Griselda Dávila-Aragón
Salvador Rivas-Aceves *Editors*

# The Future of Companies in the Face of a New Reality

## Impact and Development in Latin America

Springer

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# Foreword

Research cannot be an occupation that disregards reality. According to the methodology of each discipline, scientific inquiry seeks to produce knowledge, gain a deeper comprehension of the world's complexity, and provide solutions to the profound challenges faced by humankind and our world. The pandemic we endured in 2020, and that will continue through 2021, provides an excellent example. The crisis that we are confronting has challenged and changed us, in terms of our common forms of organization and the ways we relate to nature, and of course, with one another. Academic work cannot turn away from this predicament and should serve as one of the keys to navigating and overcoming these difficult times. Contributions from the field of medicine are an obvious application for this kind of crisis, but there are also high expectations of the roles of engineering, law, political science, humanities, and of course, the economics and business sciences.

New means and locations of work and professional functioning, the implementation of, and adaptation to, new technologies in organizations, and macroeconomic perspectives on the effects of the pandemic are just some of the issues that demand an interdisciplinary response, TC \l 2 \n with a significant contribution from specialists in economics, management, and finance. For this reason, we welcome the publication of this book, which addresses many of the different challenges triggered by the pandemic from various perspectives of analyses. To illustrate the valuable contribution of this volume to the ongoing scientific and academic discussion on the subject, I will briefly present its content.

The first chapter, "The impact of SARS-CoV-2 on the economic activity of México in 2020," presents a quantification of the economic effect of COVID-19 on the economic activity of the country. Nuñez and Mata separate the impact of a recessionary trend that has been identified in recent years, demonstrating that COVID-19 served to aggravate the economic situation that has been developing since 2019. The consequences of the crisis in México, they deduce, are negative growth rates in the primary, secondary, and tertiary sectors of the economy; a high degree of future uncertainty, higher rates of poverty in various regions of the country, and massive unemployment in both the formal and informal sectors of the nation. The authors conclude that México must rebuild its social and productive

foundations with a comprehensive vision and strategy that includes all citizens, as the weight of the crisis is monumental in particular for the informal labor market.

The chapter "Survival Likelihood of Micro and Small Businesses Facing a Catastrophe" proposes a measurement methodology to quantify the probability of the survival of micro and small enterprises facing a catastrophic event such as the pandemic, assessing whether the development of a business continuity plan can offer a unique alternative for preparing management teams and preventing companies from bankruptcy. Davila, Rivas, and Ramírez argue that for businesses with high face-to-face customer interaction, a business continuity plan might provide a useful tool in addition to developing the experience and readiness of a crisis management team. The pandemic has modified traditional economic paradigms in which physical interaction with customers was the standard. A management team with crisis experience and a comprehensive preparedness plan presents an element with a positive impact in dealing with immediate catastrophic events. The authors conclude by revealing results that the availability and nature of liquidity sources do not exert a significant impact on the probability of business survival.

Chapter 3 explores how COVID-19 accelerated the garment and financial investment industries' adoption of Environmental, Social, and Corporate Governance (ESG) standards. López, Rojas, and González indicate that expectations have developed that once the COVID-19 crisis is over there will be a grand quantity of capital inflows toward ESG investment in emerging markets, which will drive business transformation. This is particularly true for businesses that have made progress in incorporating ESG factors such as the utilities and financial sector. The benefits are clear: (1) lower risk and long-term stability, (2) positive portfolio returns and indices demonstrating the efficacy of ESG criteria, (3) the positive externalities associated with success in the application of ESG criteria, and (4) the brand reputation and gain of market share facilitated by responding to the demands of a new generation of consumers.

The chapter "contagion adverse degree, income inequality, and economic growth" calls attention to the ways in which COVID-19 has fomented more than a health crisis worldwide. Rivas-Aceves notes that the effects of the contagion adverse degree resulting from the pandemic caused an intertemporal marginal substitution rate of households as well as industry production processes to be changed. Furthermore, short and long-run economic growth rates have also been affected by the contagion adverse degree of households, human capital growth rate, and hence on their distribution dynamics. Poor households will allocate less time to leisure and rises in output or decreases in salary will occur due to the contagion adverse degree, which will lead to increased inequality. Such inequality decreases when human capital rises. Physical capital can generate small and positive changes to inequality. Financial capital also has a positive impact on inequality, and inequality also decreases when total multifactorial productivity increases. Finally, macroeconomic equilibrium depends on counterintuitive approaches as a result of the contagion adverse degree.

Chapter 5 identifies the impact of the COVID-19 contingency on economic activity in the microfinance sector of Argentina, Colombia, Ecuador, México, and Peru. Through a fuzzy autoregressive neural network with a pentagonal membership function, and correlational analysis allows the identification of levels of impact of the contingency and inferences on the effects in the microfinance industry. Castro, Medina, and Cabrera show that the agricultural sector will be the most affected by the current crisis, followed by tertiary activities and industry. These effects were observed and analyzed in the five economies, providing empirical evidence of the countercyclical condition of popular savings and credit industries, identifying that this economic sector can expect increases in profitability, and decreases in credit and liquidity risks. The Mexican savings and credit sector was the only exception in these results. The authors conclude that, in the face of public health and economic crises, financial institutions have a critical role in facilitating the positive reconstruction of the economic and social environment of Latin American families.

The chapter "Balancing Work, Family, and Personal Life in the Mexican Context" explores the future of work for the "COVID-19 Generation." The expectations of recent generations have pushed professional culture in the direction of work–life balance, which have been reinforced by the changes brought about by the COVID-19 pandemic. Responding to this shift, and inspired by the challenges of our "new normal," this chapter presents research results from a survey conducted in México with respondents from generations Y and Z. The survey results provide important insight into how these generations perceive work–life balance, as well as the expectations of young Mexicans between the ages of 18 and 30 regarding family and work life.

The chapter "Medical tourism in México. Analysis of the economic and technological model in the COVID-19 pandemic era" analyzes data obtained from various sources to determine the behaviors and preferences related to medical tourism. Dávila and Arrioja seek to identify the main factors in predicting consumption habits and facilitating various options for socially responsible medical tourism through the use of advanced analytical and artificial intelligence tools. Such tools will aid in the identification of the most attractive alternatives to benefit consumers in an adverse environment as the world is facing now due to the global COVID-19 pandemic, which represents a significant challenge for most industries, but also generates new opportunities with significant benefits for those who are equipped to take advantage of them.

The chapter "Small Coffee Companies and the Impact of Geographical Indications as Productive Innovation in México in the New Reality" analyzes the Protected Designation of Origin (PDO) as a factor of innovation in the Coffee Pluma geographical region in Oaxaca, México. Velázquez and Pérez consider the PDO as a vital tool for solving the problem of the actual crisis in the supply chain as creating a new context of business and markets post-COVID-19. The authors evaluate the benefits that the coffee sector is capable of obtaining and generating through the development of this sectorial and territorial tool, citing geographical identity as an option that will improve production through the acquisition of

exclusive rights to produce coffee within the region for the achievement of sustainable development while faced with a new reality.

Chapter 9 explores the implications of engaging in corporate social responsibility to inform crisis management and maintain stakeholder satisfaction. López-Fernández discusses a conceptual model to describe how effective and socially responsible crisis management enables firms to transition "from survival mode to survivability." The author emphasizes that creative approaches to crisis management are needed to face the current challenges and lead organizations and stakeholders to "survivability."

Finally, chapter 10, "Artificial Intelligence & Blockchain: The path to generate value for companies after the COVID-19 pandemic," explores the adoption of new technologies to avoid bankruptcy. Technological developments of the Fourth Industrial Revolution, such as blockchain and artificial intelligence, have been gradually adopted by all companies that focus on ESG criteria. Newly emerging models will facilitate companies' competition for market share (using AI algorithms to extract value from data) and improve forecasts and strategies to create value for customers with more personalized products and services. According to the authors, DLT blockchain technology will enhance product traceability and the development of new business models based on trust and decentralization.

There is no doubt that this book offers a complete panorama of many of the different challenges faced by organizations at the current moment, as well as potential approaches for responding to the crisis. Unquestionably, this work is encouraging in terms of the possible solutions that academia can provide both for understanding and unraveling the current situation and developing different strategies to overcome it. The effects of the present crisis will resonate for years to come, so the reception and discussion of this volume among scholars will be interesting and fruitful for all of us.

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# The Impact of SARS-CoV-2 on Economic Activity of Mexico in 2020

**José Antonio Núñez Mora and Leovardo Mata Mata**

**Abstract** In this document, the economic effect of Covid-19 on the economic activity of Mexico in 2020 is quantified, separating the impact of the trend that has been observed in recent years. The procedure used is an ARIMA model with an intervention that incorporates the NIG probability distribution, where it is found that the explained variance of the seasonally adjusted time series of the IGAE due to Covid-19 is 44.20% and due to the administration on duty 18.89%. These two estimates quantify that Covid-19 came to aggravate the recessionary economic situation that existed since 2019.

**Keywords** Covid-19 · SARS-CoV-2 · ARIMA · Recession · NIG

**JEL Classification** I15 · E32

## 1 Introduction

*SARS-CoV-2 in the world.*

At the end of last year, several cases of pneumonia due to a new type of coronavirus, called SARS-CoV-2 by the International Committee on Virus Taxonomy, were presented in Wuhan (China). The disease that causes it has become popular as "Covid-19". In this regard, this virus belongs to the Coronaviridae family, where there are four genera: alpha, beta, delta, and gamma, of which it is known so far that alpha and beta-type coronaviruses infect humans, causing diseases ranging from the common cold to more serious conditions (Palacios et al. 2020).

At the close of July 31, 2020, according to the World Health Organization (WHO), 678, 775 deaths attributable to Covid-19 have been reported worldwide, making this condition a global public health emergency (CSSE 2020). Figure 1 shows the ten

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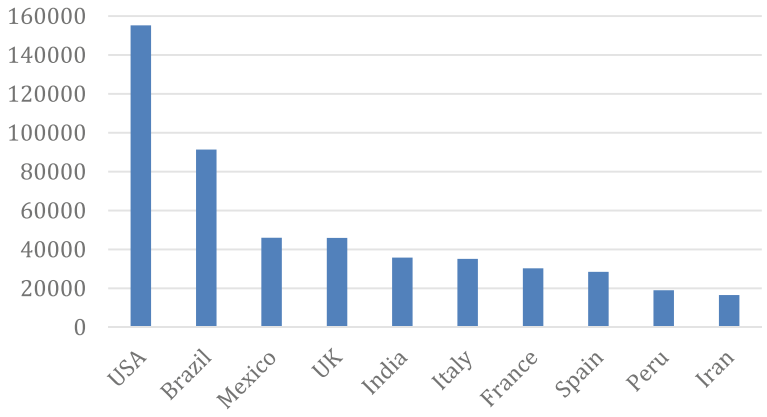


**Fig. 1** Deaths due to Covid-19 in the world *Source:* own elaboration with data from Statista (2020)

countries most affected as of July 31, 2020, where it can be seen that Mexico occupies the third position.

Now, the origin of this virus is not conclusive, but due to its close similarity to bat coronaviruses, it is likely that these are the primary reservoir of the virus, since it is 96% identical at the genome level to a bat coronavirus (Palacios et al. 2020). In terms of transmission, one person can infect approximately two to four people, which means that the infection can spread rapidly and widely among the population.

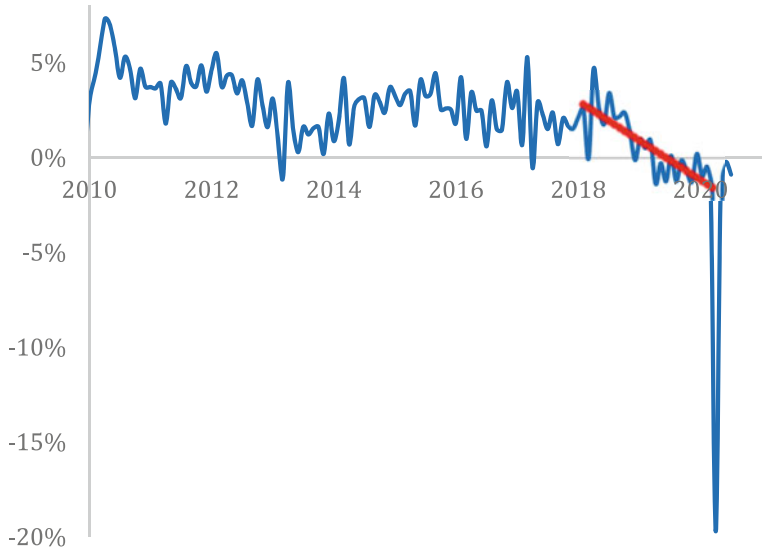


**Fig. 2** Average annual variation of the IGAE 2010–2020 Source: own elaboration with data from INEGI (2020)

**Table 1** Regional perspectives

| Region | Projected economic growth in 2020 |
|---|---|
| East Asia and the Pacific | 0.50% |
| Europe and Central Asia | −4.70% |
| Latin America and the Caribbean | −7.20% |
| Middle East and North Africa | −4.20% |
| Southern asia | −2.70% |
| Sub-Saharan Africa | −2.80% |

Source: own elaboration with data from World Bank (2020)

The new coronavirus can infect people of all ages, although older people and those with pre-existing medical conditions (diabetes, heart disease, among others) seem to be more vulnerable to becoming seriously ill with the virus, thus reporting a higher mortality rate than 8% in people over 70 years old.

However, from an economic point of view, the coronavirus pandemic and the measures taken to contain it have caused a drastic contraction in the world economy. According to the World Bank, it would be the worst recession since World War II. This year a contraction of 5.2% of world GDP is expected (World Bank 2020).

Overall, the economic impact of Covid-19 could affect the world economy at three key points: declining production, disruptions in the supply chain, and distortions in financial markets (Deloitte 2020; CEPAL 2020). In the next section, we will continue with the description of the economic impact of Covid-19, but focusing on México (Table 1).

**Economic Impact of Covid-19 in Mexico**

In the second half of 2020, one of the deepest falls in the Mexican economy occurred. The stoppage of a large part of economic activity in the face of the Covid-19 pandemic aggravated the recession that Mexico suffered since 2019. According to INEGI (2020), preliminary data in the second quarter of 2020, the Gross Domestic Product (GDP) of Mexico, presented an annualized fall of 18.9%. The most significant effect occurred in secondary activities, where an annualized contraction of 26.0% was recorded, while tertiary activities fell 15.6% and primary activities, 0.7%.

Undoubtedly, the stoppage of activities during April and May in 2020 due to the health contingency primarily influenced the fall in GDP. However, an important variable that has contributed to the country's current situation is the economic slowdown that had been observed since last year (CIEN 2020). In fact, according to the Global Indicator of Economic Activity data, during May 2020, the Mexican economy presented an annualized variation of negative economic activity of 21.6% (IDIC 2020b).

The problem is not only that, because when studying the performance by sector from November 2019 to May 2020, tertiary activities register annual decreases in

**Table 2** Steep falls of the IGAE (May 2020)

| Heading | Variation (%) |
|---|---|
| Temporary accommodation and food and beverage preparation services | −72.09% |
| Building | −35.89% |
| Manufacturing industries | −35.61% |
| Wholesale trade | −32.38% |
| Retail trade | −33.77% |
| Recreational, cultural, sporting and recreational services | −29.86% |

Source: own elaboration with data from INEGI (2020)

five of seven months. Besides, the secondary sector presents fifteen months with negative figures. Only the set of primary activities achieved positive growth rates (CIEN 2020). In this regard, the entry into force of the new trade agreement of Mexico, United States, and Canada (T-MEC) on July 1 constitutes a hope for the current Government, which has pronounced itself for a mild and transitory economic crisis (IDIC 2020a). Table 2 shows the central falls in the elements of the IGAE. It can be seen that the most affected sector is accommodation services (−72.09%), followed by the construction sector (−35.89%). These figures show the Mexican economy's reality since a decrease in economic activity of this nature had not been experienced since the 1994 recession.

The effects on the labor market have also been dramatic since, in the first half of 2020, just over 921,500 workers were discharged from the Mexican Institute of Social Security (IMSS). These data are alarming since it approximates the total number of people who lost their formal employment in Mexico. Specifically, the most affected subsectors are professional services, manufacturing, commerce, and construction (INEGI 2020).

Furthermore, considering both the formal and informal sectors of the economy, Mexico's outlook is worrying. According to figures from the National Council for the Evaluation of Social Development Policy (CONEVAL 2020), the number of people working in small establishments fell by 2.9 million, while people working in micro-business decreased by 6 million first half of 2020. Undoubtedly, this scenario is reflected in poverty levels, since the number of workers whose labor income does not allow them to access a food basket rose to 54.9% in May 2020 (Esquivel 2020).

In contrast, exports improved, since they registered a negative annual growth rate during June 2020 (−12.8%), but an increase is observed concerning May 2020. The most substantial advance was seen in the sector automotive, where a monthly rise of more than 500% happened. On the other hand, imports also showed a recovery, since, in the comparative May 2020 against June 2020, an advance of more than 20% was achieved (INEGI 2020). In this regard, the primary economic recovery strategy of the Government lies in the T-MEC. However, in an uncertain international business environment, the proposed policy may not be sufficient.

When the annual variation of the IGAE (seasonally adjusted data) is reviewed, a downward trend is observed in recent years and an abrupt drop in 2020. This effect,

naturally, is related to the Covid-19 pandemic, but also with the previous temporal inertia, hence the objective of this work is to separate the two effects (see Fig. 2). In the next section, the methodology used to analyze the effect of Covid-19 on the economic activity of Mexico in 2020 will be discussed.

## 2 ARIMA Models with Intervention

The analysis focuses on the study of the time series of the Global Indicator of Economic Activity (IGAE) in Mexico to measure the effect of Covid-19 on the development of the economic activity and separate its influence from events previous, particularly the period that comprises the Government in turn, called 4 T. This objective is carried out by an Integrated Autoregressive Moving Average (ARIMA) model will be used with intervention (Ferruz et al. 2011). The general expression of an ARIMA (p, d, q) model is given by:

$$\Delta^d y_t = \sum_{j=1}^{p} \phi_j \Delta^d y_{t-j} + \sum_{j=0}^{p} \theta_j \Delta^d \varepsilon_{t-j} + \sum_{j=1}^{k} \beta_j f\left(X_{tj}\right). \tag{1}$$

where $\Delta^d y_t$ expresses that $d$ differences have been applied to the original series $y_t$. This model can include intervention analysis using a transfer function $f\left(X_{tj}\right)$ that incorporates exogenous variables $X_{tj}$. In this way, it is possible to measure the effects of an event in the behavior of the time series and evaluate its impact (Morettin and Toloi 1989). Formally, an ARIMA model (Tsay 2015) without intervention can be expressed as

$$\phi_p(L)\left(1 - L^s\right)(1 - L)^d y_t = \theta_q(L)\varepsilon_t. \tag{2}$$

where $L$ symbolizes the lag operator, the polynomial $\phi_p(L)$ represents the autoregressive component, $\theta_q(L)$ the moving average component, and the factor $(1 - L^s)(1 - L)^d$ corresponds to the operators of simple differentiation of order $d$ and seasonal differentiation $s$. The modeling process is based on determining the appropriate values $d$ and $s$. Then an identification process is performed to find the optimal values of $p$ and $q$ using simple and partial correlograms. Exogenous intervention variables are added to this specification to estimate Eq. (1), and the best fit model is chosen using the information criteria of Akaike, Schwarz, and Hanna-Quinn (Enders 2014).

It is important to comment that the choice of parameters $d$ and $s$ is related to the concept of stationarity of $Y_t$. Besides, a time series $Y_t$ is said to be stationary if the population mean is constant over time, the population variance is constant over time, and if the covariance between any two observations is zero, that is, they do not correlate throughout the periods.

In this regard, the concept of integration is related. A time series is said to be integrated of order $d$ and written $I(d)$ if the time series can be converted into a stationary series through $d$ differences of the form

$$\Delta^d y_t = \Delta^{d-1} y_t - \Delta^{d-1} y_{t-1}. \tag{3}$$

where $d$ is an integer greater than or equal to zero (Hamilton 1994), also, it is important to note that in economics and finance, time series are usually integrated of order zero or one. The time series called $I(0)$ present finite and time-independent variance, have limited memory, tend to fluctuate around their mean value, which may or may not include a deterministic trend, and present autocorrelations that decrease rapidly as the number of lags increases.

On the other hand, the time series $I(1)$, which shows a variance that depends on time, is not constant and tends to infinity as time progresses. Furthermore, any random shock permanently affects the stochastic process, and the time series fluctuates widely over time. Also, autocorrelations tend to unity, in absolute value, for almost any order of the lag.

The usual hypothesis test to verify the stationarity condition of a time series is the augmented Dickey-Fuller test (DFA), whose null hypothesis is that there is a unit root (non-stationarity). Rejection of the null hypothesis under different specifications (Pindyck and Rubinfeld 2001; Hamilton 1994), throws evidence on the nature of the random variable of interest $y_t$. In general, the regression model estimated to perform the DFA test follows the specification

$$\Delta y_{t-1} = \mu + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \ldots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t \tag{4}$$

where the null hypothesis is translated concretely in verifying the significance of the $\gamma$ coefficient (Dickey and Fuller 1979), in other words, $H_0 : \gamma = 0$. Finally, it should be noted that the reason for using the ARIMA method with intervention is because it allows estimating the future behavior of a variable from the data observed in the past. These models do not need to be derived from a specific economic theory, since they are estimated with lags of the same variable (Kumar et al. 2011).

In the simplest form, exogenous variables are dummy variables that indicate some event in a time interval. Similarly, the intervention effect provides a movement in the time series, which is linked to a temporary or permanent structural change. This change can be verified using different hypothesis tests, such as Zivot-Andrews, Chow, and Andrews-Ploberger (Bai and Perron 2003). In this document, the key events are the pandemic due to Covid-19 and the trend observed in the economy from July 2018. The following section will present the estimates and interpret the results found in the Indicator of Global Economic Activity (IGAE) for the period 1993–2020.

## 3 Estimates and Results

The data used for this work has been obtained from INEGI (2020). The set of information covers the period from January 2010 to May 2020. This time interval covers Mexico's economic activity in the last ten years, monthly with the Global Indicator of Economic Activity (IGAE), where the year Base is 2013. This period has been chosen to analyze the variation of the IGAE in the period after the international financial crisis of the years 2008–2009 and which allows to completely encompass the last two governments that have directed Mexico's economic destiny.

The IGAE allows knowing and monitoring the monthly evolution of the real sector of the economy. This indicator uses the same conceptual scheme, the methodology, the classification of economic activities, and the sources of information that calculate the Gross Domestic Product (INEGI 2020). In this document, the seasonally adjusted figures (Census X-12) of the IGAE are considered to calculate the annual variation:

$$r_t = ln(IGAE_t) - ln(IGAE_{t-12}). \tag{5}$$

However, there are various hypothesis tests to verify if a time series is stationary, such as the increased Dickey-Fuller test (DFA), Phillips-Perron (PP), and Kwiatkowski—Phillips—Schmidt—Shin (KPSS). Specifically, the DFA and PP tests have as a null hypothesis the existence of unit root in the data set. Hence, the rejection of $H_0$ throws evidence on the stationarity of the random variable of interest. In contrast, the KPSS test has as a null hypothesis the existence of stationarity, so it is sought not to reject $H_0$ to find the same conclusion as with DFA and PP (Brooks 2010).

In this document, the DFA, PP, and KPSS tests were performed for the time series of the annual variation of the IGAE. It can be seen in Table 3 that the base hypothesis of DFA and PP is rejected and that the null hypothesis for the KPSS test is not rejected. These tests indicate that the time series $r_t$ satisfies the stationarity condition.

When carrying out a brief descriptive analysis of the time series $r_t$, the bias is found to be negative, the standard deviation is greater than the average annual variation, and the kurtosis is higher than three, which suggests the absence of normality. Furthermore, it can be seen that kurtosis is high, which accounts for the leptokurtic behavior of the annual variation of the IGAE, which reflects that atypical falls have a higher probability of occurrence than would be observed with the normal distribution (see Table 4).

Table 5 presents the ARIMA model (1, 1, 1) with the time series $r_t$, where the Normal Inverse Gaussian distribution (NIG) has been used for the maximum likelihood process that involves the random disturbance $\varepsilon_t$ of the Eq. (1). The normal

**Table 3** Unit root tests

| Variable | DFA | PP | KPSS |
|---|---|---|---|
| IGAE annual variation | −2.38 (0.017) | −5.71 (0.000) | 0.16 (0.131) |

Source: own elaboration with data from INEGI (2020)

**Table 4** Descriptive statistics

| Indicator | Statistic |
|---|---|
| Mean | 0.0152 |
| Median | 0.0230 |
| Maximum | 0.0729 |
| Minimum | −0.2160 |
| Std. Dev. | 0.0339 |
| Skewness | −2.5597 |
| Kurtosis | 13.6589 |
| Test | Statistic |
| Jarque Bera | 908.83 (0.000) |
| Anderson–Darling | 7.054 (0.000) |
| Kolmogorov | 0.154 (0.000) |

Note: p value is reported in parentheses
Source: own elaboration with data from INEGI (2020)

**Table 5** ARIMA model with intervention under the NIG distribution

| Variable | Coefficient | Std. Error | t-Statistic | p-value |
|---|---|---|---|---|
| COVID | −0.0103 | 0.0045 | −2.2692 | 0.0249 |
| 4 T | −0.0015 | 0.0008 | −2.0263 | 0.0447 |
| AR (1) | 0.9562 | 0.0318 | 30.0407 | 0.0000 |
| MA (1) | −0.6082 | 0.0866 | −7.0259 | 0.0000 |
| R-squared | 0.350864 | Akaike info criterion | | −4.562544 |
| Schwarz criterion | −4.653808 | Hannan-Quinn criterion | | −4.758994 |

Source: own elaboration with data from INEGI (2020)

distribution is not used, since the null hypothesis in Jarque–Bera (JB), Anderson–Darling (AD) and Kolmogorov–Smirnov (KS) is rejected for the time series of the annual variation of the IGAE.

In this regard, an explanation of the NIG probability distribution is presented in Annex 1. Likewise, Annex 2 shows the parameters estimated by maximum likelihood and the hypothesis tests that support the goodness of fit of the NIG. The coefficients estimated in Table 5 correspond to a model without intercept with an autoregressive term AR (1) and a moving average term MA (1), where two dummy variables COVID and 4 T have been included to capture the effect of the Covid-19 pandemic and the inertia of the current administration in Mexico.

$$COVID = \begin{cases} 1 & \text{if it corresponds to the months after February 2020} \\ 0 & \textit{another case} \end{cases}$$

$$4T = \begin{cases} 1 & \text{if it corresponds to the months after June 2018} \\ 0 & \textit{another case} \end{cases}$$

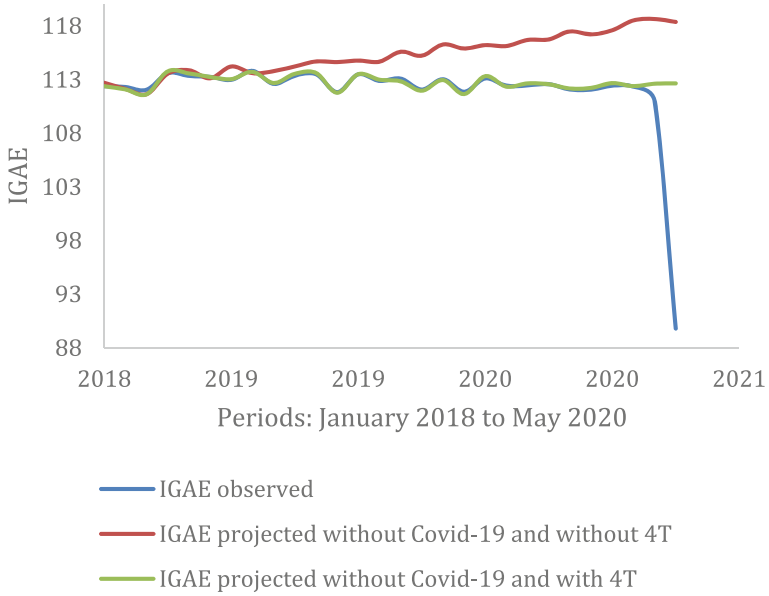


**Fig. 3** Projections of the IGAE seasonally adjusted time series *Source:* own elaboration with data from INEGI (2020)

The time series of the annual variation $r_t$ can be projected to calculate the trajectory of the seasonally adjusted series of the IGAE ($y_t$) using the model in Table 5, controlling for the COVID and 4 T effects. In this way, it is possible to have a rough estimate of the impact that the current administration and the Covid-19 have had on economic activity. The explained variation of the time series $y_t$ in 2020 due to the Covid-19 is 44.20% and due to the administration on duty 18.89%. Figure 3 illustrates the projected IGAE seasonally adjusted time series. These estimations give quantitative evidence that one of the deepest falls in the Mexican economy occurred in 2020. The Covid-19 pandemic aggravated the recession that Mexico had suffered since 2019 (CIEN 2020).

## 4 Conclusions and Discussion

The economic effect of Covid-19 globally is a new phenomenon in this century. This year a contraction of 5.2% of world GDP is expected (World Bank 2020) and the economic impact covers at least a declining production, disruptions in the supply chain, and distortions in financial markets. In Mexico, the observed effects are negative growth rates in the primary, secondary, and tertiary sectors of the economy, a high degree of uncertainty about the future, greater poverty in different regions of the country, and unemployment, both formal and informal sectors of the country.

In this sense, this document shows the changes in the effect of Covid-19 on the economic activity of Mexico, considering the downward trend that the country has shown since July 2018. For this, in the section three, the description of the ARIMA model with the intervention was briefly presented. Also, the NIG probability distribution was presented to calibrate the Eq. (1) correctly. In this regard, additional elements were described in annexes 1 and 2 that made possible the estimates on the seasonally adjusted time series of the IGAE.

Section four presents the results found on the annual variation of the IGAE seasonally adjusted time series. Specifically, it was found that the explained variance due to Covid-19 is 44.20% and due to the administration on duty 18.89%. These two estimates quantify that Covid-19 came to aggravate the recessive economic situation that had been in place since 2019 and statistically confirm that the economic context of Mexico was already in terrible shape before Covid-19.

As a result, most of the economic cycle of the components of the IGAE exhibits a downward trend that must be reversed and for which an economic and industrial policy strategy with vision is required. The central point is to propose the strategies and mechanisms of economic policy that will allow facing and reversing the negative tendencies that Mexico's productive activities suffer. However, there is no plan; it is only expected that the entry into force of the T-MEC will attenuate the fall of the Mexican economy. Although the United States has its problems with a contraction of 32.9% in the second quarter of 2020 (El País 2020).

Mexico must rebuild its social and productive fabric with a comprehensive vision and strategy since the weight of the crisis is monumental for a mainly informal labor market. Furthermore, it should be noted that 94% of economic units are microenterprises, and 50% of economic growth; it depends on bigger companies. In other words, business composition is complex. Only an increase in investment will reverse the drop in growth and potential capacity of the IGAE. The mechanism to change it is found in investment and financing aimed at strategic sectors that can drive growth, employment, and productive chains.

In this regard, it is appropriate to specify that this scenario is only the beginning since the United States' recession and elections create uncertainty in decision-making. In other words, the proper economic policy measures for Mexico will not be clear. Besides, there is the possibility of a second closure of activities towards the end of the year 2020 due to Covid-19.

The limitations of this research are that the separation of the Covid-19 effect, in relation to the trend observed by the administration in turn, was carried out under a univariate model, where other relevant endogenous variables or other exogenous variables are not considered, thus as possible control variables. The presented model is reasonable and is strengthened by the goodness of fit that the NIG distribution achieves since it allows to estimate in the best possible way the coefficients and, therefore, the effects captured by the dummies in the ARIMA specification with intervention.

As future research lines, it is expected to expand the model to the multivariate case to analyze the decline in Mexico's economic activity from a broader perspective. For

this, it is desired to have more information in the following months and estimate an extended model in exogenous and endogenous variables.

**Annex 1 Generalized Hyperbolic Distribution**

This section briefly reviews the concepts that define the generalized hyperbolic distribution, and that allows us to robustly estimate the ARIMA model with the intervention of Eq. (1). The probability density function of a generalized hyperbolic random variable (GH) is defined as:

$$f_X(x;\lambda,\alpha,\beta,\delta,\mu)=\frac{k_{\lambda-1/2}\left((x-\mu)^2+\delta^2,\alpha^2\right)}{\sqrt{2\pi}k_\lambda\left(\delta^2,\alpha^2-\beta^2\right)}\exp[\beta(x-\mu)]. \tag{A.1}$$

where is $\delta \geq 0$ and $\lambda, \mu, \beta \in \mathbb{R}$ with $\beta \in [-\alpha, \alpha]$ (Paolella 2007). Intuitively, the parameters can be interpreted as follows:

a) $\alpha$ is a parameter that determines the tails' weight in the distribution, that is, the weight of the unlikely events.
b) $\beta$ is the parameter of bias. If it acquires a null value, then the distribution is symmetric around the expected value.
c) $\mu$ is a location parameter and is related to the expected value of the random variable. In the particular case that it is true that $\beta = 0$, then $\mu$ is the mathematical expectation.
d) $\delta$ is a parameter of "sharpness" and determines the magnitude of kurtosis, and it also controls the shape of the distribution around the mode.
e) $\lambda$ is a parameter of form that influences the dispersion of the random variable, around the mean and in the tails of the distribution.

If the parameters $\chi := \delta^2$ and $\psi := \alpha^2 - \beta^2$ are defined, then the expected value is:

$$E[X]=\mu+\beta\frac{k_{\lambda+1}(\chi,\psi)}{k_\lambda(\chi,\psi)} \tag{A.2}$$

and the variance:

$$V[X]=\frac{k_{\lambda+1}(\chi,\psi)}{k_\lambda(\chi,\psi)}+\beta^2\frac{k_\lambda(\chi,\psi)k_{\lambda+2}(\chi,\psi)-\left[k_{\lambda+1}(\chi,\psi)\right]^2}{\left[k_\lambda(\chi,\psi)\right]^2} \tag{A.3}$$

where $k_\lambda(\cdot)$ is the third order Bessel function, given by:

$$k_\lambda(\chi,\psi)=\int_0^\infty x^{\lambda-1}exp\left[-\frac{1}{2}\left(\chi x^{-1}+\psi x\right)dx\right] \tag{A.4}$$

and that gives the GH function great flexibility in adjusting financial returns Corlu et al. (2016). Table A.1 presents the different generalized density functions, which are obtained under different ranges of the parameters, $\lambda$, $\mu$, $\beta$ and $\alpha$. In the literature,