and No Trend | | | |  |
| Date: 05/19/22 Time: 14:01 | | |  |  |
| Sample: 2006Q1 2021Q1 | | |  |  |
| Included observations: 56 | | |  |  |
|  |  |  |  |  |
| ECM Regression | | | | |
| Case 2: Restricted Constant and No Trend | | | | |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
| D(X) | 0.000692 | 0.000772 | 0.896601 | 0.3749 |
| D(I\_GR) | -0.002459 | 0.001854 | -1.326243 | 0.1918 |
| D(M2\_GR) | -0.684676 | 0.857235 | -0.798703 | 0.4289 |
| D(COVID19) | 0.505528 | 0.273287 | 1.849806 | 0.0712 |
| CointEq(-1)\* | -0.668308 | 0.109454 | -6.105833 | 0.0000 |
|  |  |  |  |  |
| R-squared | 0.579180 | Mean dependent var | | 0.007976 |
| Adjusted R-squared | 0.546174 | S.D. dependent var | | 0.380704 |
| S.E. of regression | 0.256467 | Akaike info criterion | | 0.201415 |
| Sum squared resid | 3.354551 | Schwarz criterion | | 0.382250 |
| Log likelihood | -0.639614 | Hannan-Quinn criter. | | 0.271524 |
| Durbin-Watson stat | 1.961204 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| \* p-value incompatible with t-Bounds distribution. | | | | |
| The results of the ARDL error correction regression of the short run relationship show that the short run relationship is statistically significant as confirmed by the F-bound test for the long run relationship in Table 3.11. The null hypothesis of no levels relationship has to be rejected at 5 percent level of significance because the calculated probability is less than 5 percent. We, therefore, accept the alternative hypothesis that there is a short run relationship. In addition, the results have produced expected sign of the short run relationship. The coefficient of the lagged cointegrating equation is negative and significant at 5 percent level as presented in Table 3.10. As the used data series are quarterly the estimated short run for the lending interest rate is equal to 60 days that is two months as the speed of adjustment is 67 percent while the short run for money supply is 61 days as the corresponding speed of adjustment is 68 percent.  Table 3.11: F-Bounds Test for the short run relationship | | | | |
| F-Bounds Test | | Null Hypothesis: No levels relationship | | |
|  |  |  |  |  |
|  |  |  |  |  |
| Test Statistic | Value | Signif. | I(0) | I(1) |
|  |  |  |  |  |
|  |  |  |  |  |
| F-statistic | 3.492574 | 10% | 1.92 | 2.89 |
| k | 7 | 5% | 2.17 | 3.21 |
|  |  | 2.5% | 2.43 | 3.51 |
|  |  | 1% | 2.73 | 3.9 |
|  |  |  |  |  |
|  |  |  |  |  |

Source: Study data processed in Eviews

# Variance decomposition and impulse response

The variance decomposition presented in the Annex 1 of this paper leads to the following observations:

* In the short run, the lending interest rate is independent; it explains itself; whereas in the long run exports, money supply, and economic growth play a role in its behavior;
* In the short run, exports seem independent whereas in the long run they are well explained by economic growth and the lending interest rate;
* The variance decomposition of COVID-19 variable shows that in the short run COVID-19 was linked with international trade, exports (17 percent) and starting a new business (7 percent). In the long run exportation dominates with a share of 23 per cent followed by the lending interest rate with 10 percent and investments with 7 percent.

The impulse response function results are presented in Annex 2 of this paper. This is another way of looking at the variations in the variable vis-à-vis others over time. This helps in assessing the short run and long run behavior of each variable in reaction to shocks in other model variables.

# Analysis of Rwanda’s monthly external trade data and the impact of COVID19 (period 2018 to 2021)

This is a summary analysis of Rwanda’s monthly external trade statistics for the period 2018 to 2021. We have considered the changes over time on the basis of monthly data series. During the period 2018 to 2021, consider month-to-month change, it is observed that the imports trend was moderate from 2018 to 2019. Towards the start of 2020, the outbreak of COVID19 severely hit Rwanda leading to total lock down. The obstacle is observed with a gradual decrease that caused a fall in total imports until June 2020.

From June 2020, the enforcement of social distancing, lockdowns, and other measures in response to the COVID-19 pandemic has led consumers to ramp up online shopping, social media use, internet telephony and teleconferencing, and streaming of videos and films. As observed, the import trade normalized with a sharp increase towards September 2020.

Rwanda’s monthly imports have accused a consistent increase. Comparing January 2021 with the same month of 2020, the total value of imports fell from USD 352.5 million to USD 228.5 million. The figure below presents Rwanda’s monthly import trade data for the values in million USD and net weight in tonnes.

Figure 2: Monthly import data trends: 2018-2021

Source: NISR, 2022

Rwanda’s general export is even from 2018 till August 2019. After, it is observed that value of exports has expanded upward against the quantity of goods until June 2020. In general, it is observed that COVID19 resulted to an increase in the export value of goods as compared to the quantity exported. A sharp increase happened in June 2020 and August 2020. This was due to two house lockdowns of 21 March 3May 2020 and 17 July 26 July 2020.

The export trade normalized from February 2020 with a moderate increase of export value and quantity. There was a slight decrease of export in August 2021 due to the second wave of COVID 19 leading to a lockdown from 17 July to 3 August 2021. The figure below details the exports trends for the values in million USD and net weight in tonnes.

Figure 3: Monthly exports data trends: 2018-2020

Source: NISR, 2022

# Conclusions and recommendations

According to the steps followed, it can be stated that the stability of the VAR model was demonstrated. The Johansen cointegration test, as well as the integration order I (1) of some variables, required the autoregressive vector to run. Also, by analyzing the inverse roots of the autoregressive characteristic polynomial, it was found that they were distributed in the center of the unit circle, demonstrating the validity of the VAR model. The general picture of the correct estimation of the autoregressive vector was outlined by the analysis of model residuals related to the absence of autocorrelation, heteroskedasticity, as well as their normal distribution.

The variance decomposition and impulse response function has been estimated as well as the identification of the changes occurring on the dependent variable in the case of a shock produced by the independent variable. In this way, it has been possible to specify how the variables are interconnected and affected by COVID-19 counter measures.

Furthermore, Rwanda experienced three total COVID19 lockdowns between 21st March - 3rd May 2020, 17th July – 26th July 2020 and 17th July – 3rd August 2021. The trade for goods and services has been adversely impacted by the same factors such as inflation, exchange rates, the purchasing power of the consumers and the competition brought about by the current international economic globalization. All of these factors have caused disruption in supply and demand overall. Such disruptions have resulted in delivery delays or outright cancellation of orders.

Based on the results presented in this paper, the following key recommendations are proposed:

* As effective vaccines have now been produced and as long as Rwandans are willing to be vaccinated, it is optimistic that there will be a solid recovery of all economic sectors very soon, followed by above-average growth for about three years before full-employment is restored. Therefore, some COVID-19 restrictions, like house lockdown, restricting the number of persons to gather at a certain place or venue, testing costs, should be removed progressively to help in restoring full-employment in the short-run because so many workers have lost jobs and will not get the same jobs back again so that they can look for other alternative jobs. Such initiative will also improve the pace of economic growth in the long-run.
* Investing into internet based activities that generate revenues should be encouraged as they are not prone to social gathering like e-commerce, e-marketing, telemedicine, merchanting (buying goods and services from one country and selling them in another country without moving from you host economy), etc.
* The studied model should be used to predict future behavior of the economy as a whole through the lending interest rate, domestic business startups, investments, savings, international trade (exports) and economic growth. This is because the studied vector autoregressive model has proved to satisfy the stability condition because all roots of the characteristic polynomial are less than one which implies that forecasting with a stable VAR model will converge towards the unconditional mean of the variables in the model, and the MSE matrix of the forecast errors will converge towards the unconditional variance of the variables in the model. Density forecasts and forecast intervals could then be constructed based on the normality assumptions of the errors. In fact, if A VAR is unstable; the impact of the shocks will never die-out (rather will explode). Unstable VAR implies that the variables entered in the system are non-stationary.

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**Annex 1: Variance decomposition outcome**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variance Decomposition of LR: | | | | |  |  |  |  |  |
| Period | S.E. | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 0.40 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.56 | 98.90 | 0.06 | 0.00 | 0.03 | 0.01 | 0.00 | 0.99 | 0.00 |
| 3 | 0.68 | 98.14 | 0.19 | 0.01 | 0.02 | 0.01 | 0.00 | 1.62 | 0.01 |
| 4 | 0.78 | 97.63 | 0.39 | 0.03 | 0.04 | 0.02 | 0.00 | 1.87 | 0.01 |
| 5 | 0.87 | 97.16 | 0.67 | 0.07 | 0.09 | 0.04 | 0.00 | 1.95 | 0.02 |
| 6 | 0.95 | 96.66 | 1.02 | 0.12 | 0.16 | 0.06 | 0.00 | 1.95 | 0.03 |
| 7 | 1.03 | 96.12 | 1.43 | 0.17 | 0.24 | 0.10 | 0.00 | 1.91 | 0.03 |
| 8 | 1.10 | 95.52 | 1.88 | 0.22 | 0.34 | 0.14 | 0.01 | 1.85 | 0.04 |
| 9 | 1.16 | 94.89 | 2.37 | 0.27 | 0.45 | 0.19 | 0.01 | 1.79 | 0.05 |
| 10 | 1.22 | 94.22 | 2.87 | 0.32 | 0.57 | 0.23 | 0.01 | 1.72 | 0.06 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Variance Decomposition of X: | | | |  |  |  |  |  |  |
| Period | S.E. | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 54.82 | 19.65 | 80.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 74.25 | 17.68 | 73.70 | 0.05 | 3.69 | 3.24 | 1.57 | 0.00 | 0.07 |
| 3 | 87.80 | 16.19 | 70.20 | 0.17 | 8.13 | 3.02 | 1.94 | 0.26 | 0.08 |
| 4 | 98.62 | 15.19 | 67.65 | 0.30 | 11.48 | 2.68 | 1.90 | 0.72 | 0.08 |
| 5 | 107.54 | 14.58 | 65.76 | 0.39 | 13.77 | 2.48 | 1.77 | 1.18 | 0.07 |
| 6 | 114.98 | 14.24 | 64.34 | 0.44 | 15.33 | 2.37 | 1.65 | 1.57 | 0.07 |
| 7 | 121.23 | 14.08 | 63.23 | 0.47 | 16.43 | 2.31 | 1.54 | 1.88 | 0.06 |
| 8 | 126.52 | 14.04 | 62.32 | 0.49 | 17.23 | 2.28 | 1.45 | 2.13 | 0.06 |
| 9 | 131.03 | 14.09 | 61.57 | 0.49 | 17.83 | 2.26 | 1.38 | 2.33 | 0.05 |
| 10 | 134.91 | 14.19 | 60.92 | 0.49 | 18.31 | 2.24 | 1.33 | 2.48 | 0.05 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Variance Decomposition of B: | | | |  |  |  |  |  |  |
| Period | S.E. | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 356.68 | 23.14 | 35.06 | 41.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 473.72 | 20.79 | 26.90 | 40.75 | 9.04 | 0.15 | 1.95 | 0.14 | 0.29 |
| 3 | 566.22 | 18.45 | 21.65 | 36.74 | 18.79 | 0.67 | 2.33 | 0.16 | 1.20 |
| 4 | 644.39 | 17.08 | 18.52 | 32.96 | 25.09 | 1.33 | 2.26 | 0.35 | 2.41 |
| 5 | 710.12 | 16.56 | 16.77 | 29.97 | 28.67 | 1.68 | 2.14 | 0.52 | 3.69 |
| 6 | 766.41 | 16.55 | 15.88 | 27.54 | 30.61 | 1.81 | 2.06 | 0.63 | 4.92 |
| 7 | 815.96 | 16.85 | 15.57 | 25.47 | 31.58 | 1.82 | 2.04 | 0.67 | 5.99 |
| 8 | 860.71 | 17.30 | 15.68 | 23.63 | 31.99 | 1.78 | 2.07 | 0.69 | 6.87 |
| 9 | 901.97 | 17.81 | 16.12 | 21.97 | 32.06 | 1.70 | 2.13 | 0.68 | 7.53 |
| 10 | 940.60 | 18.34 | 16.82 | 20.45 | 31.92 | 1.61 | 2.21 | 0.67 | 7.98 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Variance Decomposition of Y\_GR: | | | | |  |  |  |  |  |
| Period | S.E. | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 4.11 | 4.33 | 4.63 | 0.33 | 90.71 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 5.16 | 3.95 | 3.26 | 0.59 | 81.85 | 1.71 | 2.64 | 5.30 | 0.70 |
| 3 | 5.56 | 3.59 | 2.81 | 1.38 | 77.93 | 1.55 | 3.88 | 7.15 | 1.71 |
| 4 | 5.77 | 3.35 | 2.61 | 2.47 | 75.59 | 1.44 | 4.16 | 7.42 | 2.96 |
| 5 | 5.92 | 3.19 | 2.51 | 3.54 | 73.78 | 1.37 | 4.05 | 7.21 | 4.36 |
| 6 | 6.04 | 3.07 | 2.48 | 4.38 | 72.16 | 1.33 | 3.88 | 6.93 | 5.75 |
| 7 | 6.16 | 3.00 | 2.59 | 4.94 | 70.67 | 1.34 | 3.78 | 6.67 | 7.02 |
| 8 | 6.27 | 2.94 | 2.88 | 5.23 | 69.29 | 1.37 | 3.76 | 6.45 | 8.08 |
| 9 | 6.38 | 2.91 | 3.43 | 5.33 | 68.00 | 1.38 | 3.79 | 6.25 | 8.91 |
| 10 | 6.49 | 2.89 | 4.25 | 5.28 | 66.78 | 1.38 | 3.85 | 6.06 | 9.51 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Variance Decomposition of S\_GR: | | | | |  |  |  |  |  |
| Period | S.E. | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 73.98 | 0.63 | 0.03 | 0.18 | 0.28 | 98.88 | 0.00 | 0.00 | 0.00 |
| 2 | 76.00 | 0.78 | 0.15 | 0.28 | 0.34 | 96.98 | 0.68 | 0.44 | 0.35 |
| 3 | 76.61 | 0.93 | 0.26 | 0.31 | 0.42 | 96.18 | 0.80 | 0.48 | 0.62 |
| 4 | 76.90 | 1.07 | 0.38 | 0.33 | 0.45 | 95.69 | 0.80 | 0.47 | 0.81 |
| 5 | 77.08 | 1.18 | 0.53 | 0.34 | 0.45 | 95.29 | 0.81 | 0.48 | 0.92 |
| 6 | 77.25 | 1.27 | 0.71 | 0.36 | 0.45 | 94.90 | 0.83 | 0.49 | 0.98 |
| 7 | 77.41 | 1.35 | 0.93 | 0.40 | 0.45 | 94.52 | 0.86 | 0.49 | 1.00 |
| 8 | 77.57 | 1.41 | 1.18 | 0.44 | 0.46 | 94.13 | 0.88 | 0.49 | 1.01 |
| 9 | 77.73 | 1.47 | 1.44 | 0.48 | 0.48 | 93.75 | 0.90 | 0.49 | 1.01 |
| 10 | 77.89 | 1.51 | 1.70 | 0.52 | 0.50 | 93.37 | 0.91 | 0.49 | 1.00 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Variance Decomposition of I\_GR: | | | | |  |  |  |  |  |
| Period | S.E. | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 16.72 | 0.14 | 0.22 | 0.74 | 17.86 | 30.34 | 50.71 | 0.00 | 0.00 |
| 2 | 19.58 | 0.17 | 0.16 | 0.54 | 21.52 | 27.09 | 47.15 | 3.35 | 0.02 |
| 3 | 21.03 | 0.15 | 0.15 | 0.71 | 21.93 | 25.71 | 45.13 | 5.87 | 0.35 |
| 4 | 21.70 | 0.15 | 0.15 | 1.30 | 21.94 | 24.92 | 43.89 | 6.64 | 1.00 |
| 5 | 22.08 | 0.18 | 0.17 | 2.10 | 21.94 | 24.25 | 42.80 | 6.69 | 1.87 |
| 6 | 22.37 | 0.23 | 0.17 | 2.86 | 21.94 | 23.63 | 41.76 | 6.55 | 2.86 |
| 7 | 22.63 | 0.30 | 0.17 | 3.47 | 21.93 | 23.10 | 40.79 | 6.40 | 3.84 |
| 8 | 22.88 | 0.39 | 0.19 | 3.87 | 21.93 | 22.65 | 39.95 | 6.27 | 4.75 |
| 9 | 23.12 | 0.49 | 0.29 | 4.11 | 21.95 | 22.26 | 39.21 | 6.16 | 5.52 |
| 10 | 23.34 | 0.61 | 0.51 | 4.21 | 22.00 | 21.90 | 38.57 | 6.07 | 6.14 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Variance Decomposition of M2\_GR: | | | | |  |  |  |  |  |
| Period | S.E. | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 0.04 | 1.61 | 3.73 | 0.00 | 0.32 | 0.00 | 2.06 | 92.28 | 0.00 |
| 2 | 0.04 | 1.48 | 5.23 | 0.47 | 2.34 | 0.97 | 3.21 | 86.08 | 0.21 |
| 3 | 0.04 | 1.42 | 5.63 | 0.73 | 2.81 | 1.15 | 4.44 | 83.24 | 0.58 |
| 4 | 0.04 | 1.43 | 5.76 | 0.79 | 2.76 | 1.33 | 5.01 | 82.01 | 0.91 |
| 5 | 0.04 | 1.50 | 5.82 | 0.79 | 2.80 | 1.46 | 5.16 | 81.31 | 1.17 |
| 6 | 0.04 | 1.59 | 5.85 | 0.79 | 2.89 | 1.51 | 5.16 | 80.86 | 1.34 |
| 7 | 0.04 | 1.69 | 5.86 | 0.79 | 2.98 | 1.51 | 5.14 | 80.57 | 1.46 |
| 8 | 0.04 | 1.78 | 5.86 | 0.79 | 3.04 | 1.51 | 5.13 | 80.37 | 1.53 |
| 9 | 0.04 | 1.86 | 5.85 | 0.79 | 3.08 | 1.51 | 5.13 | 80.22 | 1.57 |
| 10 | 0.04 | 1.94 | 5.84 | 0.80 | 3.10 | 1.51 | 5.14 | 80.10 | 1.58 |
|  |  |  |  |  |  |  |  |  |  |
| Variance Decomposition of COVID19: | | | | | |  |  |  |  |
| Period | S.E. | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 0.13 | 2.37 | 16.83 | 7.04 | 0.38 | 2.01 | 1.91 | 0.00 | 69.45 |
| 2 | 0.17 | 4.02 | 12.71 | 7.39 | 0.28 | 1.83 | 1.23 | 1.54 | 71.01 |
| 3 | 0.19 | 5.42 | 9.73 | 6.91 | 0.23 | 2.01 | 2.00 | 3.32 | 70.38 |
| 4 | 0.21 | 6.59 | 8.26 | 6.14 | 0.20 | 2.25 | 3.32 | 4.60 | 68.64 |
| 5 | 0.23 | 7.59 | 8.37 | 5.42 | 0.28 | 2.35 | 4.66 | 5.27 | 66.07 |
| 6 | 0.24 | 8.39 | 9.94 | 4.89 | 0.51 | 2.31 | 5.73 | 5.45 | 62.78 |
| 7 | 0.25 | 8.98 | 12.64 | 4.61 | 0.89 | 2.15 | 6.46 | 5.30 | 58.97 |
| 8 | 0.26 | 9.36 | 16.01 | 4.56 | 1.37 | 1.97 | 6.85 | 4.97 | 54.91 |
| 9 | 0.27 | 9.55 | 19.61 | 4.65 | 1.91 | 1.83 | 6.96 | 4.60 | 50.88 |
| 10 | 0.28 | 9.61 | 23.09 | 4.83 | 2.47 | 1.75 | 6.88 | 4.25 | 47.13 |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Cholesky Ordering: LR X B Y\_GR S\_GR I\_GR M2\_GR COVID19 | | | | | | | | |  |
|  |  |  |  |  |  |  |  |  |  |

**Annex 2: Results of the impulse response**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Response of LR: | |  |  |  |  |  |  |  |
| Period | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.38 | -0.01 | 0.00 | -0.01 | 0.01 | 0.00 | -0.06 | 0.00 |
| 3 | 0.38 | -0.03 | 0.01 | 0.00 | 0.00 | 0.00 | -0.07 | 0.01 |
| 4 | 0.38 | -0.04 | 0.01 | 0.01 | -0.01 | 0.00 | -0.06 | 0.01 |
| 5 | 0.38 | -0.05 | 0.02 | 0.02 | -0.01 | 0.00 | -0.06 | 0.01 |
| 6 | 0.37 | -0.06 | 0.02 | 0.03 | -0.02 | 0.00 | -0.05 | 0.01 |
| 7 | 0.37 | -0.08 | 0.03 | 0.03 | -0.02 | 0.00 | -0.05 | 0.01 |
| 8 | 0.37 | -0.09 | 0.03 | 0.04 | -0.03 | 0.00 | -0.05 | 0.01 |
| 9 | 0.36 | -0.10 | 0.03 | 0.04 | -0.03 | 0.00 | -0.04 | 0.01 |
| 10 | 0.36 | -0.11 | 0.03 | 0.05 | -0.03 | 0.00 | -0.04 | 0.01 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Response of X: | |  |  |  |  |  |  |  |
| Period | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | 24.30 | 49.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 19.59 | 40.59 | -1.64 | -14.27 | 13.37 | 9.31 | 0.17 | -1.93 |
| 3 | 16.55 | 36.72 | -3.28 | -20.57 | 7.36 | 7.93 | -4.52 | -1.50 |
| 4 | 15.14 | 34.18 | -3.94 | -22.14 | 5.31 | 5.97 | -7.05 | -1.20 |
| 5 | 14.44 | 32.03 | -3.98 | -21.81 | 5.05 | 4.49 | -8.14 | -0.97 |
| 6 | 14.00 | 30.00 | -3.72 | -20.84 | 5.16 | 3.50 | -8.43 | -0.73 |
| 7 | 13.66 | 28.04 | -3.33 | -19.69 | 5.17 | 2.88 | -8.33 | -0.47 |
| 8 | 13.36 | 26.16 | -2.90 | -18.54 | 5.02 | 2.50 | -8.02 | -0.19 |
| 9 | 13.09 | 24.39 | -2.49 | -17.45 | 4.75 | 2.28 | -7.62 | 0.09 |
| 10 | 12.83 | 22.74 | -2.11 | -16.42 | 4.42 | 2.14 | -7.19 | 0.35 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Response of B: | |  |  |  |  |  |  |  |
| Period | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | 171.58 | 211.21 | 230.59 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 131.23 | 125.54 | 195.66 | -142.41 | 18.21 | 66.07 | 17.42 | 25.39 |
| 3 | 111.74 | 95.10 | 162.30 | -199.93 | -42.69 | 55.80 | -14.30 | 56.65 |
| 4 | 108.61 | 86.52 | 138.08 | -209.60 | -58.07 | 43.47 | -30.56 | 78.53 |
| 5 | 112.03 | 87.59 | 119.36 | -201.00 | -54.44 | 37.38 | -34.49 | 92.80 |
| 6 | 117.20 | 93.43 | 103.28 | -187.61 | -46.45 | 36.51 | -32.38 | 101.21 |
| 7 | 122.20 | 101.91 | 88.38 | -174.57 | -38.69 | 38.58 | -28.32 | 104.93 |
| 8 | 126.36 | 111.84 | 74.08 | -163.44 | -31.93 | 41.74 | -24.44 | 104.87 |
| 9 | 129.53 | 122.38 | 60.32 | -154.34 | -25.84 | 44.80 | -21.66 | 101.83 |
| 10 | 131.73 | 132.83 | 47.23 | -146.97 | -20.07 | 47.16 | -20.22 | 96.52 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Response of Y\_GR: | | |  |  |  |  |  |  |
| Period | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | 0.86 | 0.88 | -0.24 | 3.92 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.56 | 0.29 | -0.32 | 2.53 | 0.67 | 0.84 | 1.19 | -0.43 |
| 3 | 0.25 | 0.07 | -0.52 | 1.54 | 0.16 | 0.71 | 0.90 | -0.58 |
| 4 | 0.07 | -0.01 | -0.63 | 1.04 | -0.01 | 0.43 | 0.51 | -0.68 |
| 5 | -0.03 | -0.08 | -0.65 | 0.81 | 0.02 | 0.18 | 0.23 | -0.73 |
| 6 | -0.08 | -0.17 | -0.60 | 0.71 | 0.09 | 0.00 | 0.06 | -0.76 |
| 7 | -0.12 | -0.27 | -0.52 | 0.68 | 0.15 | -0.13 | -0.03 | -0.75 |
| 8 | -0.14 | -0.39 | -0.43 | 0.66 | 0.17 | -0.21 | -0.08 | -0.72 |
| 9 | -0.16 | -0.51 | -0.33 | 0.65 | 0.16 | -0.26 | -0.09 | -0.67 |
| 10 | -0.18 | -0.63 | -0.24 | 0.65 | 0.13 | -0.28 | -0.08 | -0.61 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Response of S\_GR: | | |  |  |  |  |  |  |
| Period | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | 5.89 | 1.22 | -3.15 | 3.92 | 73.56 | 0.00 | 0.00 | 0.00 |
| 2 | 3.21 | 2.63 | -2.55 | 2.09 | 13.77 | -6.27 | -5.07 | 4.49 |
| 3 | 3.14 | 2.58 | -1.35 | 2.18 | 6.61 | -2.79 | -1.53 | 4.06 |
| 4 | 2.91 | 2.70 | -0.99 | 1.46 | 3.65 | -0.45 | 0.18 | 3.34 |
| 5 | 2.63 | 2.99 | -1.03 | 0.65 | 1.95 | 0.74 | 0.72 | 2.62 |
| 6 | 2.40 | 3.35 | -1.22 | -0.01 | 1.09 | 1.23 | 0.73 | 1.94 |
| 7 | 2.21 | 3.66 | -1.41 | -0.49 | 0.74 | 1.35 | 0.52 | 1.32 |
| 8 | 2.04 | 3.88 | -1.56 | -0.81 | 0.67 | 1.28 | 0.24 | 0.78 |
| 9 | 1.90 | 4.00 | -1.65 | -1.03 | 0.72 | 1.13 | -0.04 | 0.33 |
| 10 | 1.76 | 4.00 | -1.67 | -1.16 | 0.81 | 0.94 | -0.28 | -0.03 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Response of I\_GR: | | |  |  |  |  |  |  |
| Period | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | 0.62 | -0.79 | 1.43 | 7.06 | 9.21 | 11.90 | 0.00 | 0.00 |
| 2 | 0.52 | -0.03 | 0.03 | 5.71 | -4.36 | 6.24 | 3.58 | -0.29 |
| 3 | 0.19 | 0.13 | -1.04 | 3.81 | -3.15 | 4.34 | 3.62 | -1.21 |
| 4 | -0.17 | 0.28 | -1.74 | 2.53 | -1.92 | 2.69 | 2.31 | -1.77 |
| 5 | -0.40 | 0.32 | -2.02 | 1.91 | -0.93 | 1.41 | 1.16 | -2.10 |
| 6 | -0.53 | 0.21 | -2.02 | 1.67 | -0.19 | 0.52 | 0.41 | -2.27 |
| 7 | -0.63 | -0.03 | -1.85 | 1.59 | 0.28 | -0.06 | -0.03 | -2.32 |
| 8 | -0.71 | -0.36 | -1.59 | 1.58 | 0.53 | -0.43 | -0.25 | -2.27 |
| 9 | -0.77 | -0.73 | -1.29 | 1.58 | 0.61 | -0.65 | -0.34 | -2.16 |
| 10 | -0.82 | -1.11 | -0.99 | 1.60 | 0.58 | -0.78 | -0.35 | -1.99 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Response of M2\_GR: | | |  |  |  |  |  |  |
| Period | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | 0.00 | -0.01 | 0.00 | 0.00 | 0.00 | -0.01 | 0.04 | 0.00 |
| 2 | 0.00 | -0.01 | 0.00 | -0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Response of COVID19: | | |  |  |  |  |  |  |
| Period | LR | X | B | Y\_GR | S\_GR | I\_GR | M2\_GR | COVID19 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| 1 | 0.02 | -0.05 | 0.03 | -0.01 | -0.02 | -0.02 | 0.00 | 0.11 |
| 2 | 0.03 | -0.03 | 0.03 | 0.00 | -0.01 | 0.01 | 0.02 | 0.09 |
| 3 | 0.03 | -0.01 | 0.02 | 0.00 | -0.02 | 0.02 | 0.03 | 0.08 |
| 4 | 0.03 | 0.01 | 0.01 | 0.00 | -0.02 | 0.03 | 0.03 | 0.07 |
| 5 | 0.03 | 0.02 | 0.00 | -0.01 | -0.01 | 0.03 | 0.03 | 0.06 |
| 6 | 0.03 | 0.04 | 0.00 | -0.01 | -0.01 | 0.03 | 0.02 | 0.04 |
| 7 | 0.03 | 0.05 | -0.01 | -0.02 | -0.01 | 0.03 | 0.01 | 0.03 |
| 8 | 0.03 | 0.05 | -0.01 | -0.02 | 0.00 | 0.03 | 0.01 | 0.02 |
| 9 | 0.03 | 0.06 | -0.02 | -0.02 | 0.00 | 0.02 | 0.00 | 0.02 |
| 10 | 0.02 | 0.06 | -0.02 | -0.02 | 0.01 | 0.02 | 0.00 | 0.01 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Cholesky Ordering: LR X B Y\_GR S\_GR I\_GR M2\_GR COVID19 | | | | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |