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The Indirect Effect of Coronavirus Disease (COVID-19) Pandemic on Economic Growth in Malaysia: Evidence from The ARDL Approach

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ABSTRACT

This study explores the indirect effect of corona virus (COVID-19) infections on economic growth in Malaysia using the industrial production index (IPI) as a proxy. Since the prevalence of COVID-19 infection, Malaysia's economy has experienced swindles in its growth, just like other countries economy, and the struggle for survival among countries in which Malaysia's economy is not exceptional becomes the current issue. This study incorporates the COVID-19 indirect impacts on economic growth which is conditional to COVID-19 deaths. It also explains a way forward for recuperation among economic sectors for faster economic growth in Malaysia. This paper uses the Auto Regressive Distributed Lag (ARDL) model to explore the indirect effect of COVID-19 infections on economic growth conditional on COVID-19 deaths in Malaysia. As an empirical study, the data used were monthly secondary data and were obtained from reliable sources. The findings from the results of the ARDL model, considering the unconditional model show that COVID-19 infections have a negative relationship with economic growth in Malaysia. The conditional models used to find the indirect impact of COVID-19 on economic growth considering the interaction of the variables at mean, maximum and minimum, prove that COVID-19 has an indirect negative effect on economic growth when COVID-19 deaths are at their mean and maximum. The marginal effect result shows a negative relationship and significance at 1%, indicating that increase in COVID-19 infections leads to decrease in economic growth in Malaysia conditional to COVID-19 deaths.

JEL Classification: L60, D24

Keywords: ARDL Model; COVID-19 Infections and Deaths; Industrial Production Index; Malaysia

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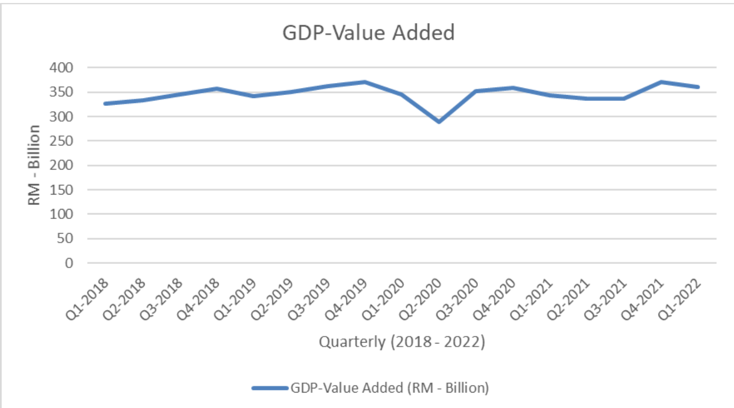
INTRODUCTION

Malaysia is a country with a diversified economic structure, sound financial system, effective public health response as well proactive macroeconomic policies which help in fostering the country's economic growth and development. With all these attributes, in the year 2009 Malaysia implemented a program known as "Malaysia Economic Monitor (MEM)", which its purpose is to achieve better-informed policy analysis and also debates on issues that are regarded as key challenges that the Malaysia economy experiences with its efforts to meet with rapid, sustainable and inclusive economic growth. The MEM has two parts, the first considers the review of recent economic developments and macroeconomic issues and the second part looks into some special topics which are key to Malaysia's development prospects, mostly as the country targets moving towards a high-income economy, World Bank (2017). Despite all these plans and programs, Malaysia's economic growth has slowed down over these few years but remained resilient to external headwinds. Malaysia's economic growth rate slowed from 5% in 2015 to 4.2% in the first three quarters of 2016. Consumption from the private sector slowed down as a result of the softening labour market and the households' amendment to the context of fiscal consolidation.

In addition, the public investment towards infrastructure is going through moderation in investment in the oil and gas industry. In Addition, it is expected that the gross domestic product (GDP) growth will be 4.2% in 2016, with a slow improvement towards acceleration, Munoz Moreno et al. (2017). Malaysia's economic growth increased tremendously in the first quarter of the year 2017. The government projection for the GDP growth rate in 2017 ranged from 4.3 to 4.8 percent. Surprisingly the GDP growth rate for 2017 is expected to increase to 4.9 percent, which is slightly above the government projection and anticipation. The current account surplus declined from 3.8% of GDP in the fourth quarter of 2016 to 1.6% in the first quarter of 2017. This is a result of strong gross import growth which is mainly of capital and intermediate goods, which outpaced the significant increases in gross exports and resulted to lower goods surplus, Simler et al. (2018)

In the third quarter of 2019, Malaysia's GDP slowed to 4.4%, because of the global conditions and heightened uncertainty which continued to affect the economy. Trade and investments were slower than expected during this quarter, while some businesses remain mute. In 2020, Malaysia's economy was expected to expand at a moderate pace irrespective of the uncertainty and external headwinds. The GDP growth rate was projected to be 4.5% in 2020. Also, investment was expected to improve but the outcome is that it remained subdued, with private and public sectors adopting a caution stand towards capital spending. Also, the slower movement in export growth continued in 2021.



Source: Department of Statistics Malaysia (DOSM) (2022)

Figure 1 Malaysia Quarterly GDP – Value Added, 2018 – 2022

Figure 1 above is the Malaysia quarterly GDP – value added from 2018 to 2022. The figure exposed the decrease associated with Malaysia's GDP from Quarter 4 of the year 2019 (Q4-2019). The decrease continued until quarter 2, 2020 (Q2-2020), which was the period Malaysia implemented the movement control order.

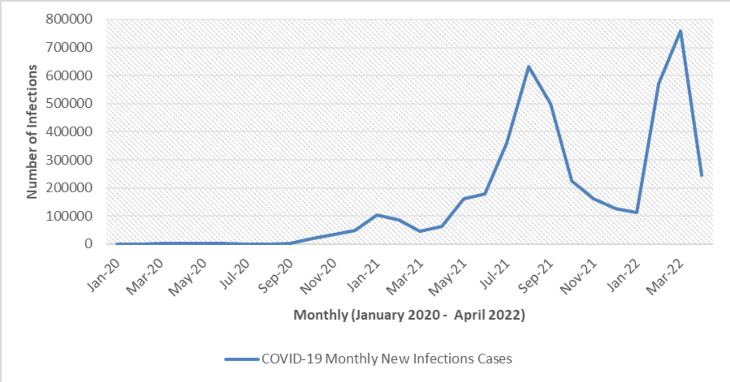
Source: Department of Statistics Malaysia (DOSM) (2022)

Figure 2 Malaysia Quarterly GDP – Percentage (%) Change, 2018 – 2022

Figure 2 is the quarterly GDP percentage change in Malaysia from 2018 to 2022. The figure shows that the percentage change of Malaysia's GDP started decreasing from quarter 3, 2019 and it had its worst decrease in quarter 2, 2020 which was the period MCO was enforced in Malaysia.

The coronavirus (COVID-19) pandemic started in the fourth quarter of 2019. Like other countries in the world, Malaysia economy has been severely affected by the COVID-19 pandemic. In 2020, Malaysia's economy was expected to contract by 3.1%, but in the first quarter of 2020, the growth rate slowed to 0.7%, which resulted in an effort by the Malaysia government to minimize the prevalence of the COVID-19 pandemic by enacting the series of movement control orders (MCO) but in the midst of uncertainty regarding the growth prospects and factors constituting to economic growth. It was believed that an output contraction of about 10% in the second quarter of 2020 is forecasted, relating to the impact of the economic disruptions resulting from the MCO imposed during the quarter. There was an implementation of short-term policies focused on measures to boost resilience and protect the vulnerable. The federal debt increased, and government revenue as a share of GDP declined and is even expected to decline further in the next year 2021, World Bank (2020). With all these challenges mitigating the Malaysian economy, Malaysia's anticipation of fostering economic growth and development of becoming a developed country becomes uncertain at present.

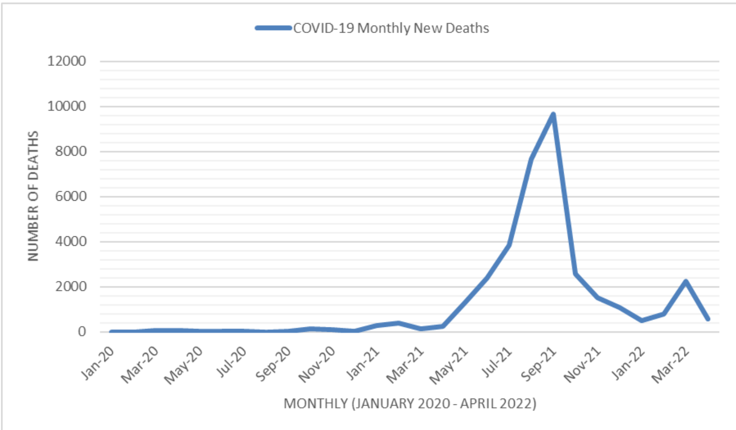
From the onset of COVID-19 prevalence in Malaysia, Malaysia has witnessed a steep increase in the number of COVID-19 new cases on daily bases. The poor act it which is disturbing is the number of deaths because by those infected with COVID-19. The increase in the number of new cases continues to evolve, from March 2020 to date, Malaysia has been recording a tremendous increase in daily cases of those infected with COVID-19. In addition to this, as the new cases surge, so also the number of deaths. The number of deaths in the first 2 weeks of June 2020 alone was more than 500. Worrying is that the number of brought-in dead (BID) cases increased sharply, and in May 2021, the number of BID accounts for about one-third of the total number of deaths resulting from COVID-19. The whole situation and the fear associated with the prevalence of COVID-19 in Malaysia is that the overall capacity of the health system was overwhelmed by this dangerous disease as the number of daily new cases and deaths continue to increase tremendously, irrespective of the containment measures like mass testing, contact tracing which was effectively implemented by the government, World Bank (2021).



Source: Ministry of Health (MOH) Malaysia (2022)

Figure 3 COVID-19 Monthly New Infection Cases in Malaysia, January 2020 – April 2022

Figure 3 depicts the monthly new infection cases of COVID-19 in Malaysia. The monthly new cases have experienced fluctuations but showed a high infection rate in March 2022. Following the surge in COVID-19 infections in Q3 2021, Malaysia is gradually emerging from the worst wave of the pandemic, irrespective of the number of deaths resulting from the COVID-19 pandemic as shown in Figure 4 below.



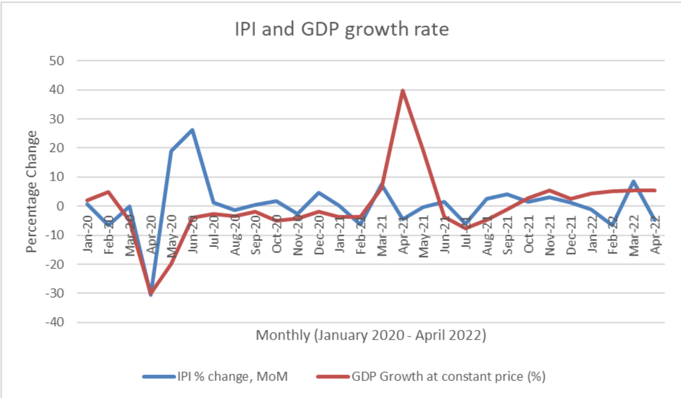
Source: Ministry of Health (MOH) Malaysia (2022)

Figure 4 COVID-19 Monthly New Death Cases in Malaysia, January 2020 – April 2022

Figure 4 shows the number of deaths in Malaysia on monthly bases resulting from the COVID-19 pandemic since its prevalence in Malaysia. The figure showed that the number of deaths was at its apex in September 2021 despite the fluctuations in the trend experienced within the time frame of this study. The roll out of the vaccination program in Malaysia has become a helping tool to control the negative effects the pandemic has caused in Malaysia's economic trajectory growth plan, taking into cognisant the industrial production index (IPI) of Malaysia.

The Industrial Production Index (IPI) covers three main sectors in the economy which are Mining, Manufacturing and Electricity sectors. The IPI measures the rate of changes in the production of industrial goods and commodities from different industries in the economy within a given period of time. The industrial production index (IPI) of Malaysia has been swinging since 2020 when the pandemic started. IPI grew 1.7 percent in December 2020 in comparison to the same month of the previous year 2019, as a result of the manufacturing index which increased by 4.1 percent. But the mining and electricity index decreased by 5.4 percent and 0.2 percent respectively. In August 2021, IPI marginally decreased by 0.7 percent when compared to August 2020. The decline is a result of the decrease in Mining and electricity index which were recorded to be -4.2 percent and -4.8 percent respectively. In addition, the Manufacturing index increased by 0.6 percent.

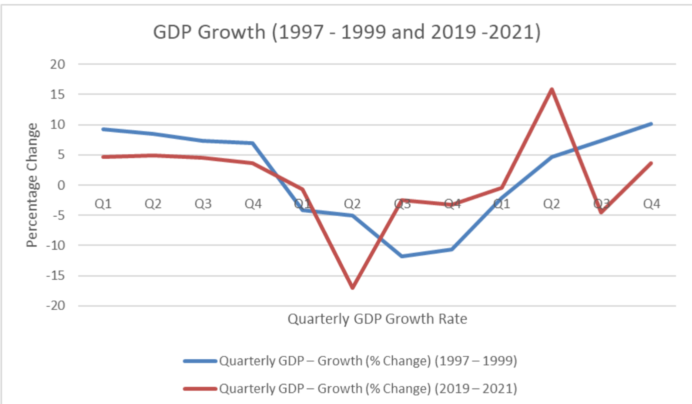
In November 2021, The IPI increased to 9.4 percent compared to the same month of the previous year. The expansion of IPI in November was the contribution to the increase in Manufacturing, electricity, and mining index which recorded 9.5%, 2.3% and 1.5% increases respectively. In December 2021, IPI increased to 5.8 percent as compared with December 2020. The expansion was a result of the increases in the manufacturing index of 8.4 percent and 3.4 percent from the electricity index. Meanwhile, the mining Index recorded a decrease of 2.5 percent. The Malaysia cumulative IPI increased to 7.4% in 2021 in comparison to the previous year which recorded a contraction of 4.2%. This fluctuation in the rate of changes of the IPI also affected the rate of changes in the gross domestic products (GDP). The figure below is the changes that occurred in IPI and GDP of Malaysia since January 2020.



Source: Department of Statistics Malaysia (DOSM) (2022)

Figure 5 Malaysia Monthly IPI and GDP – Percentage (%) Change, January 2020 – April 2022

Figure 5, shows the downward and upward swing of the IPI and GDP percentage change in Malaysia within the period of 2020 to 2022 which is the years the COVID-19 pandemic prevalence has been in its enormous in the country. Meanwhile, in May 2022, the IPI increased to 4.1 percent unlike its previous month of April 2021 which recorded a decrease of -4.8 percent, as well when compared to May 2021. The increase in the IPI was contributed by the Manufacturing and electricity sectors whose increase was recorded to be 6.9 percent and 2.8 percent respectively. In addition, the GDP growth had its worst decrease in April 2020 rating -30%. The fluctuations continued to date. The COVID-19 pandemic has resulted in an unprecedented crisis in the GDP and IPI of Malaysia which requires a large-scale and unconventional policy response by the Malaysian government. The COVID-19 economic shock in Malaysia is a resemblance to the 1998 Asia financial crisis which affected some Asian countries and Malaysia was not exceptional. The Asian financial crisis and COVID-19 have the same economic shock in Malaysia. Figure 6 below is the comparison between the COVID-19 pandemic and Asia financial crises in Malaysia using the Quarterly GDP growth rate in percentage from 1997 to 1999 for the Asian financial crisis period and 2019 to 2021 for the COVID-19 period to know which of this incidence has the highest shock in Malaysia economy.



Source: Bank Negara Malaysia (2000) and Department of Statistics Malaysia (2022)

Figure 6 Malaysia Quarterly GDP Growth – Percentage (%) Change, 1997-1999 and 2020 – 2022

Figure 6 is the plot of the quarterly GDP growth in percentage from 1997 -1999 which was characterized as the period of the Asia Financial crisis and from 2020 – 2022 which was also characterised as the period of the COVID-19 pandemic. The 2019 – 2022 period in Figure 6 proved to have the highest negative GDP growth (-17.1) which happened in quarter 2 (Q2) in 2021. This evidence proves that the COVID-19 pandemic shock in the Malaysian economy intensified than the shock of the Asian financial crises in the period 1997 -1999. Also considering the recovery values of the GDP growth, the 2019 – 2022 period was slower compared to the 2019-2022 GDP growth. This is a second proof that the negative impact and the economic shock manipulated by the COVID-19 pandemic is more to the Asian economic crises.

The government intervention in the Asia financial crises and also in the COVID-19 pandemic was different because the two economic situations were different. Asia's financial crisis was a result of currency devaluation which resulted in the failure of the currency market, stock market declines, reduced import revenues and a decrease in export of goods and services with government upheavals, while the COVID-19 pandemic was a result of the emancipation and prevalence of a new infectious disease that is deadly and can cause death in few days. International Monetary Fund (IMF), intervened during the Asia financial crisis by providing loans to the countries affected in order to stabilize their economies. Also during the COVID-19 crisis, the government of every country provided palliatives and financial support to their citizens, because the MCO governments embarked on stopping the spread of the diseases. In all, the intervention of the government during the two crises period was adequate for the citizens.

Considering the Covid-19 pandemic era, this study will answer the research question "What are the indirect effects of COVID-19 pandemic on economic growth in Malaysia?", by considering the research objective which is "to analyse the indirect effect of COVID-19 pandemic on Malaysia's economic growth, conditional to the death rates resulted from COVID-19 infections". The significance of this research is to contribute to the existing pieces of literature relating to the COVID-19 pandemic. Also, this study will intensify and clarify the indirect effect of the COVID-19 pandemic on economic growth in Malaysia by exposing and evaluating the importance of the number of deaths caused by COVID-19 to economic growth in Malaysia. The indirect assumption used in this study will inculcate the death rates as a major setback to economic growth in Malaysia hence the cause is known.

Furthermore, this study's significance lies in the assumption of many economic policymakers in Malaysia questioning the actual effect of the Covid-19 pandemic on Malaysia's economy, tending to focus on production, export and import as a result of MCO, failing to understand that the increasing death rate caused by COVID-19 may cause more economic harm even when the MCO is lifted. This study on the research outcome will make a suggestion that will help the government to manage and remodel the Malaysian economy in order to foster economic growth in this era as well as maintain healthy living for the people despite the continuous challenges posed by the Covid-19 pandemic in Malaysia economic growth. This study is organized as follows, section one is the introduction, followed by section two which is the literature review. Then there is section three which is the methodology and data, and section four which presents the estimation and analysis of the results. The last is section five, and it is the conclusion, policy implication and study limitation.

LITERATURE REVIEW

Theoretical Review

Because of the lack of economic theories supporting infectious diseases and economic growth, this study will consider the biological science theories, by adopting the Germ theory of diseases, Antoni Van Leeuwenhoek (1677) which explained how infectious diseases affect human beings which directly and indirectly affect economic growth. Germ Theory of diseases explains that the air we breathe, and the food and water intake of humans have the existence of microorganisms in them. These microorganisms are known as Germs or Pathogens, they intrude in the system of a human being via the food and water we eat and drink. The growth and reproduction of these germs in the host cause diseases. The increasing ability via reproduction of the germs in the host causes high severe infections from one person to another. The dwelling of these microorganisms in the environment people lives causes infectious diseases, Louis Pasteur (1860).

Therefore, the health outcome of the people considering the prevalence of infectious diseases (COVID-19) depends on the level of investment, people implement in their health system and wellbeing. Health outcome which is vital for economic growth has a direct relationship with the prevalence of infectious diseases. If the health outcome of the people in the economy is poor as a result of the prevalence of infectious diseases, the economic growth of the society will definitely dwindle because the labour force is weak. Hence health outcome is seen as both a consumption and investment goods, and the level of consumption and investment an individual engaged in his health, determines his health outcome and life span. Good health outcome leads to healthy living which fosters economic growth, Grossman (1972a, 1972b).

Empirical Review

Hasanat et al. (2020) in their study titled "The Impact of Coronavirus (Covid-19) on E-Business in Malaysia", using a primary data collection and survey of study analysis, concluded that Covid-19 has lowered the economic growth in Malaysia and because of lockdown (MCO), import and export dwindled. Also, Tong and Gong (2020) in their studies titled "The impact of COVID-19 on SME digitalization in Malaysia", using secondary data analysis explained that within a week of the lockdown, 70% of the SMEs reported a 50% drop in their business and a 20% increase on the Malaysia digital economic corporation. The study concluded that it is important for SMEs to participate in the digital economy if they are to survive and progress in the post-COVID world. Omar et al. (2020), studied "The impact of Covid-19 Movement Control Order on SMEs' businesses and survival strategies" by applying a qualitative approach conducted through phone call-based interviews with 6 SMEs owners and find out that there is a certain undiscovered impact of the control order towards SMEs in Malaysia. The study also pointed out that operation and supply chain disruption, cash flow imbalance and risk of bankruptcy evaded the SMEs' owners.

Menhat et al. (2021) in their studies titled "The impact of Covid-19 pandemic: A review on maritime sectors in Malaysia", explained that the COVID-19 pandemic affected many economic operations which were put on hold from operating as a result of the lockdown enacted by the government of many countries in order to contain the COVID-19 prevalence. Also, Hamdan et al. (2021), in their studies with the title "The covid-19 pandemic crisis on micro-entrepreneurs in Malaysia: impact and mitigation approaches", using primary data analysis suggested that the COVID-19 outbreak has a negative impact on micro-entrepreneurs in Malaysia as a result of different financial issues and operational disruption associated with the lockdown meant for the control of the COVID-19 prevalence. The study suggested a mitigation approach to the problem. Adnan and Nordin (2021) in their studies known as "How COVID 19 effect Malaysian paddy industry? Adoption of green fertilizer a potential resolution", lamented that in Malaysia, the COVID-19 pandemic has caused resilience in the agricultural sector and Malaysia depends on 30% food imports during the pandemic era which has caused a triple increase of foods like rice in Malaysia and insisted that the government of Malaysia should adopt a policy to increase the production sustainability.

METHODOLOGY AND DATA

Empirical Model

For this study's empirical model, there is a need to adopt the economic model to express the relationship that exists between the industrial production index (IPI) (dependent variable) and economic growth (EG), COVID-19 infections (CI) (new) and COVID-19 deaths (CD) (new) which are the independent variables. The model for IPI and its independent variables is emulated from the production function theory which explained how the output was specified as a function of factors of production which generally explained the relationship between physical outputs of a production process and inputs (factors of production). It explains the amount of products that can be obtained from every combination of factors. It evaluates the marginal productivity of a particular factor of production, i.e the change in output for every additional unit of the factor of production, Mishra (2007).

A mathematical expression that explains the relationship between outputs and inputs is:

$$Y = f(K, L, A) \tag{1}$$

where Y is output, K is capital, L is labour, and A is technical change, are inputs that are combined in different ratios to obtain Y, and f is the functionality, Solow (1956). This study adopts the same production function model stated in (1) to incorporate the effect of percentage changes in economic growth, Covid-19 infections and Covid-19 deaths as an input to the outcome of the Industrial Production Index (IPI). The advantage of this function form is that Industrial Production Index (IPI) depends on the level of Covid-19 infections and deaths as well percentage change of the economic growth which is compatible with the relationship usually estimated in micro and macro-economic studies.

$$IPI = f(EG, CI, CD) \tag{2}$$

It is important to understand that from equation 2, IPI represents Y, EG represents K, CD represents L and CI represents A as stated in equation 1. Continuing equation 2 is stated as:

$$IPI = EG^{\beta 1} CI^{\beta 2} CD^{\beta 3} \tag{3}$$

where IPI = Industrial Production Index, EG = percentage change of economic growth, CI = Covid-19 Infections, and CD = Covid-19 deaths. β_1, β_2 and β_3 measure the monthly rate of the independent variable incidences within the period of this research. Statistically, Equation (3) is reduced to the form:

$$IPI = A + \beta_1 EG_t + \beta_2 CI_t + \beta_3 CD_t + \varepsilon_t \tag{4}$$

For more understanding of the indirect effect of Covid-19 infections on economic growth, this study assumes the effects depend only on the multiplicative interactive terms, which will be associated in the model, Brambor et al. (2006). A more realistic multiplicative interactive model stated below would allow the indirect effect of Covid-19 infections on IPI in Malaysia which is conditional on COVID-19 deaths resulting from COVID-19 infections in Malaysia.

$$IPI = A + \beta_1 EG_t + \beta_2 CI_t + \beta_3 CD_t + \beta_4 CI*CD + \varepsilon_t \tag{5}$$

Also, it is important to include other constituent terms in the model as an interaction with the conditioning variable hence EG has to interact with CI as stated below:

$$IPI = A + \beta_1 EG_t + \beta_2 CI_t + \beta_3 CD_t + \beta_4 CI*EG + \varepsilon_t \tag{6}$$

where A = intercept; t = time; ε = error term; β_1, β_2, β_3, and β_4 are the coefficient of the independent variables and CI*CD and CI*EG are the interactive terms that made the model a multiplicative interactive model. For policy needs, we estimate the indirect effect of the Covid-19 pandemic, in particular its infections that cause deaths of the people in the society to the Industrial Production Index which is expected to have greater or lesser effects. Interactive models are different from linear models because of the marginal effects and standard errors associated with the models. The marginal effect of CI on IPI in the interactive models of equations 5 and 6 are conditioned on the interactive variables which are CD and EG as suggested by the multiplicative interactive theory, Brambor et al., (2006). The marginal effects are obtained through the following differential equations from equations 5 and 6 respectively:

$$\frac{\partial IPI}{\partial CI} = \beta_2 + \beta_4 CD \tag{7}$$

$$\frac{\partial IPI}{\partial CI} = \beta_2 + \beta_4 EG \tag{8}$$

The marginal effects are obtained from every given value of the conditioned variable. It is important to calculate the standard error which corresponds to each calculated marginal effects for each value of the conditioned variable. Below are the standard errors of the interactive models in equations 5 and 6 respectively.

$$\sigma \frac{\partial IPI}{\partial CI} = \sqrt{\text{var}\ (\beta 2)\ +\ \text{CD2var}(\ \beta 4)\ +\ 2\text{CDcov}(\beta 2, \beta 4)} \tag{9}$$

$$\sigma \frac{\partial IPI}{\partial CI} = \sqrt{\text{var}\ (\beta 2)\ +\ \text{EG2var}(\beta 4)\ +\ 2\text{EGcov}(\beta 2, \beta 4)} \tag{10}$$

Take note that COVID-19 deaths (CD) and percentage change in economic growth (EG) are the conditioned variables in Equations 7 and 8 respectively.

Methodology

The method of analysis used in this study is the Auto Regressive Distributed lag (ARDL) model approach. The reason for choosing the ARDL instead of Non-linear Auto Regressive Distributed Lag (NARDL) in this study is because there are no asymmetric (Square terms) variables in the model, all variables are linear despite the existence of the interaction of some variables in order to expose the indirect relationship in the model associate with the objective of the study. Secondly, because there are no Square terms in the model, there are no threshold/turning point characteristics existing in the model which suit the NARDL. This study will emulate from Brambor et al. (2006) to explain the interaction existing among the variables in the model in analyzing the relationship and indirect effect among the variables in the model.

This study initially conducted the unit root test among the variables in the model to find out their stationarity. The unit root test is conducted to know if the variables in the model are stationary at the level I(0), the first difference I(1) or mix mode, that is the variables are stationary both at I(0) and I(1). If all the variables are stationary at I(0), this study will not use the ARDL model approach for its estimation, rather the Ordinary Least Square (OLS) approach will be used because variables exhibit their stationarity at I(0) suits the OLS method of analysis. Also if the variables are stationary at I(1) or mix mode, then the ARDL method suits the analysis. Moreover, the ARDL method has the advantage over other methods like the OLS in the estimation of linear relationships among variables because the lag of the dependent variable can be used as an independent variable in the estimation process. Other methods of analysis lack this characteristic.

After conducting the unit root test, it proved that the variables in the model are stationary at mix mode, therefore this study continued to adopt the ARDL method for its analysis. ARDL bound test approach is the first conducted which is to examine the cointegration existing between variables during the period of study. This test is done by computing the F-statistic to find the significant level of the variables. When F-statistic value is higher than the upper bound critical value, it implies there is cointegration between the variables**.** When the F-statistics is below the lower bound critical value, it implies there is no cointegration between the variables and when the F-statistic is between the lower bound and upper bound critical values, it implies the result is inconclusive. The hypothesis for the ARDL bound test is stated as:

$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ (There is no cointegration between the variables)
$H_1 : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$ (There is cointegration between the variables)

After the estimation of the ARDL bound test, the next is the estimation of the coefficient relationship test between the variables to find out the equilibrium relationship between the dependent and independent variables. The formula is stated as:

$$\text{IPI}_t = A + \sum_{i=1}^{P} \beta_1 \text{IPI}_{t-i} + \sum_{i=0}^{q} \beta_2 \text{EG}_{t-i} + \sum_{i=0}^{r} \beta_3 \text{CI}_{t-i} + \sum_{i=0}^{s} \beta_4 \text{CD}_{t-i} + \sum_{i=0}^{T} \beta_5 \text{CI*CD}_{t-i} + \varepsilon_t \tag{11}$$

$$\text{IPI}_t = A + \sum_{i=1}^{P} \beta_1 \text{IPI}_{t-i} + \sum_{i=0}^{q} \beta_2 \text{EG}_{t-i} + \sum_{i=0}^{r} \beta_3 \text{CI}_{t-i} + \sum_{i=0}^{s} \beta_4 \text{CD}_{t-i} + \sum_{i=0}^{T} \beta_5 \text{CI*EG}_{t-i} + \varepsilon_t \tag{12}$$

Estimation of the coefficient relationship is the next test after the ARDL bound test. This is to find out the equilibrium relationship that exists between the dependent and independent variables. The formula is thus:

$$\text{InIPI}_t = A + \sum_{i=1}^{P} \beta_1 \text{InIPI}_{t-i} + \sum_{i=0}^{q} \beta_2 \text{InEG}_{t-i} + \sum_{i=0}^{r} \beta_3 \text{InCI}_{t-i} + \sum_{i=0}^{s} \beta_4 \text{InCD}_{t-i} + \varepsilon_t \tag{13}$$

The next is the estimation of the Error Correction Model (ECM) which is conducted to measure the speed at which the variables adjust as well as restore equilibrium in the dynamic model. The test formula is stated as:

$$\Delta IPI_t = \delta_0 + \varphi\, ECT_{t-1} + \sum_{i=1}^{P} \delta_1 \Delta IPI_{t-i} + \sum_{i=0}^{q} \delta_2 \Delta EG_{t-i} + \sum_{i=0}^{r} \delta_3 \Delta CI_{t-i} + \sum_{i=0}^{s} \delta_4 \Delta CD_{t-i} + \sum_{i=0}^{T} \delta_5 \Delta CI{*}CD_{t-i} + \varepsilon_t \quad (14)$$

$$\Delta IPI_t = \delta_0 + \varphi\, ECT_{t-1} + \sum_{i=1}^{P} \delta_1 \Delta IPI_{t-i} + \sum_{i=0}^{q} \delta_2 \Delta EG_{t-i} + \sum_{i=0}^{r} \delta_3 \Delta CI_{t-i} + \sum_{i=0}^{s} \delta_4 \Delta CD_{t-i} + \sum_{i=0}^{T} \delta_5 \Delta CI{*}EG_{t-i} + \varepsilon_t \quad (15)$$

The φ in equations 14 and 15 is the error correction term. It is the parameter that measures the speed of adjustment. A good and stable ECM should have a negative sign and be statistically significant, Pahlavani et al., (2005). The diagnostic test is the next test. The cusum and cusum of the square test check the stability of the model. The auto serial correlation test is conducted to find the correlation existing between the variables in the model. A heteroscedasticity test is conducted to check if there is an existence of non-constant variance in the model.

Data Sources and Justification of the Sample Size

The sources for data are important in every research and study mostly when the data is secondary. Data can be collected from different sources mostly from trusted agencies and sources. This study used secondary data and most of them are collected from the Department of Statistics Malaysia (DOSM), Ministry of Health Malaysia and Bank Negara Malaysia. The collected data are monthly time series starting from January 2020 to April 2022 which is 28 months of observation.

Table 1 Data Sources and Justifications

NO.	DATA	SOURCE	MEASUREMENT
1	Industrial Production Index, (January 2020 – April 2022)	DOSM	Percentage (%) change, month on month in Malaysia
2	GDP Growth at constant price (January 2020 – April 2022)	DOSM	Percentage (%) change, month on month in Malaysia
3	COVID-19 new infection cases (January 2020 – April 2022)	Ministry of Health Malaysia (MOH)	Total number of New infections, monthly
4	Covid-19 new deaths(January 2020 – April 2022)	Ministry of Health Malaysia (MOH)	Total number of New Deaths, monthly

Table 1 presents the sources and justifications of the variables used in this study. The dependent variable is IPI, which was the percentage change in total production in Malaysia monthly. The independent variables are GDP growth at a constant price (EG), i.e. the percentage of monthly GDP growth in Malaysia within the period of study. Another independent variable is COVID-19 new infections cases (CI), it is the monthly total number of individuals infected with COVID-19 diseases. Finally, is CD which is the COVID-19 total number of deaths monthly.

RESULT ESTIMATION

Descriptive statistics

Table 2 is the descriptive statistics of the variables, it shows the months of observation (obs), the mean standard deviation (Std. Dev), maximum (Max) and minimum (Min) values of all the variables used in this study. It is depicted that CI is highest in Maximum value (759183.0) and also the highest in minimum value (8.0) indicating the CI is high in Malaysia.

Table 2 Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Max.	Min
IPI	28	0.4607	9.3998	26.3000	-30.5000
EG	28	0.0321	11.6953	39.7000	-30.0000
CI	28	158730.5	213450.7	759183.0	8.0000
CD	28	1265.750	2322.521	9667.000	0.00000
CI*CD	28	5.38E8	1.28E9	4.84E9	0.00000
CI*EG	28	303974.3	1486689.0	1486689.0	-2975030.0

Also, the computation of descriptive statistics will help for the calculation of marginal effects considering the mean, minimum and maximum values of the multiplicative interactive terms.

Covariance Matrix

Also, table 3 is the covariance matrix table which is used to calculate the standard error of the marginal effect of the interactive variables. The covariance matrix also shows the diagonal relationship associated with all the variables in the model. Consider for example, the relationship between IPI and EG is positive with a value of 11.0962, also the relationship between CI and EG is positive at 298872.3 as well between CI and 1PI is 59090.3 proving that there is a positive correlation and the prevalence of CI does not affect IPI and EG negatively. On the contrary, the relationship between CD and EG is negative (-604.34) which implies that an increase in CD leads to a decrease in EG which will definitely affect IPI because IPI and EG have a direct relationship.

Table 3 Covariance Matrix of coefficient of IPI model

E(VI)	IPI	EG	CI	CD	CI*CD	CI*EG
IPI	85.2016					
EG	11.0962	131.895				
CI	59090.3	298872.3	4.39E10			
CD	1389.31	-604.34	3.37E8	5201458		
CI*CD	-7.35E8	1.95E14	2.77E12	1.58E18		
CI*EG	312260.9	9292605	5.33E10	-1.10E9	-5.70E14	2.13E12

Table 3 is the covariance matrix for coefficients of the variables. It explains the relationship of the variables whether they are negative or positive. For example, the relationship between CD and EG is negative (-604.34), and CI and CD are 3.37E8. The covariance matrix coefficient relationship does not give a complete analysis of the relationship among the variables. This study will continue with other necessary analyses needed to ascertain the objective of this study.

Unit Root Test

The unit root test was performed using the Augmented Dickey Fuller (ADF) test to find the stationary properties of the variables used in this study. Also, the Philip Perron (PP) unit root test was conducted to confirm the ADF test result. The variables can be stationary at the level I(0), at the first difference I(1), at the second difference I(2) or at mix mode. If a variable fails to be stationary at I(0), I(1) or I(2) using ADF or PP test, then another test known as Kwiatkowski-Philips-Schmidt-Shin (KPSS) unit test can be conducted to ensure that the variable must exhibit a stationary character in any of the levels.

Table 4 Unit Root Test Result

	ADF TEST		PP TEST	
	Constant	Constant and Trend	Constant	Constant and Trend
	LEVEL			
IPI	-5.4990***	-5.3851***	-6.4987***	-6.2840***
EG	-3.6458**	-4.6229***	-2.6416*	-2.8263
CI	-1.9442	-2.4402	-2.1223	-2.7108
CD	-2.0328	-2.5251	-2.0328	-2.0653
CI*CD	-3.2251**	-3.4167*	-2.5986	-2.6899
CI*EG	-3.6850**	-3.6262*	-2.6247	-2.5264
	FIRST DIFFERENCE			
IPI	-6.3042***	-6.1740***	-17.3794***	-17.4851***
EG	-53836***	-5.2526***	-5.3890***	-4.7723***
CI	-0.7914	-0.3732	-1.6467	-1.0075
CD	-4.3461***	-4.2734**	-4.2670***	-4.4023***
CI*CD	-4.9613***	-4.8708***	-4.5440***	-4.4023***
CI*EG	-6.0578***	-5.8481***	-2.5959	-2.1122
	SECOND DIFFERENCE			
CI	-8.2541***	-8.6421***	-1.5529	-1.2386
	KPSS UNIT TEST			
CI	0.6268**	0.1158	0.1954	0.1707**

Note: Significant level *10%, **5%, and ***1% respectively.

Table 4 above is the unit root test results of all the variables (including the multiplicative terms) used in the model. It shows that IPI, EG, CI*CD and CI*EG are stationary at the level I(0) and the first difference I(1), while CD is stationary at the first difference I(1). CI is not stationary at the level and first difference considering the ADF and PP test. In addition, CI was stationary at the second difference I(2) with the ADF test result as well as stationary at I(0) and I(1) with the KPSS unit test result. Therefore, the result of the unit test is in agreement with the ARDL model testing approach.

ARDL Bound Test

The ARDL bound test for cointegration connects with the comparison between the F-statistics and critical values. The result of the ARDL bound test shown in Table 5 below comprises the unconditional model, conditional model (1) and conditional model (2).

Table 5 ARDL Bound Test Result

Unconditional Model			Conditional Model (1)			Conditional Model (2)		
Variables: (IPI/EG, CI, CD)			F (IPI/EG, CI, CD, CI*CD)			F(IPI/EG, CI, CD, CI*EG)		
F-Statistics: 7.51***			F-Statistics: 6.05***			F-Statistics: 7.90***		
K = 3; N = 27			K = 4; N = 27			K = 4; N = 27		
Critical Values	*I*(0)	*I*(1)	Critical Values	*I*(0)	*I*(1)	Critical Values	*I*(0)	*I*(1)
1%	4.61	5.966	1%	3.29	4.37	1%	3.29	4.37
5%	3.27	4.306	5%	2.56	3.49	5%	2.56	3.49
10%	2.67	3.58	10%	2.2	3.09	10%	2.2	3.09

Note: Significant level at the *10%, **5%, ***1%

Table 5 above is the result of the ARDL test considering the unconditional and conditional models 1 and 2 which shows that during the period of study, there is cointegration existing among the variables in the models at a 1% significant level. This is because the F-statistics value of the unconditional model is 7.51 and the F-statistics of the conditional models (1) and (2) are 6.05 and 7.90 respectively, these values are greater than the upper bound I(1) value of 5.966 for the unconditional model and the upper bound value of 4.37 for the conditional models 1 and 2 respectively. Therefore, this study concludes that all the variables in the models adopted in this study are cointegrated.

Coefficient Estimation

The result of coefficient estimation proves a relationship between Industrial Production Index (IPI) which is a proxy for economic growth, GDP percentage change (EG), COVID-19 infections (CI) and COVID-19 deaths (CD). Because, since the objective of this study is to find the indirect effect of CI on IPI, this study included conditional models 1 and 2 in order to achieve its aim. Further, the magnitude of the coefficient may not be used in the conclusion of the relationship in this study because every conditional model exhibits a marginal effect which is mostly used for the conclusion of the impacts of the variables in the model. The result of the coefficient estimation presented in Table 6 below will help to calculate the marginal effects of the independent variable on the dependent variable.

Table 6 Coefficient Estimation

Variables	Unconditional Model	Conditional Model (1)	Conditional Model (2)
EG	-0.081(0.6235)	-0.1104(05462)	-0.4402(0.1198)
CI	-8.05E-7(0.9411)	1.49E-6(0.9030)	-3.57E-5(0.1118)
CD	0.0003(0.7453)	0.0015(0.6013)	0.0042(0.0723)
CI*CD		-2.52E-9(0.6600)	
CI*EG			6.64E-6(0.0673)
Constant	0.1437	-0.4019	-1.4329
ARDL Lag	1,1,0,0	1,1,0,0,0	1,1,1,0,1

Note: Significant at *10%, **5% and ***1%. The numbers in bracket are the probability values of the coefficient.

From Table 6, considering the unconditional model, EG and CI show a negative relationship with IPI but the relationship is not significant. It simply implies that any increase in CI and EG leads to a decrease in IPI. Under normal circumstances, EG is supposed to have a positive relationship with IPI, but the high prevalence of CI within the study period has affected EG until it has a reverse relationship with IPI, such that even when IPI is increasing, EG will be decreasing. CD also shows a positive relationship with IPI as well not significant, but this study will not determine the mentioned relationship between CD and IPI in anticipation of the marginal effect result, knowing that it is a conditional variable.

In addition, the impact of COVID-19 infection (CI) on economic growth (IPI) is the condition on the COVID-19 deaths (CD). To achieve the indirect effect of COVID-19 infection on economic growth (IPI), CI has interacted with CD. The result is shown in Table 6 as the conditional model (1). The conditional mode (2) in table 6 is the interaction of GDP percentage change (EG) and CD as a constituent variable in the model. The coefficients of the constitutive terms (CI*CD) and (CI*EG) in the conditional models (1) and (2) in Table 6, cannot be interpreted as a linear model (unconditional model). The coefficients of the conditional models are used to calculate the marginal effects of the conditional variable in order to predict the result of the effects, Brambor et al. (2006).

Error Correction Model (ECM)

The ECM determines the short-run dynamics in the model. The Error correction term (ECT)(CointEq(-1)* is the speed of adjustment toward the long-run equilibrium. The result of this test is presented in Table 7 below.

Table 7 ECM Result

	Dependent Variable: ΔIPI		
	Conditional Model Coefficient	Unconditional Model(1) Coefficient	Unconditional Model(2) Coefficient
CointEq(-1)*	-1.139***	-1.146***	-1.0734***
Probability	0.0000	0.0000	0.0000

Note: Significant level at *10%, **5% and ***1%.

Table 7 is the result of the ECM. The unconditional and conditional models (1) and (2) results as tabulated show that the ECT (CointEq(-1)) falls within the value of 0 and 1 (-1.139, -1.146 and -1.0734 respectively) and all the ECT are negatives as well they are significant at 1% level, indicating that the result lies in accuracy and satisfaction of the ECM criteria, Banerjee et al., (1998). Therefore, the speed of adjustment of the variables in the models towards the long-run equilibrium is thus normal. Any disequilibrium in the model in the short-run will take 11.3%, 11.4% and 11.0% to adjust to equilibrium within the period of this study in consideration of the models respectively.

Stability of the Models

The stability of the model is also examined for the long-term and short-term variables in the model to make sure that the robustness of the specified models both in the long-run and short-run have stability coefficients. This stability is tested using the CUSUM and CUSUMSQ considering both the unconditional and conditional models. See Figures 7, 8 and 9 below.

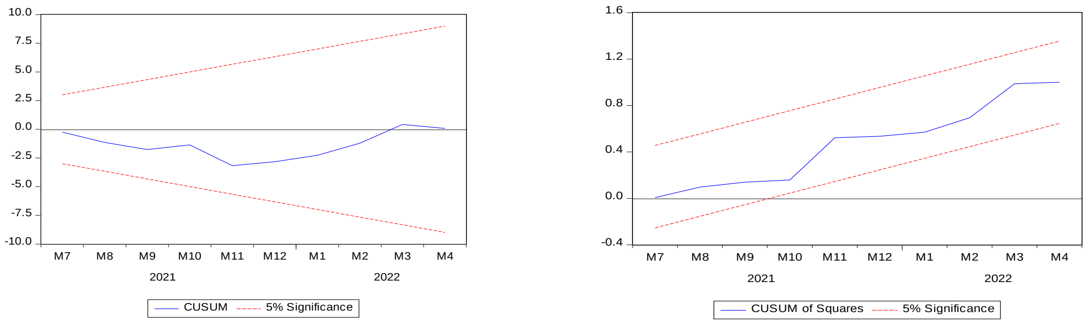


Figure 7 Cusum and Cusumsq Test for the Unconditional Model

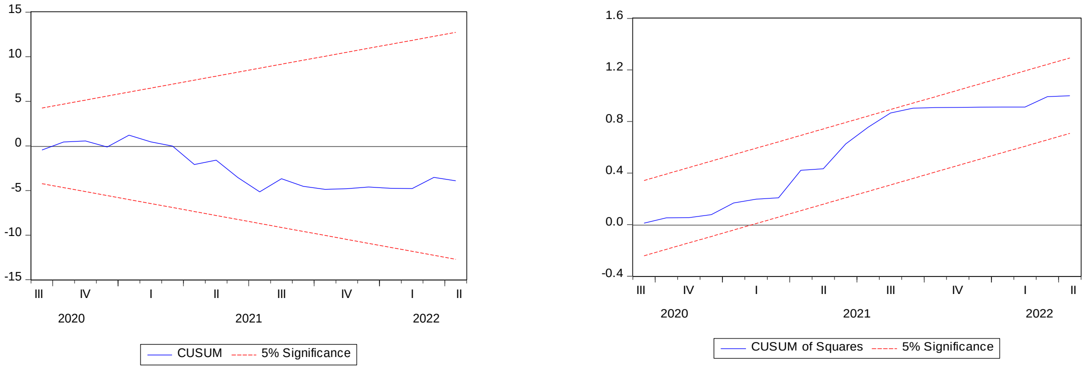


Figure 8 Cusum and Cusumsq Test for the Conditional Model (1)

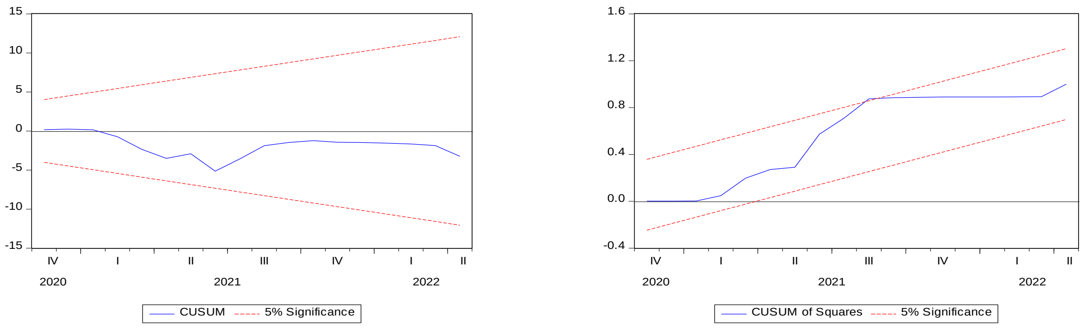


Figure 9 Cusum and Cusumsq Test for the Conditional Model (2)

From the result of the stability test, all the specified models are stable because all the test lines fall within the boundary of the 5% significance level. Hence there is a long-run relationship and stability of coefficient existing among the variables in the models over the sample period of January 2020 – April 2022.

Diagnostic Test

Having concluded the stability test, the next test is the diagnostic test, which is the serial correlation and heteroscedasticity test. These tests are to check if there is any problem with serial correlation and constant variance existing in the models. See Table 8 below.

Table 8: Serial Correlation and Heteroscedastic Test

	Unconditional Model		Conditional Model (1)		Conditional Model (2)	
Test-Stat.	Obs*R-Square	Prob.	Obs*R-Square	Prob.	Obs*R-Square	Prob.
Serial Correlation	3.5928	0.1659	7.8000	0.1176	12.043	0.2822
Heterosce-dasticity	3.5411	0.6172	11.7619	0.3818	4.8565	0.7728

Table 8 is the Serial Correlation and Heteroscedastic test result. The test for serial correlation indicates that there is no serial correlation problem in the unconditional and conditional models (1) and (2) because the value of Obs*R-square in the models is greater than the value of the prob. chi-square. The recorded values of the Obs*R-square are 3.5928, 7.8000 and 12.043 respectively while the value of the prob. Chi-square is recorded as 0.1659, 0.1176 and 0.2822 respectively. Converting the prob. chi-square to percentage, it is 16.59%, 11.76% and 28.22% respectively, which is above the 10% significance level indicating there is no serial correlation problem in the models. The same result analogy is applicable to the Heteroscedasticity test, hence there is no residual heteroscedasticity or constant variance in the model.

Marginal Effects (Indirect Impact) of COVID-19 infections on Economic Growth (IPI)

The indirect impact of COVID-19 infections on economic growth (IPI) is predicted from the marginal effect of COVID-19 infection (CI) on COVID-19 deaths (CD) and percentage increase in GDP (EG). Table 9 is the results.

Table 9 Marginal effects of Covid-19 Pandemic infection on Economic Growth

CD as the conditioning variable				EG as the conditioning variable			
CD	Marginal Effect	Standard Error	T-statistics	EG	Marginal Effect	Standard Error	T-statistics
Mean	-1.6E-6***	1.59E12	0.0000	Mean	-3.5E-5***	222523.3	0.0000
Max	-2.2E-5***	1.21E13	0.0000	Max	2.27E-4***	57916093.6	0.0000
Min	1.44E6	209523.2	6.87	Min	-2.3E-4***	43747524.5	0.0000

Source: Author's Computation 2022. Note: Significant at *10%, **5%, ***1%.

The marginal effect (indirect impact) of COVID-19 infections on economic growth (IPI) depends on the value of the conditional variables which are CD and EG. The marginal effects is calculated based on the formula $\frac{\partial IPI}{\partial CI} = \beta_2 + \beta_4 CD$ and $\frac{\partial IPI}{\partial CI} = \beta_2 + \beta_4 EG$ according to table 9 above. The standard error is calculated based on the formula given in equations 9 and 10 respectively and the t-statistics is the quotient between marginal effect and standard error. The mean, maximum and minimum values of CD and EG used in the calculation are obtained from the descriptive statistics in table 2, the β_2 and β_4 used in the calculations are obtained from coefficient estimation and table 6 for the conditional models. And Var(β_2), Var(β_4) and Cov(β_2 β_4) used in the calculation of the standard error are obtained from the Covariance Matrix of coefficient of IPI model in Table 3.

Table 6 column 2 is the result of the conditional variable COVID-19 deaths (CD). The constitutive terms are COVID-19 infections (CI) and CD which made up the interaction term (CI*CD). The coefficient of CI is positive (1.49E-6) and but it is not significant, while the coefficient of the interactive term is negative (-2.52E-9) but not significant too. Also, the marginal effect values from table 9 when CD is at mean and maximum are -1.6E-6, -2.2E-5 and they are negative and significant at a 1% level, as well as the minimum value of 1.44E6 which is positive but not significant. The marginal effect result proves that if CI increases by 1%, when CD is at its mean and maximum then economic growth (IPI) will decrease by 1.6E-6 and 2.2E-5 respectively and when CD is at its minimum, CI has no impact on economic growth (IPI), hence the relationship is positive but has no significant impact.

Column 3 of Table 6 is the column that contains the conditional model result where the percentage change of GDP (EG) is the conditioning variable. The coefficient (-3.57E-5 and 6.64E-6) of CI and interactive terms (CI*EG) appeared negative and positive respectively. In table 9, the marginal effect's values (-3.5E-5, 2.27E-4 and -2.3E-4) of CI on EG appeared negative at mean, positive at maximum and negative at minimum respectively and they are significant at the 1% level. The positive results imply that CI impact on IPI is positive mostly when EG is at its maximum and also negative when EG is at its mean and minimum. It implies that a 1% increase in CI will lead to a 2.27E-4% increase of IPI when EG is at its maximum. Also, any 1% increase in CI will lead to a 3.5E-5% and 2.3E-4% decrease of IPI when EG is at its mean and minimum. In conclusion, when CD is at mean and maximum, an increase in CI leads to a decrease in IPI, and when EG is at its mean and minimum increase in CI leads to decrease in IPI, but when EG is at its maximum, increase in CI does not affect IPI hence it will continue to increase. Finally, when CD is at its minimum, CI has no impact on IPI in Malaysia.

CONCLUSION

Conclusion

This study focused on the indirect effect of COVID-19 infection on economic growth (IPI) in Malaysia. The motivation for this study is a result of the increase in COVID-19 infections and deaths, as well as how it affected economic activities which have resulted in an economic meltdown in Malaysia. These resulted in joblessness, reduction in workers' salary, increase in the price of goods and services, and reduction in production. These entire economic malfunctions as a result of COVID-19 infection need to be engaged. This study has come to the following conclusions.

First, COVID-19 infections (CI) have truly affected Malaysia's economic growth (IPI), because there is proof of the indirect impact of CI on IPI which is dependable on CD and EG in Malaysia. Secondly, the marginal effect result proved that when CD is at its minimum, CI has no impact on IPI and when EG is at its maximum, the relationship between CI and IPI is positive. Therefore, there is a need for the government to enforce a strategy to reduce CD to its minimum through vaccination programs and increase EG by supporting the economic agents and activities.

Finally, Malaysia's economic growth has been hit by the pandemic with slow annual growth since the commencement of the pandemic. The government's efforts to maintain healthy living and a good standard of living among Malaysians become a big challenge to the government. The government's attention is now focused on rebuilding the country's economy considering the negative effect of the Covid-19 pandemic in Malaysia which has as well affected the whole world.

Policy Recommendation

For the Malaysian economy to recover from the negative effect of Covid-19, the government of Malaysia should give good financial support to Small and Medium Enterprises (SMEs) to boost them to continue operations in Malaysia. These will help increase employment in Malaysia, hence the financial support will help to revive businesses that have crashed because of the pandemic. The money or palliatives the government is giving to their citizens should stop, the money should be channelled to financial support for SMEs.

Government must actively involve the private health care system across the country for the establishment or restoration of good health outcomes by giving them license to join the ongoing covid-19 vaccination in the country. This will help to speed the process in order to bring normalcy at a faster rate to the whole country/economy. Government should implement a speedy and compulsory vaccination plan to the people and allow people to go on their daily business and activities. Staying indoors for a long time can cause death or commit suicide by the citizens. The vaccination should not be limited to Malaysians only but to all residents (both legal and illegal immigrants) in Malaysia. Government should provide a mobile vaccination system to help those who have less mobile to vaccination centres.

Limitations of Study

This study focused on the effect of Covid-19 infections on Malaysia's economy using the IPI to denote economic growth. There are other proxies that are more relevant to be used as a proxy for economic growth, one of such variables are gross domestic product per capita. This study is an empirical study that used secondary data. The monthly secondary data were taken from January 2020 to April 2022. But COVID-19 infections are still increasing when this research was conducted. So further or future research may give a different result. Also, primary data research may also give a different result because there may be some people infected with COVID-19 that the government may not know about. Finally, further studies may use different techniques in their analysis.

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