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Covid-19 Pandemic and Pre-pandemic Economic Shocks to Brazil, India, and Mexico: A Forecast Comparison Evaluating the Impact and Recovery

Haydory Akbar Ahmed[1], Rownak Jahan Tamanna[2], Md. Israt Rayhan*[2] and Ishizaka Takami[3]

[1]*Department of Accounting, Economics, and Finance, St. Edward's University, United States.*
[2, *]*Institute of Statistical Research and Training, University of Dhaka, Bangladesh.*
[3]*College of Economics Department of Economics, Kanto Gakuin University, Japan.*

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Abstract

The covid-19 pandemic and the pre-pandemic internal-external economic shocks have inflicted the economies of Brazil, India, and Mexico. In this research, we hypothesize that both the shocks and pandemic perpetrated these economies. We employ the artificial neural network model to forecast GDP, consumption spending, and consumption to GDP ratio for these three economies over three cut-offs in 2016, 2019, and 2020. Our comparison of actual values with the forecasts over these three cut-offs shows that the pre-pandemic shocks have an impact albeit smaller than the pandemic. During the pandemic, we observed a V-shaped slump followed by recovery for both GDP, consumption spending, and consumption to GDP ratio. The Brazil and Indian economy's recovery is perhaps weak. The Indian economy is going through a deeper slump in the post-pandemic era. We recommend cash transfer to low and low-middle income households to spur consumption spending and economic recovery.

Keywords: Covid-19 pandemic, economic shocks, recovery, artificial neural network, forecasting, demand shock

I. Introduction

Covid-19 pandemic led to a global economic slowdown. Countries adopted lockdown to prevent the spread of the virus. This shutdown led to an economic slowdown all over the globe. The GDP declined for almost all the economies with varying economic impacts.[1,2] The Covid-19 pandemic as the major shock caused a dramatic double-digit negative GDP growth at an annualized rate for eight major economies of the world including India and Mexico.[3] The decline in economic activity has been disproportionate as countries adopted shut down with different intensities and lax enforcement. Almost all the major economies in the world have taken measures to support people and businesses with financial support to sustain during the pandemic. Emerging economies like Brazil, India, and Mexico have taken considerably different steps to mitigate poverty and inequality as an aftermath of the pandemic.Brazil being proactive in helping the struggling economy, whereas Mexico adopted an ill-timed austerity.[4] Brazil is highly dependent on foreign currency-denominated external debt and is heavily exposed to the pandemic-induced collapse of world trade, especially commodity trading. As a result, Brazil recorded a surplus in trade during the Covid-19 pandemic.

It is worth noting that some economies experienced external and internal economic shocks before the global pandemic. Is the Covid-19 pandemic the only major shock for Brazil, India and Mexico? Economic and foreign policy had become more uncertain and more protectionist under the Trump presidency, as India and Mexico imposed new tariffs on American imports in reaction to US tariff hikes.[5] Low-skilled migrant workers and illegal migrant refugees are affected by border construction between Mexico and USA.[6] The Trump Administration's anti-trade commercial policies and inconsistent foreign policiesmay have resulted in an external shock for the rest of the world, especially the Mexican economy.[7,8] The United States trade policy faced uncertainty during President Trump's tenure is a significant predictor of global output volatility.[9] Brazil,India, and Mexico have higher country risk relative to the USA among G20 countries.[10] The impact of the United States-China trade war during President Trump's era may have some positive impact on developing economies despite some welfare loss.[11] The Indian economy underwent an internal economic shock caused by domestic policies such as the demonetization in 2016 and the domestic tax-rate restructuring in 2017 that inflicted the Indian economy.[12] Demonetization since November 2016 in India resulted in a significant contrary effect on the economy, which dramatically affected trading and value chain over the country.[13-15] That in turn resulted in a downfall of consumers' utility, raised the inflation, hampered demand-supply chain, and decreased the banks' credit growth in India.[16,17] Among the G20 countries, interest rates are bit higher in Brazil.[10] Brazil's economy was going through an economic recession and political instability until 2016 and recovery was not robust in 2017.[18,19] Economic policy's uncertainty leads to variation in the GDP for Brazil, India, and Mexico.[20] In this research, we argue that these pre-pandemic external and internal shocks may have inflicted Brazil, India, and Mexico economies before the pandemic

*Author for correspondence. e-mail: israt@israt.ac.bd

shock. The pre-pandemic external and internal shocks along with the pandemic may have resulted in a profound negative impact on these three economies. In addition, the path to recovery after the pandemic may also depict some delayed impact from these shocks.

The government debt as a share of GDP is the highest for Brazil, followed by Mexico and India among emerging economies.[21] Unemployment rates were also high in these three economies even before the pandemic with Brazil, India, and Mexico are ranked as fourth, fifth, and ninth respectively.[21] China's rapid economic growth created new risks and also prospects for Latin America since 2000.[22] As members of the G20 economies, these three countries have significant economic clout. These economies have large populations and have relatively larger urban population densities. These economies also experienced relatively large Covid infection and death rates. These countries used lockdown during the pandemic, however, the enforcement may have been slack. This research uses the artificial neural network (ANN) model with time-series data on GDP, consumption spending, and consumption to GDP ratio to analyse the impact of the pre-pandemic and pandemic shocks on these three economies. The ANN model for forecasting as there is a plethora of work that provides evidence of its superiority over other competing models.In relation to the hypothesis, three cut-off dates are used in the ANN forecasting to capture the impact of the pre-pandemic and pandemic shocks. The first cut-off is in 2016 for the pre-pandemic internal and external shocks. A second cut-off in 2019 for the pandemic shock. Finally,the last cut-off in 2020 to capture the recovery. This study estimates and forecasts GDP, consumption spending, and consumption to GDP ratio for Brazil, India, and Mexico using the above three cut-off dates. Results indicate that the pre-pandemic shocks are relevant for all three economies. The comparison between actual GDP (consumption spending and consumption to GDP ratio) and the GDP (consumption spending and consumption to GDP ratio) forecasts for all the three cut-offs depict that the pre-pandemic economic shock has led to economic decline reflected by a decline (or slow down) in the GDP before the pandemic. The economic slowdown is further intensified during the pandemic for all three economies. We observe a V-shaped slump and recovery for GDP, consumption, and consumption to GDP ratio during the pandemic. This research argues that perhaps demand shock may have been the dominant factor for the decline and recovery of GDP. The recovery is not uniform as the Brazilian and Indian economies seem to be marred by the lagged effect of the internal and external shocks.

The rest of the paper is organized as follows: Section II discusses the data methodology, section III discusses the results and analysis, and the final section presents the conclusion.

II. Data and Methodology

This study uses seasonally adjusted quarterly data on real GDP and real aggregate consumption spending for Brazil, India and Mexico from the Federal Reserve Bank of St. Louis online database. The data spans from 1996:Q1 to 2021:Q2 for Brazil and India. For Mexico, the data spans from 1993:Q1 to 2021:Q2. Then construct the consumption to GDP ratio for all three economies using the above two variables. In the ANN estimation, the natural log of real GDP and real consumption spending were used. A detailed discussion is given in the methodology section. The ANN approach is used in economic forecasting.[23] In this section, the key aspects of the ANN method for simulation and forecasting are concisely discussed. Analyses were done using statistical software R and Stata-18. Hyperparameters with figure of ANN model is given in appendix 1.

Simulation procedure

To analyse the impact of a shock on the economic variables GDP, consumption, and consumption to GDP of Brazil, India, and Mexico, this study employs rigorous econometric modelling using nonlinearANN models. The ANN models are used extensively in time series forecasting in recent times. We can find a variety of applications in financial economics, exchange rate modelling, macroeconomic forecasting, and so forth.[23] The ANN forecasting method has an advantage over linear and nonlinear time series estimation techniques due to its assumption of nonlinearity with desired precision and superiority to linear regression and random walk models for in-sample and out-of-sample forecasting.[24-26] To predict the GDP, GDP growth and economic models with more accuracy ANN performed better than the traditional additive and linear models.[27,28] The annual GDP of 15 industrial countries is analysed with a conclusion that ANN performed better in predicting than the ARIMA.[29] The GDP of three African countries aretested and found that ANN showed superior estimates than the ARIMA.[30] In the presence of multicollinearity, missing cases and variation of data availability may violate the assumptions of additive linear models.[31] A current popular method for economic forecasting is dynamic factor modeling (DFM).[32,33] DFM implies a few latent factors that capture the movements of different variables and their idiosyncratic components.[28] But ANN is found to produce superior estimates over DFM.[34,35] As perstatistical models are inappropriate for prediction when the data are highly nonlinear, uncorrelated, nonstationary, and chaotic.[36] ANN imposes fewer assumptions on the underlying data generation process and thereby making it less susceptible to

model misspecification, which remains accurate and robust with non-stationary time series.[26]

Variables and cut-off period

This study uses the natural log of real GDP and consumption spending, and consumption to GDP ratio in our ANN forecasting. The simulation of the ANN-MLP prediction model is conducted by using R software. The steps are explained in the following section. Table 1 discusses the dataset and calibration details. In our calibration and subsequent forecasting, we use three separate cut-off periods. This study begins with 2016 as the first cut-off to evaluate the external and internal shocks. Later uses two separate cut-off dates in 2019 and 2020 to evaluate the impact of the pandemic shock and subsequent recovery. The variables are normalized between zero to one by dividing each value of the observation by the maximum value of the distribution. In case of large differences among the observations, the normalization improves convergence in the calibration process.[3]

Table 1. Details of the data

Country	Length of time-series	Observations	Total no. of patterns extracted	Total no. of training patterns	Total no. of testing patterns
Mexico	1993:Q1-2021:Q2	114	112	92	20
Brazil	1996:Q1-2021:Q2	102	100	80	20
India	1996:Q1-2021:Q2	101	99	79	20

(Source: Author'sown compilation based on available data)

Training of the model

The training set of the model is created by using 82per cent of total data patterns for Mexico and 75per cent of the data for Brazil and India according to the availability of time-series data. The ANN model fits to produce the output. There are five hidden nodes between the input and the output. Then the output value is compared with the corresponding targeted value to calculate the error. The errors are used to evaluate model performance.

Testing or performance of the model

To test the model performance, we use 18per cent of the input or data patterns for Mexico and 25per cent of the data for Brazil and India, which are not used during the training set model. The testing patterns are input into the trained model sequentially, and the output is obtained after weighting, adding, and passing through the activation function. Each of the outputs of the model is compared with the available target value to calculate the root mean square prediction error (RMSPE) using equation (1) and mean absolute error (MAE) using (2). Smaller the value of the RMPSE test statistic and MAE test statistic implies the predicted value is closer than the actual value.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (P_i - O_i)^2}{n}} \quad (1)$$

and,

$$MAE = \frac{\sum_{i=1}^{n} |P_i - O_i|}{n} \quad (2)$$

where, O_i = actual value of the i-th testing pattern, P_i = predicted value of the ithtesting pattern, n= total number of testing patterns.

III. Result and Analysis

It is interesting to note that 2016 and onwards is the period for Brazil, India, and Mexico for the pre-pandemic external and internal shocks. We argue that these pre-pandemic shocks combined with the shock caused by the pandemic may have had a relatively larger impact on Brazil, Mexico and India. We hypothesize that the Trump-era United States foreign and trade policies may have inflicted these economies with an external shock prior to the economic shock caused by the pandemic. The Indian economy, along with the external shock, may have been inflicted by an internal shock prior to the pandemic. This researchcompares three large economies namely Brazil, India and Mexico to evaluate this research question. All these economies are members of the G-20 with significant clout in the global economic system. These economies have

large populations that have relatively larger urban population densities. These economies also experienced relatively large Covid infection and death rates. These countries used lockdown during the pandemic, however, the enforcement may have been slack. The GDP, Consumption, and Consumption to GDP forecast comparisons for Brazil, India, and Mexico are used to find evidence in support of the research question. The Artificial Neural Networkforecasts over three cut-off timelines. The first one is 2016 for the pre-pandemic external and internal shocks, the second one is 2019 for the pandemic, and finally 2020. These three cut-offs will allow us to evaluate our research questions for these three economies.

The key findings aresummarized as follows: first, a sharp decline in GDP and consumption spending followed by a sharp recovery. This V-shaped slump and recovery may have been linked to the shutdown and subsequent reopening of economic activities in these economies during the pandemic. Second, the sharp decline in consumption spending and subsequent recovery is indicative of the demand-driven nature of the slump and recovery of the economy. Arguably, the pandemic shock is perhaps dominated by demand-driven shock by nature. Third, the Indian economy seems to be heading towards a decline as profound as the pandemic-induced shock. The internal economic shocks are perhaps inflicting the economy relatively harder in a lagged manner. Fourth, pre-pandemic economic shock, both internal and external, have intensified the economic shock faced by these economies during the pandemic for all three economies.

GDP Forecast Comparison

The GDP forecast comparisons using the three cut-off dates show some common patterns and interesting insights. This study begins with the pandemic followed by the 2016 cut-off, and finally the overall trend comparisons for the forecast. Figures 1(a),1(b), and 1(c) show the comparison of actual GDP and GDP forecasts over the three cut-off periods. Later a major discuss the major findings in the following paragraphs.

First, a comparison of actual GDP and GDP forecasts for the two cut-off dates of 2019 and 2020 allows us to evaluate the extent to which the pandemic has inflicted these economies. The pandemic shock depicts a deep drop in GDP followed by recovery for all three economies as observed. The shock caused by the shutdown during the pandemic is large as we compare the forecast from the 2019 cut-off with the actual GDP for all these economies. For Brazil, India and Mexico economies, we observe the GDP forecast for 2019 onwards continues to increase but the actual GDP drops sharply followed by a fast recovery. The V-shaped drop and recovery were predictable as these economies relaxed shutdown and the economy reopened towards normalcy. The 2020 cut-off captures the drop in pandemic and forecasts a recovery. The cut-off of 2020 forecasts and actual GDP depict a similar trend for Mexico and Brazil. For India, however, the recovery follows a slowdown with a decline in actual GDP vis-à-vis the forecast. Perhaps, rising oil prices, inflation and pre-pandemic internal shocks may have hindered the recovery in India. We will compare consumption spending forecasts to develop further insight for all these economies in the next section.

Second, a comparison of GDP forecast and actual GDP with the 2016 cut-off shows some interesting insight. All three economies depict a slowdown though not as profound as the shock due to the pandemic. The recovery is also not similar for these economies. Mexican GDP falls initially followed by a recovery and then falls again. Perhaps, the Trump Administration's policies impacted Mexico earlier than Brazil or India. Arguably, being a member of the North American Free Trade Agreement may have impacted Mexico excessively. The gap between actual GDP and GDP forecast for India depicts two distinct phases of slowdown. The first phase shows a smaller gap between GDP forecast and actual GDP. However, the second one shows a larger gap arising between the GDP forecast and actual GDP. The external shock from Trump Administration's anti-trade and unpredictable foreign policy shock coupled with India's domestic policy shocks may have led to these two distinct phases. The impact on Brazil also arises around the same time as in India. Brazil was going through a recession and political instabilityand the recovery was not robust perhaps. These economies are members of the G20 and BRICS and are relatively more integrated with the major global economies. Therefore, the external shock has inflicted these economies prior to the pandemic.

Third, the comparison of the forecast at the last cut-off of 2020 with the 2016 and 2019 forecasts depicts that the pre-pandemic shock had lowered the GDP forecasts trajectory for all these three economies, substantiating our earlier hypothesis. The pre-pandemic shocks have reduced the GDP for all these three economies and the pandemic shock has led to further decline. The Indian economy seems inflicted by the pre-pandemic internal shocks that may have a lasting impact even after the pandemic as the actual GDP is decreasing as observed. The pandemic shock is profound, and the pre-pandemic shock is also significant for all these three economies. This study will analyze consumption forecasts in the next section to develop further insight in this regard.

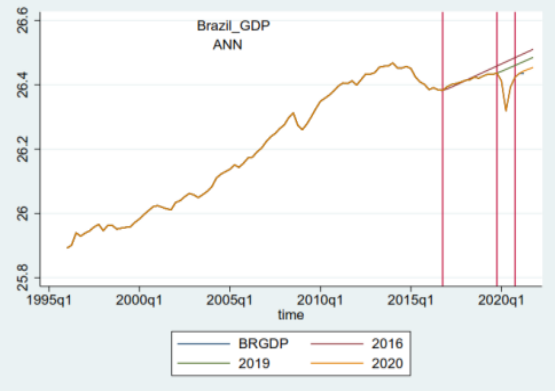
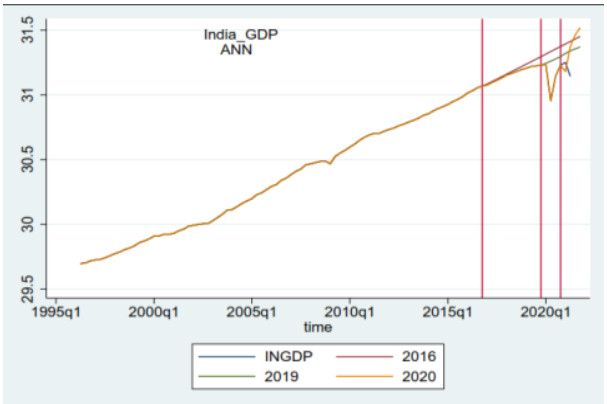
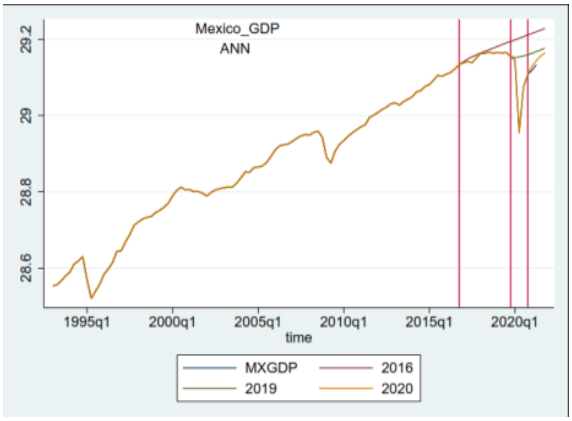


Fig. 1(a). GDP comparisons for Brazil



(b). GDP comparisons for India



(c). GDP comparisons for Mexico

(Source: Author'sown compilation based on available data)

Consumption Forecast Comparison

Consumption spending includes household spending on goods and services in an economy. Household spending on goods includes spending on durable and non-durable goods. Consumption spending accounts for a large fraction of the GDP of an economy. During the shutdown, the service sector took a hit and consumer spending on services and goods declined significantly. The actual consumption and consumption forecasts during the three cut-off periods are discussed earlier. A similar pattern is observed for consumption spending for these economies to their respective GDP. Figures 2(a), 2(b), and 2(c) show the comparison of actual consumption spending and consumption spending forecasts over the three cut-off periods.

First, analysis begins with the 2019 and 2020 cut-offs for the pandemic. The 2019 cut-off forecast shows a steady increase in consumption spending, but the actual consumption spending shows a sharp decline for all three economies. This decline follows a speedy recovery as the economies reopen and move towards normalcy. This again depicts a V-shaped recovery for the three economies. The shutdown reduced household spending on goods and services that increased again as the economies relaxed the shutdown, and this conforms with a sharp decline followed by a recovery in GDP. The sharp decline in GDP during the pandemic is triggered by the sharp decline in consumption spending. The 2020 cut-off forecasts are interesting. For Mexico, it is observed that an increase in the consumption spending forecast consistent with expected recovery. The Mexican case shows a healthy trajectory for recovery in consumption spending and GDP as well. For Brazil, actual consumption spending is showing a decline vis-à-vis the forecast. Perhaps, the pandemic caused a decline in household income and consumers are yet to recover from that. For India, it is observed that inconsistency between actual consumption spending and the forecast. Even after the pandemic, household consumption spending continues to decline. As argued earlier, rising oil prices, inflation, and pre-pandemic shocks may have a telling impact on consumer spending in India. Perhaps the pre-pandemic internal shocks in India may have a lagged impact. The decline in actual consumption spending in India is perhaps a major factor that is causing the decline in Indian GDP after the pandemic. The next section discusses the 2016 cut-off.

Second, the 2016 cut-off does not depict any significant changes for India and Brazil. This study observes a sharp decline in consumption spending forecast and actual consumption spending in Mexico. This explains the slowdown in Mexico's GDP before the pandemic caused by the external shock. Perhaps, the Trump Administration's stance towards Mexico may have hurt their economy relatively more than India and Mexico.

Third, the comparison of the forecast for the three cut-offs in 2016, 2019, and 2020 again depict a decline in consumption. This divergence between the 2016 and 2020 forecasts is arguably depicting the pre-pandemic shock having a lasting impact on these economies even after the pandemic.

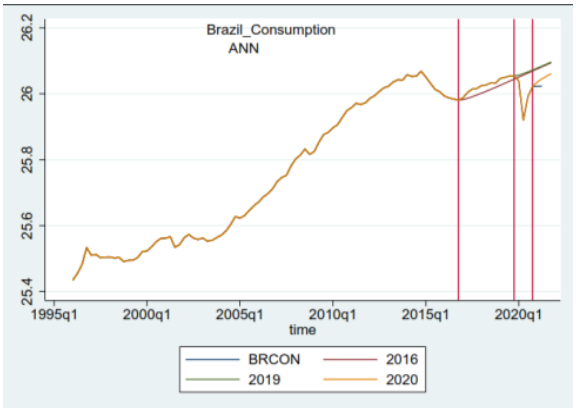
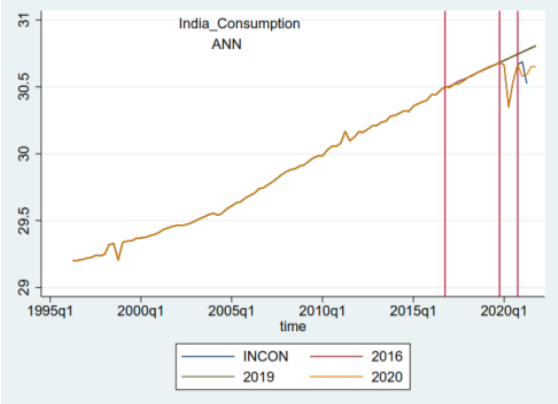
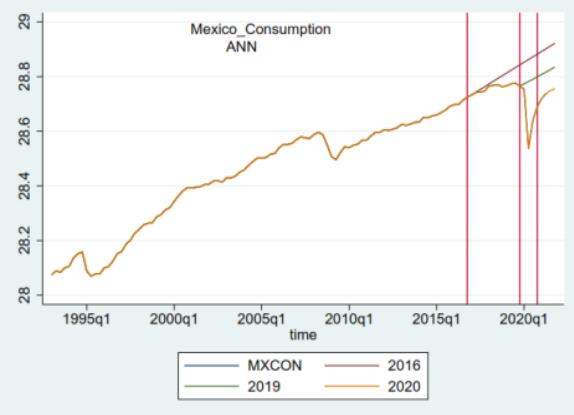


Fig. 2(a). Consumption comparisons for Brazil



(b). Consumption comparisons for India



(c). Consumption comparisons for Mexico

(Source: Author'sown compilation based on available data)

Consumption to GDP Forecast Comparison

The following discussion uses the Consumption to GDP forecast comparisons for the three economies over the three cut-off dates. We envisage this discussion will provide more insight into the dynamics between consumption spending and GDP providing further insight related to our research question. We will begin our discussion with the 2019 and 2020 cut-off periods. The ANN forecast comparisons provide three different scenarios for the three economies.

The 2019 cut-off depicts the Consumption to GDP forecasts and actual Consumption to GDP are showing a profound decline during the pandemic for all three as expected. However, the recovery is not uniform in these three economies. The Mexican economy seems to be doing relatively well in comparison to Brazil and India. The actual Consumption to GDP and its forecast depicts a decline followed by recovery with a V-shape, conforming to GDP and consumption. The actual recovery shows a stronger recovery vis-à-vis the forecast of 2020.

For Brazil and India, divergence is found between the forecast and actual data. Both these economies show a decline in the actual consumption to GDP ratio. This

slowdown in Brazil is perhaps caused by a slow recovery in Brazil. For India, it is noteworthy that the decline in India's actual Consumption to GDP ratio plunged to a level lower than the pandemic scenario. The 2019 forecast also predicted a decline with a trajectory of recovery. However, the actual data depicts a sharp decline. This finding is crucial and extraordinary that conforms to our earlier proposition that external and internal shocks in India may have inflicted the Indian economy along with the pandemic. A similar pattern is found when investigated the GDP and Consumption separately for India. Arguably, the recovery in Brazil and India is marred by domestic economic conditions. It could be argued that Brazil's economy is perhaps marred by a slow recovery. Whereas the Indian economy is marred by rising oil prices, inflation, and pre-pandemic internal shocks. Both these economies may adopt some cash transfer programs for the low and low middle income families to spur consumer spending, which in turn will stimulate investment and GDP. The Indian economy may also reduce excise duty on energy prices to curb inflationary pressure.

When this study compares the 2016 cut-off, we find a different scenario altogether. The Consumption to GDP ratio, both forecast and actual, rises implying consumption may have been rising faster than GDP for Brazil. Perhaps, the Brazilian economy was doing relatively better during the Trump-era inconsistencies. For Mexico and India, on the other hand, the forecast and actual consumption to GDP are divergent. The divergence, at times, is dominated by rising consumption relative to GDP, and at times, is dominated by falling consumption relative to GDP. Arguably, this implies the economies were perhaps going through some uncertainty resulting from either internal or external shocks.

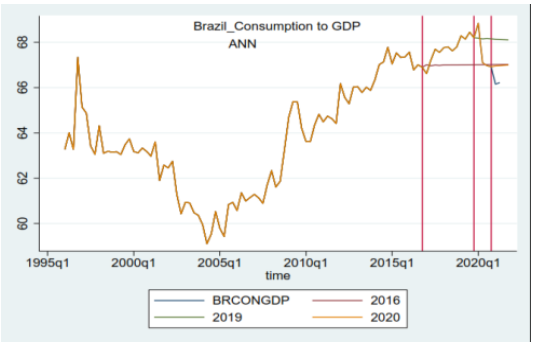
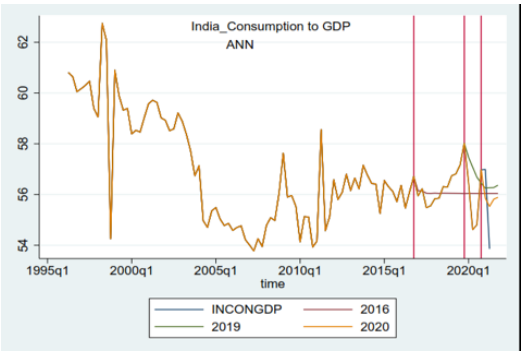
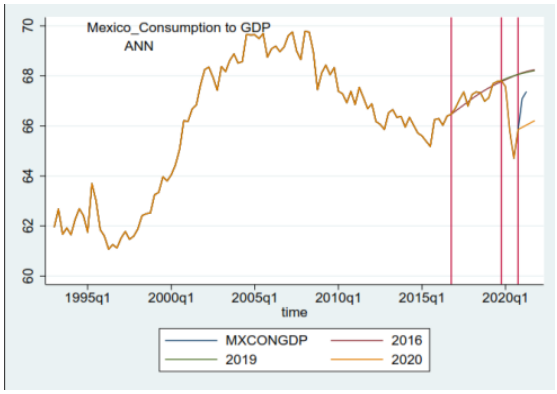


Fig. 3(a). Consumption to GDP comparisons for Brazil



(b). Consumption to GDP comparisons for India



(c). Consumption to GDP comparisons for Mexico

(Source: Author'sown compilation based on available data)

The Consumption and Consumption to GDP forecasts and actual observations are perhaps indicative of a demand-driven economic shock caused by the pandemic. The economic collapse during the pandemic and subsequent recovery depicts a similar pattern for GDP and Consumption spending.

Table 2. RMSPE and MAE results

Country	Variables	RMSPE	MAE
Brazil	GDP	0.0502	0.0319
	Consumption Spending	0.0448	0.0323
	Consumption to GDP Ratio	0.8956	0.7591
India	GDP	0.1332	0.0837
	Consumption Spending	0.1154	0.0579
	Consumption to GDP Ratio	0.9816	0.7760
Mexico	GDP	0.9908	0.0489
	Consumption Spending	0.1248	0.0850
	Consumption to GDP Ratio	1.1248	0.6786

(Source: Author'sown compilation based on available data)

The RMSPE and MAE test statistics indicate that they are well below two percent.also reports similar results for their ANN estimates. The estimates are thus within reasonable limits and are robust.

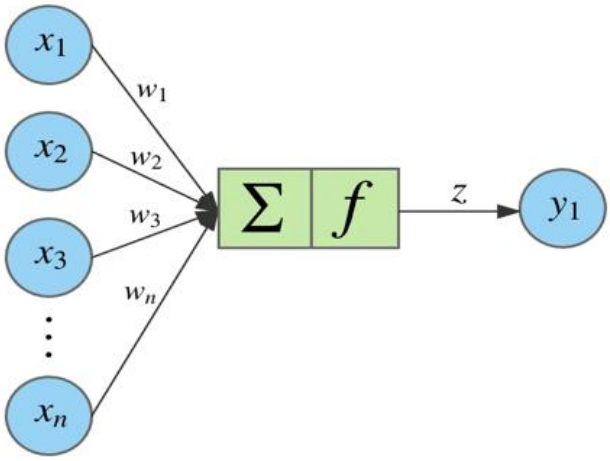


Fig. 4. Flow-chart of hyperparameter of ANN model (source: https://www.google.com/ann)

IV. Conclusion

The Covid-19 pandemic has led to a global economic slowdown. Emerging economies like Brazil, India and Mexico have been experiencing internal and external shocks prior to the pandemic. These pre-pandemic shocks may have had a significant impact, and envisaged both the pre-pandemic and pandemic shocks have had a profound impact. In addition, the economic recovery may also be affected by these shocks. The ANN model is used for forecasting GDP, consumption spending, and consumption to GDP for three different cut-offs beginning with 2016, followed by 2019, and 2020. Comparison of actual and forecast allows us to evaluate our research questions.

The key findings can be summarized as follows: first, we find evidence of a sharp decline in GDP and consumption spending followed by a sharp recovery. This V-shaped slump and recovery may have been linked to the shutdown and subsequent reopening of economic activities in these economies during the pandemic. Second, the sharp decline in consumption spending and subsequent recovery is indicative of the demand-driven nature of the slump and recovery of the economy. Arguably, the pandemic shock is perhaps dominated by demand-driven shock by nature.

Third, the Indian economy seems to be heading towards a decline as profound as the pandemic-induced shock. The internal economic shocks are perhaps inflicting the economy relatively harder in a lagged manner. Fourth, pre-pandemic economic shock, both internal and external, have intensified the economic shock faced by these economies during the pandemic for all three economies.

These economies should adopt structural policy reforms to ensure steady macroeconomic performance. This study recommends Brazil and Indian governments should adopt cash transfers to low and lower middle-income households to increase consumption spending. These cash transfers may stimulate consumption spending, which in turn will increase investment and GDP by increasing consumer demand. The Indian government may also reduce excise duty on energy prices to curb inflationary pressure.

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