



University of
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THE ECONOMICS OF COVID-19 PANDEMIC: ASSESSING THE MACROECONOMIC IMPACT

A Thesis submitted by

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ABSTRACT

Severe Acute Respiratory Syndrome (SARS-COV-19) is a viral respiratory disease that emerged at the end of 2019, leading to devastating economic consequences globally and significant financial losses. The main objective of this thesis is to comprehensively analyse the macroeconomic impacts of COVID-19 with a primary focus on OECD countries. The motivation for this study is rooted in profound shifts in macroeconomic variables and policy measures due to the coronavirus outbreaks. Therefore, the overall purpose is to identify the implications of unprecedented economic shocks such as a pandemic, and to develop strategies to navigate the economic challenges these shocks pose, focusing on both immediate and long-term effects. This thesis, structured as a PhD thesis by publication, comprises six research articles including a systematic literature review. Data was collected from the Oxford COVID-19 Government Response Tracker (OxCGRT), the International Monetary Fund database and Organisation for Economic Cooperation and Development (OECD) database at fortnightly and quarterly intervals for OECD countries. Initially, a systematic, PRISMA-guided literature review is conducted to better understand COVID-19's economic implications and identify gaps in the existing literature. Subsequent studies examine fiscal and monetary policy changes, evaluate the efficacy of government strategies to combat the impacts of the pandemic, conduct a cost analysis of the COVID-19 pandemic, and assess the macroeconomic impact of vaccinations in relation to various macroeconomic factors, providing valuable policy insights. The results of the six studies reveal that: (1) the pandemic has behaved as a systematic shock on macroeconomic variables, (2) it is imperative to expand fiscal support during pandemics, even amid low tax revenue and high creditworthiness, (3) swiftly transitioning patterns of monetary policy measures in response to economic shocks like pandemics are important, (4) income support, debt relief facilities and stringent government standards are associated with reduced infection and death rates, (5) an inpatient's per-day unit cost is estimated to be AUD 836, with the hospital bed occupancy rate being a highly significant proxy for the cost of a COVID-19 patient, and (6) COVID-19 vaccinations are associated with an increase in economic growth and a reduction in both price levels and unemployment. Overall, accurate macroeconomic policy decisions, enhanced income support, and debt relief, combined with enforcing strict public health guidelines and ensuring a safe environment for workers and customers, along with proper healthcare cost management and efficient distribution and administration of vaccines, can foster a resilient and sustainable economic recovery.

CERTIFICATION OF THESIS

I Imalka Wasana Rathnayaka declare that the PhD thesis entitled *The Economics of COVID-19 Pandemic: Assessing the Macroeconomic Impact* is not more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references, and footnotes.

This thesis is the work of Imalka Wasana Rathnayaka except where otherwise acknowledged, with most of the contribution to the papers presented as a Thesis by Publication undertaken by the student. The work is original and has not previously been submitted for any other award, except where acknowledged.

Date: 22 Feb 2024

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STATEMENT OF CONTRIBUTION

The following detail outlines the agreed share of contribution for candidate and co-authors in the published and submitted papers presented in this thesis:

Paper 1:

Rathnayaka, I.W., Khanam, R. and Rahman, M.M. (2023), "The economics of COVID-19: a systematic literature review", *Journal of Economic Studies* Vol. 50 No. 1, pp. 49-72. <https://doi.org/10.1108/JES-05-2022-0257>.

Imalka Wasana Rathnayaka contributed 70% of the paper. Collectively Professor Rasheda Khanam and Professor Mafiz Rahman contributed to the remainder. This paper is recognised as the most cited article in the journal for the year 2023.

Paper 2:

Rathnayaka, I.W., Khanam, R. and Rahman, M.M. (2024) Fiscal support during the COVID-19 pandemic and its determinants: evidence for OECD countries, *Journal of Economic Policy Reform*, <https://doi.org/10.1080/17487870.2024.2302123>.

Imalka Wasana Rathnayaka contributed 65% of the paper. Collectively Professor Rasheda Khanam and Professor Mafiz Rahman contributed to the remainder.

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Imalka Wasana Rathnayaka contributed 65% of the paper. Collectively Professor Rasheda Khanam and Professor Mafiz Rahman contributed to the remainder.

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Imalka Wasana Rathnayaka contributed 75% of the paper. Collectively Professor Rasheda Khanam and Professor Mafiz Rahman contributed to the remainder.

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Imalka Wasana Rathnayaka contributed 70% of the paper. Collectively Professor Rasheda Khanam and Professor Mafiz Rahman contributed to the remainder.

This thesis has also contributed towards several engagements:

1. Virtual Higher Degree by Research Seminars, organised by School of Business, University of Southern Queensland in 2021.
2. Showcase Event in Health Economics and Technology, organised by Centre for Health Research, University of Southern Queensland in 2021.
3. Three Minutes Thesis Competition organised by University of Southern Queensland in 2022.
4. Promoting Doctoral Student Wellbeing and Excellence Workshop, organised by the International Doctoral Education Research Network, Australia in 2022.
5. 29th Early Career Research Symposium, organised by the University of Southern Queensland in 2023.

6. Asian Universities Alliance Academic Conference on Public Health Resilience in the COVID-19 Pandemic in 2023 and awarded best oral presentation award in Health Economics.
7. 30th Early Career Research Symposium, organised by University of Southern Queensland in 2023.
8. 44th Australian Health Economic Society Conference, organised by Australian Health Economic Society in 2023.
9. Virtual Poster Showcase and Competition, organised by Graduate Research School, University of Southern Queensland and awarded runner up in 2023.
10. Australian Research Council Kathleen Fitzpatrick PhD Thinkers Program organised by Australian Research Council in 2023.

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ABBREVIATIONS

Abbreviation	Definition
AIC	Akaike Information Criteria
ADF	Augmented Dickey-Fuller
ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
ARDL	Autoregressive Distributed Lag
CHOICE	Choosing Interventions that are Cost-Effective
CGE	Computable General Equilibrium
CPI	Consumer Price Index
COVID-19	Coronavirus Disease of 2019
CD	Cross Section Dependence
EU	European Union
FE	Fixed Effect
FDI	Foreign Direct Investment
GMM	Generalised Method of Moments
GE	Government Expenditure
GDP	Gross Domestic Product
GCF	Gross Fixed Capital Formation
HQ	Hannan Quinn
HIC	Huber-White-Hinkley
HDI	Human Development Index
ICU	Intensive Care Unit
IMF	International Monetary Fund
JBI	Joanna Briggs Institute
MLE	Maximum Likelihood Estimation
MG	Mean Group
MS	Money Supply
OLS	Ordinary Least Squares
OECD	Organisation of Economic Cooperation and Development
OxCGRT	Oxford COVID-19 Government Response Tracker data
PARDL	Panel-Autoregressive Distributed Lag
PCR	Polymerase Chain Reaction

PMG	Pooled Mean Group
PPP	Purchasing Power Parity
QTM	Quantity Theory of Money
RE	Random Effect
RQ	Research Question
SBC	Schwarz Bayesian Criterion
SARS-COV-19	Severe Acute Respiratory Syndrome
SD	Standard Deviation
SDGs	Sustainable Development Goals
SLR	Systematic, Literature Review
AD-AS	The Aggregate Demand and Aggregate Supply
TC	Total Cost
TR	Trade-GDP Ratio
VIF	Variance Inflation Factor
WB	World Bank
WHO	World Health Organisation

CHAPTER 1: INTRODUCTION

1.1 Background

The COVID-19 pandemic, stemming from Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-COV-19), has evolved into a global health emergency of unprecedented scale and complexity. According to the World Health Organisation (WHO), while the majority of individuals infected with the virus develop mild symptoms or recover without hospitalisation, a significant portion experience severe illness, with approximately 15 percent requiring oxygen, and 5 percent progression to critical conditions necessitating intensive care. There have been more than 771 million confirmed cases of COVID-19, including 6.97 million deaths reported globally till the end of December 2023, and a total of 13 billion vaccine doses have been administered (WHO, 2023). The origins of the pandemic trace back to the city of Wuhan, China, where the first cases were reported in early December 2019. Since then, COVID-19 has rapidly spread across countries, triggering widespread disruptions to healthcare systems, economies, and social norms. The virus's relentless spread, coupled with ongoing mutations and variants, continues to present challenges to public health and global stability.

The COVID-19 pandemic is primarily a public health crisis, yet it is also significantly influential for both the economy and the financial system. In response to the pandemic, nations-imposed restrictions on international travel and enforced social distancing measures, leading to substantial disruptions in global economic activities. Even though many countries have previously been affected by epidemics, this disease has created unprecedented impacts on both health and economic conditions of countries worldwide. The economic impacts of COVID-19 involve high healthcare costs, and stringent policies that created adverse effects on economic factors such as unemployment, inflation, consumption, poverty levels, and labour market conditions (Alam et al., 2020, Rodela et al., 2020).

Throughout the history, pandemics have been reported, with the witnessing several epidemics, including SARS, The H5N1 virus, e H1N1 influenza, Ebola, and COVID-19. However, the COVID-19 is unlike any other, bringing significant uncertainty

regarding its impact on people's lives and livelihoods. The spread of the virus and the resulting public health measures, such as lockdowns and social distancing, directly disrupted economic activity, leading to widespread economic consequences.

Previous economic crises were primarily caused by financial imbalances and subsequent policy responses. For instance, in the 1930s, a series of banking panics led to a significant decline in liquidity. Similarly, the 2008-09 global financial crisis stemmed from imbalances in the financial system, particularly associated with the financing of subprime mortgages. Despite its severity, the aggressive response by governments helped mitigate the recession that ensued, albeit milder in comparison to the Great Depression (Engemann, 2020).

In contrast, the COVID-19 pandemic has had a wide-ranging impact across various sectors of the economy. Industries such as travel, tourism, hospitality, and entertainment were severely affected due to lockdowns and restrictions on gatherings, while others, such as technology and e-commerce, experienced accelerated growth. Moreover, the pandemic has precipitated lasting structural changes, accelerating trends such as remote work, digitalization, and e-commerce. These shifts are anticipated to have long-term implications for business operations and consumer behavior, reshaping the post-pandemic economic landscape in ways distinct from previous crises. The unique nature of the COVID-19 pandemic as a health-driven, globally synchronized crisis, coupled with unprecedented policy responses and enduring structural changes, distinguishes it from previous economic downturns in terms of scale, scope, and impact.

The trends and impacts of different variants of COVID-19 varied according to country-specific characteristics. Even though many researchers have focused on the short-term effect of COVID-19 and considered several macro and microeconomic variables, less priority has been given to fiscal support with country-level macroeconomic comparison (Amewu et al., 2020; Ataguba, 2020; Binder, 2020). Analysis of macroeconomic policies and factors present during the COVID-19 pandemic is therefore necessary because, the repercussions of the pandemic, felt globally by countries, are likely to have far-reaching effects that extend beyond individual nations.

The study is motivated by the comprehensive variations of macroeconomic conditions due to COVID-19. This pandemic has been an enormous, synchronised global economic shock on a scale that has not been seen since the Second World War. Therefore, painful economic lessons will form policy strategies good enough to reduce the impacts of another epidemic and nations can take pre-emptive steps to advance pandemic preparedness in the future.

This research provides a comprehensive analysis of how macroeconomic variables and policy measures were affected by the COVID-19 pandemic and subsequent economic recovery. It delves into the macroeconomic impacts during the pandemic period (from 1st March 2020 to 5th May 2023), while also examining the dynamics of the post-pandemic recovery phase (after 5th May 2023). By addressing both periods, this study offers valuable insights into the full spectrum of challenges and adaptations in the economic landscape, contributing to a nuanced understanding of the pandemic's effects on policy and economic resilience. In particular, policymakers and economists need to be concerned about the macroeconomic implications of rising uncertainty. More significantly, it is necessary to preserve employment and production during a pandemic while preventing excessive inflation. It is therefore important to define a policy instrument to assess whether inflation and unemployment should be the key concerns during such an outbreak.

Moreover, health-care policies influence labour force participation, productivity, and human capital formation through various channels, thereby influencing overall macroeconomic outcomes (Zoellick, 2009). As health policies exert indirect influences on macroeconomic settings, government responses play a pivotal role in shaping future directions and determining the behaviour of monetary and fiscal policies.

Furthermore, in this study, immediate strategies have been identified that the government should implement to achieve economic recovery during a pandemic and beyond. Therefore, this study benefits the world's people, governments, and policymakers by utilising the short-term and long-term dynamics of macroeconomic factors. Finally, this research fills a gap in the literature and supports government policy making to attain long-term economic goals.

1.2 Statement of the Problem

The COVID-19 pandemic represents both public health and economic crises. The public health crisis relates to disease containment measures, treatment, and the development of vaccines (Cutler and Summers, 2020, Gaffney et al., 2020, Varona and Gonzales, 2021). Meanwhile, economic impacts are reflected in variations in macroeconomic factors such as gross domestic product (GDP), unemployment, inflation, consumption, and investment (Ataguba, 2020; Chudik et al., 2020; Ghaffari Darab et al., 2021; Jin et al., 2021). Aside from the labour shortage caused by illness and the increase in deaths, the pandemic has closed workplaces while restricting production, trade and travel, and it has created fiscal and monetary policy constraints, all of which have accelerated the economic slowdown (Ibn-Mohammed et al., 2021).

In view of the above arguments, a strong empirical research study is necessary in the global context. All countries are approaching a new regulatory scheme to reduce the economic shocks. Analysis of fiscal adjustments will provide fruitful contributions to the policy debate, and policy suggestions for the investigated countries and other countries in general. Since the pandemic and its legacy continue to cause high real costs to the economy, in terms of losses in production, consumption, investment, and employment, it is crucial to identify the country-specific economic factors to mitigate this, ensure stability, and defend the economy from major breakdowns.

Governments must develop innovative tools to combat the economic consequences of the coronavirus-induced crisis. Because of the epidemic's diverse territorial impacts, there is some uncertainty about whether economically sensitive measures should be included in policy decisions on fiscal support and to what extent economic policy aspects should be incorporated into government interventions. This study makes a significant contribution to the growing body of literature on the interaction of government policy responses to the COVID-19 pandemic, to gain economic recovery. It makes a noteworthy contribution to policy design.

1.3 Aims, Objectives, and Research Questions

The main objective of this thesis is to comprehensively analysis the macroeconomic impacts of COVID-19 pandemic on countries across the world. In this context, the specific research objectives (ROs) are to:

RO1: Examine the impacts of the COVID-19 pandemic on key macroeconomic factors.

RO2: Study the determinants of fiscal support to guide future economic decisions.

RO3: Examine the changes in monetary policy measures due to COVID-19 and their impact on macroeconomic variables.

RO4: Analyse the efficacy of governments epidemic prevention responses to mitigate the risk of COVID-19.

RO5: Analyse the cost of the COVID-19 pandemic.

RO6: Assess the impact of COVID-19 vaccination rates on economic recovery.

To achieve these objectives, this thesis address research gaps identified in the existing literature. These gaps are precisely presented in the literature review section of each study. Several research questions (RQs) have been formulated. The answers to these research questions constitute an attempt to fill the gaps identified. Each RQ is explored with a separate empirical study. The studies conducted in this research provide clear justifications for the research and the findings offer feedback for policy measures. The RQs are:

RQ1: What are the macroeconomic impacts of the COVID-19 pandemic?

RQ2: What factors determine the level of fiscal support available to a country during the pandemic?

RQ3: How do monetary policy measures affect macroeconomic variables during and after COVID-19 era?

RQ4: What government epidemic prevention responses are effective in mitigating the risk to the economy?

RQ5: How much does COVID-19 cost the economy?

RQ6: What are the impacts of the emergence of a vaccine on the economy?

1.4 Overview of Methods

This section provides an overview of the data collection and research design.

1.4.1 Data Collection

To achieve the research objectives, data was collected from the International Monetary Fund (IMF), the Oxford COVID-19 Government Response Tracker (OxCGRT), the WHO, Our World in Data, the OECD and the World Bank. The IMF publishes a variety of time series data on economic and financial indicators. The OxCGRT data provides a cross-national and cross-temporal technique for measuring government response evolution. This tracker compiles data on government initiatives based on 19 different metrics. Also, the WHO, Our World in Data, the OECD, the Australian Bureau of Statistics (ABS), the Australian Institute of Health and Welfare, and the European Centre for Disease Prevention and Statistics manage and maintain a wide range of data sets related to global health and well-being.

The datasets mainly contain quarterly or fortnightly observations from 2020 to 2023. They incorporate a significant number of variables in quarterly and fortnightly data from countries to examine the short-term and long-term economic impacts of the COVID-19 pandemic. "EViews" econometric software was used for estimation purposes.

1.4.2 Study Design

A concise overview of the study design and methodology outlined in the upcoming chapters is given in this section. Further details regarding the methodology for each individual study can be found within their respective chapters.

This research incorporates a systematic literature review to enhance understanding of COVID-19's economic implications and identify gaps in existing literature. Additionally, it mainly employs a quantitative econometric approach for conducting both cross-sectional and panel data studies.

General macroeconomic policy changes are analysed while delving into economic factors that compound the challenges posed by the pandemic. As outlined in the conceptual framework, the model is grounded in the New Keynesian theoretical approach, examining fiscal support to mitigate the adverse economic effects of

COVID-19 as a cross-sectional study. Then, a panel data analysis was conducted, specifically the autoregressive distributed lag (ARDL) model, to scrutinise monetary policy measures and their changes both during and after the pandemic in OECD countries. This panel ARDL framework was applied to evaluate the efficacy of government policy responses in 22 selected countries.

To assess the economic impact of COVID-19, the WHO choice model and bottom-up costing methods are integrated to analyse the costs associated with COVID-19. Lastly the impact of COVID-19 vaccination rates on economic recovery is assessed, based on 34 countries, again utilising panel data analysis. Table 1 provides a concise overview of the research focus, research question, study design, data source, analytic sample, and method of each study. Subsequently, Figure 1 lists the studies included under each of the research themes, along with the publication or journal submission details of each paper.

Table 1: Objectives, research questions and study designs of six studies

Research Theme	Study No	Study objective/s	Research questions	Study design and statistical measures	Main variables	Key findings
Macroeconomic Impact	1	To study the main economic research approaches in the COVID-19 literature. To review the literature on the fluctuations and estimations of the economic factors caused by COVID-19. To investigate the knowledge gaps to identify avenues for future research.	What are the economic consequences of COVID-19? (RQ1)	PRISMA guided systematic literature review.	Economic impact: The effects of COVID-19 on macroeconomic variables. Economic cost: Direct health cost and indirect cost. Government policies: different policy tools to reduce health and economic risks	Out of the 31 selected studies, 22 articles focused on examining the economic consequences and macroeconomic activities, while 7 articles explored microeconomic costs and healthcare trade-offs. Additionally, 2 studies reviewed economic uncertainty and macroeconomic expectations.

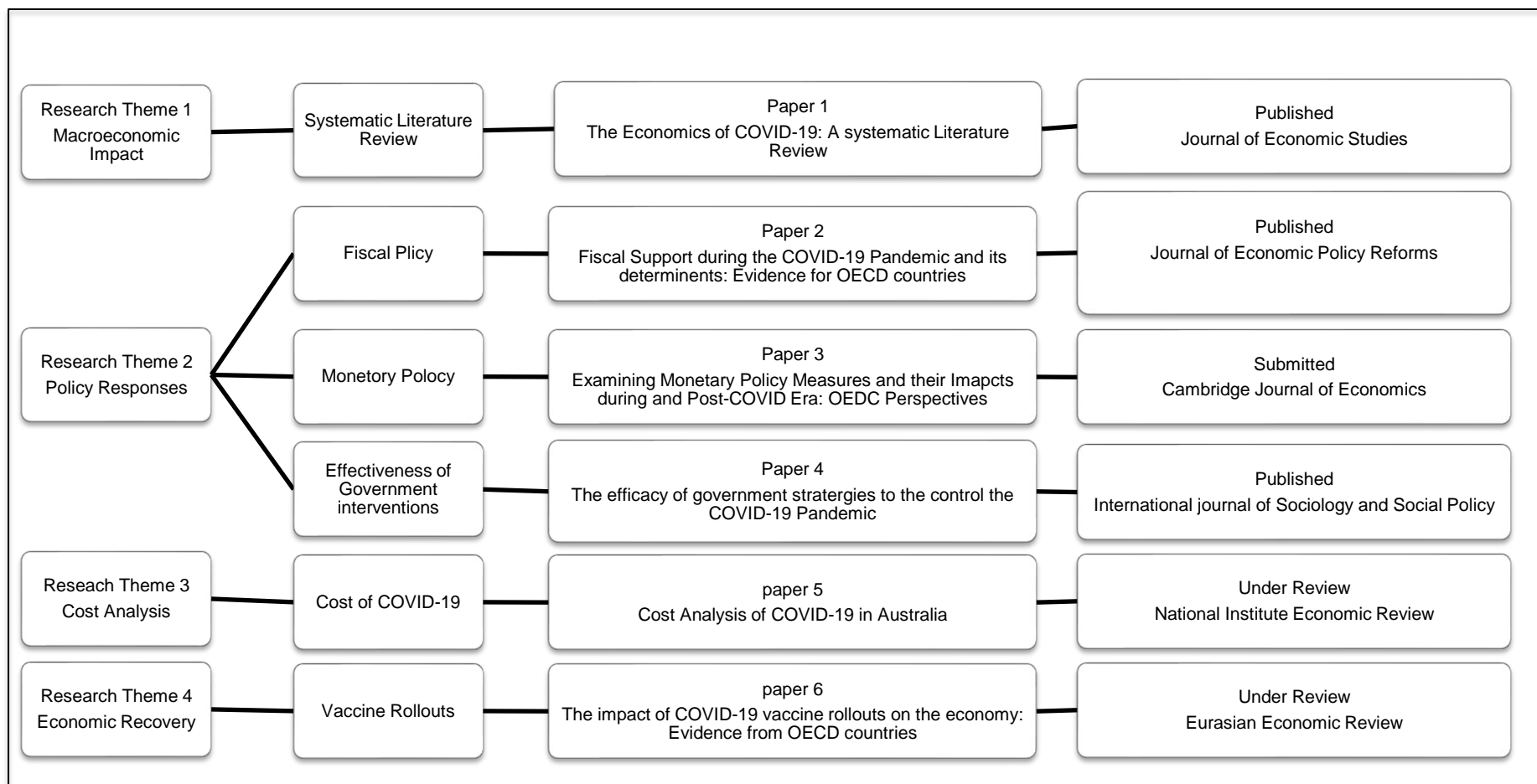
Research Theme	Study No	Study objective/s	Research questions	Study design and statistical measures	Main variables	Key findings
Policy Responses	2	To analyse the factors influencing governments' decisions concerning fiscal support.	What factors determine the level of fiscal support available to a country during the pandemic? (RQ2)	Cross-sectional data analysis using the Generalised Method of Moments. The study is based on OECD countries	Dependent variables: each country's overall fiscal support as a percentage of GDP. Independent variables : per capita GDP, tax revenue, public debt and unemployment, and quasi-independent variables are population, the Human Development Index, and the Democracy Index	The findings highlight the imperative of expanding fiscal support during pandemics to advance progress toward Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Wellbeing) and SDG 10 (Reducing Inequality).
Policy Responses	3	To analyse the effects of monetary policy measures on key economic indicators, such as GDP, inflation, and unemployment.	How do monetary policy measures affect macroeconomic variables during and after the COVID-19 era? (RQ3)	Panel Auto Regressive Distributed Lag (ARDL) model. The study is based on OECD countries from 2020 to 2023	Dependent variables: GDP growth rate, inflation rate and unemployment rate Independent variables: interest rate, uncertainty, exchange rate. government expenditure, gross fixed capital formation.	The findings underscore the importance of swiftly transitioning patterns of monetary policy measures in response to economic shocks like pandemics. However, it is crucial for governments to manage inflationary pressures, a notable drawback of expansionary monetary policy.

Research Theme	Study No	Study objective/s	Research questions	Study design and statistical measures	Main variables	Key findings
Policy Responses	4	To examine the government strategies mitigating the risks of COVID-19 and propose policy directions to reduce its impact.	What are the effects of government responses in mitigating COVID-19 infection and death rates? (RQ4)	Panel Auto Regressive Distributed Lag model. This study utilises data from 22 countries from 2020 to 2022	Dependent variables: mortality rate and infection rates. Independent variables: stringency indicator, government response indicator, containment and health Indicator, and economic support indicator.	The study reveals the following key findings: (1) Income support and debt relief facilities, and stringent standards of governments are associated with reduced infection and death rates. (2) The response of governments has resulted in decreased mortality rates while simultaneously leading to an unexpected increase in infection rates. (3) Containment and healthcare practices have led to a decrease in infection rates but an increase in mortality rates, presenting another counterintuitive outcome.

Research Theme	Study No	Study objective/s	Research questions	Study design and statistical measures	Main variables	Key findings
Cost Analysis	5	<p>To estimate the direct health costs of the COVID-19 pandemic.</p> <p>To identify country-specific cost factors.</p> <p>To analyse the macroeconomic impacts of this pandemic in Australia.</p>	<p>How much does COVID-19 cost the economy? (RQ5)</p>	<p>The bottom-up cost approach to calculate the direct cost of COVID-19 inpatient per day cost.</p> <p>The WHO CHOICE model to identify the factors which determine the cost.</p> <p>The study is based on Australia.</p>	<p>Dependent variable: unit cost per inpatient day in Australian dollars.</p> <p>Independent variables: GDP per capita, bed occupancy rate, average length of stay, total inpatient admissions, dummy variable for public hospitals and dummy variable for private hospitals.</p>	<p>The unit cost of inpatients per day is estimated to be AUD 836. The estimated total inpatient cost of COVID-19 in 2021 based on 4473 patients is AUD 3.7 million for 2021 in Australia.</p>

Research Theme	Study No	Study objective/s	Research questions	Study design and statistical measures	Main variables	Key findings
Economic Recovery	6	To analyse the relationship between the GDP growth rate, inflation rate, unemployment rate, and COVID-19 vaccination rates.	What are the impacts of the emergence of a vaccine on the economy? (RQ6)	Panel Auto Regressive Distributed Lag model The study is based on OECD countries from 2020 to 2023.	Dependent variables: GDP growth rate, inflation rate and unemployment. Independent variables: gross capital formation, trade openness, inflation rate, government consumption expenditure , foreign direct investment, and rate of COVID-19 vaccination. money supply, interest rate, household consumption and population growth.	The findings indicate that COVID-19 vaccines have a significant impact on macroeconomic factors. Specifically, a 1 percent increase in vaccinations per 100 population is associated with a 0.02 percent increase in GDP growth rate. The research also identified a negative impact of COVID-19 vaccines on inflation and unemployment rates.

Figure 1 Research theme and study papers included in the thesis.



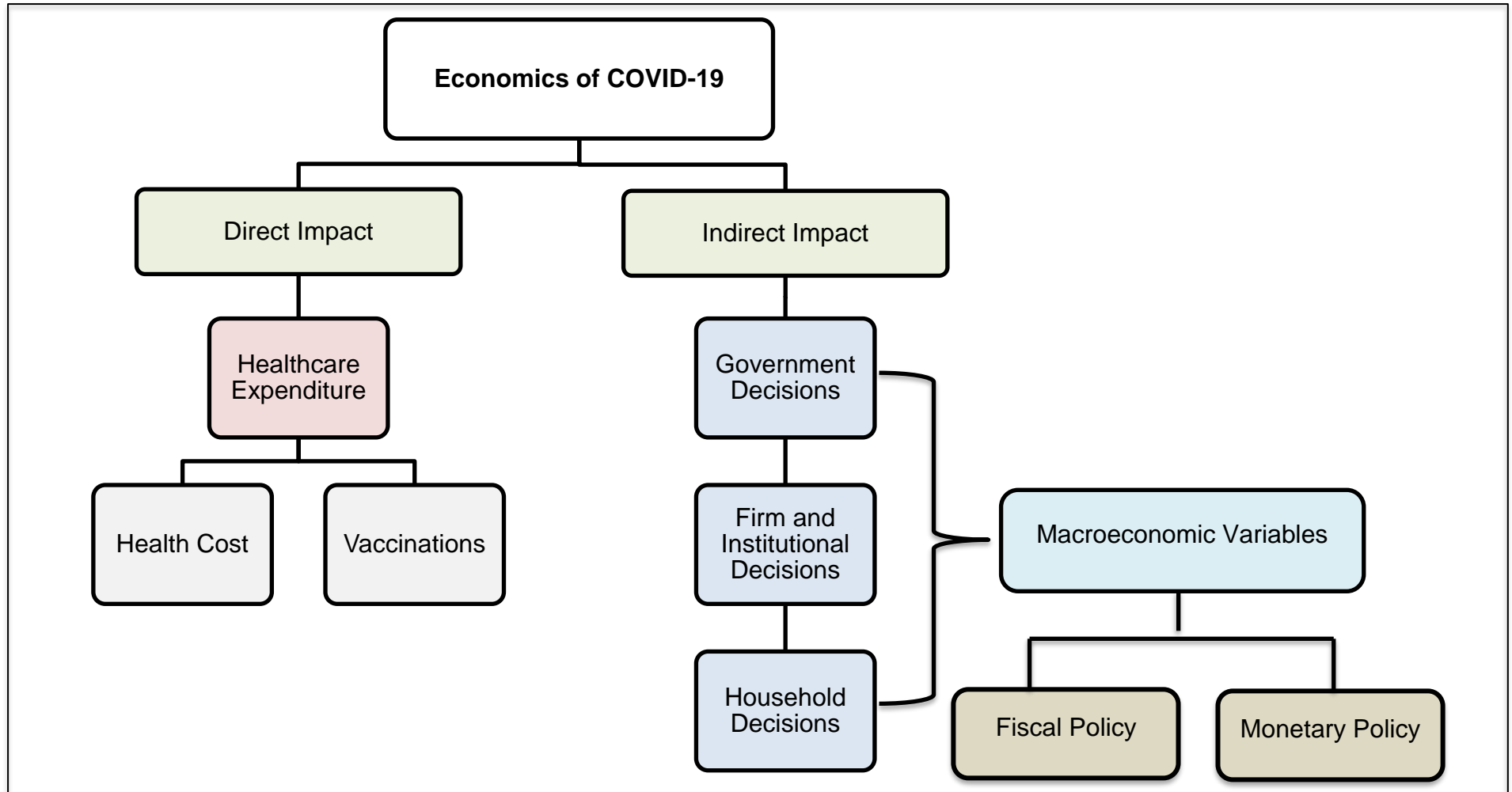
1.5 The scope of the Research

This research mainly focuses on the global macroeconomic impacts of COVID-19 and the policy responses from governments worldwide. It places a critical emphasis on assessing macroeconomic endurance as a long-term policy strategy, with a specific focus on fiscal allocations and monetary policy measures in relation to policy decisions. It also includes a comprehensive analysis of the direct and indirect cost of COVID-19 utilising a single country approach (Australia). Further, the macroeconomic impact of COVID-19 vaccine rollouts is examined. It is important to note that detailed discussions of microeconomics, international trade flows, and the financial performance of individual countries are intentionally excluded. Furthermore, cross-border policy options and structural changes in economies are not within the scope of this research.

1.6 Conceptual Framework of the Thesis

A conceptual framework has been developed for this study to manage the research process. The theories of Keynes, developed during the Great Depression are particularly relevant to the present economic situation rather than mainstream neoclassical economic theories (Pollitt et al., 2020). The computable general equilibrium and dynamic stochastic general equilibrium models are not well fitted to evaluate the economic effects of the crisis, (McKibbin and Fernando, 2020) while the New Keynesian economic models provide more useful insights into maintaining economic stability during epidemics. New Keynesian economics has focused on Keynes' findings that government spending was necessary to boost economic activity during recovery from a recession. The models derived from New Keynesian theories continue to be the most appropriate in such situations today (Varona and Gonzales, 2021). Therefore, this conceptual framework reveals the possibility of estimating the impact of the COVID-19 pandemic on key macroeconomic factors.

Figure 2: Conceptual framework



Source: Author's adaptation of Hevia, C. and A. Neumeyer (2020).

The direct and indirect economic impacts provide a summary of the total macroeconomic impacts of the COVID-19. As depicted in the figure above, the indirect economic impacts of COVID-19 emanate from three sources:

1. Governments Decisions: policy decisions on different types of activities (lockdown, workplace closure, Taxation, public debt measures)
2. Firms' and Institutions' Decisions: proactive measures to avoid infection (investments, business closures, working from home, limited labour)
3. Household Decisions: travel reduction, modified economic behaviours (consumption, savings, investments), and other adaptations to social activities.

More importantly, government decisions are influenced by decisions made by firms, institutions, and households. The government, in turn, responds to these influences through fiscal and monetary policies to manage and stimulate the economy. On the other hand, it has become crucial to assess the direct impact of COVID-19 and factor in its influence to determine health costs. COVID-19 vaccinations have made a significant impact on economic recovery as a preventive measure.

1.7 Impact of this Research

According to the extant literature, this research is poised to be distinctive and unique and add some significant knowledge. This research provides some comprehensive insight into the economic and public health emergencies. One of the key contributions of this research lies in offering valuable insights for policymakers in determining budgetary allocations for healthcare expenditure. Moreover, the model developed in this research sheds light on the behaviour of macroeconomic factors amid the COVID-19 pandemic. Furthermore, this model concentrates on the behaviour of macroeconomic factors during the COVID-19 pandemic. Another noteworthy contribution is the identification of economic growth paths through an examination of macroeconomic changes. This can guide governments, firms, and households to take rational future decisions and actions by reducing the impacts caused by any future pandemic.

Additionally, the research plays a role in evaluating the effectiveness of government responses during the pandemic. Treating vaccination rates as an investment in human capital, the research includes an effort to quantify productivity gains while assessing the impact on GDP. In essence, this research is anticipated to furnish a preliminary framework for strategically repositioning a country's economy in the face of any future pandemic.

1.8 Thesis Structure

This PhD thesis follows a thesis by publication format, comprising nine chapters. Chapter 1 offers an overview of the study, presenting the problem statement, research objectives, research design, conceptual framework, and impact of the research. In Chapter 2, the literature review is outlined, identifying research gaps within the targeted field. Chapter 3 focuses on Study 1, which entails a PRISMA guided systematic literature review based on 31 selected research articles. Chapters 4 and 5 comprise Studies 2 and 3, respectively, addressing the impacts of changes to fiscal support and monetary policy measures due to the COVID-19 pandemic. Chapter 6 represents Study 4, examining the efficacy of government responses during the COVID-19 pandemic. Chapter 7 incorporates Study 5, delving into analysing the cost of COVID-19 in a single country, Australia. Chapter 8 features Study 6, exploring the impact of COVID-19 vaccination on macroeconomic factors. The thesis concludes with Chapter 9, a summary of all empirical studies conducted and a discussion of their discussing the limitations and strengths. Implications for policy and considerations for future research are also deliberated upon.

CHAPTER 2: LITERATURE REVIEW

This chapter provides an overview of the existing evidence regarding the economic impact of COVID-19, specially focusing on its macroeconomic effects. A brief summary of the theoretical foundation and empirical literature related to the four distinct topics will shed light on the existing knowledge. This background information is designed to assist readers in comprehending the rationale behind conducting the current set of studies for this thesis.

2.1 Theoretical Literature Review

Keynes (1936) advocated for increased government spending and lower taxes to stimulate demand and lift the global economy out of the Depression. Keynes contended that insufficient overall demand could result in extended periods of high unemployment and explained that an economy's total output of goods and services comprises four elements: consumption, investment, government spending, and net exports. For demand to increase, it must originate from one of these components. However, during a recession, various factors typically suppress demand, leading to reduced spending. This situation necessitates government intervention to boost output and stabilize the economy. According to Keynes, state intervention is essential to moderate the fluctuations of the business cycle and mitigate the impacts of economic downturns.

Further, Keynes argued against a policy of government non-intervention, asserting that such a stance would lead to a loss of economic output and prolonged suffering for millions of people (Alozie et al., 2020; Byrialsen et al., 2021). In contrast, non-traditional economists have criticised Keynesian arguments for their perceived neglect of supply-side issues, emphasising a singular focus on aggregate demand (Byrialsen et al., 2021; Eichenbaum et al., 2021). For instance, Eichengreen (2020) expounded that calibrated versions of the neoclassical model, a flexible price model with monopolistic competition, and a New Keynesian approach with a sticky prices' model all generate recessions in response to an epidemic.

On the other hand, the New Keynesian economic approach posits that in an economy where firms hold some market power but do not appropriate all rents, the fiscal policy multiplier exceeds one, aligning with Keynes's original argument. This is because, given that prices remain above marginal costs, firms are consistently inclined to expand investment. An expansionary fiscal policy stimulates aggregate expenditure, resulting in increased profits. This, in turn, fosters higher levels of investment and employment, creating a positive feedback loop where heightened expenditure continues to drive the cycle (Padilla, 2020).

Therefore, fiscal policy becomes a more potent tool for enhancing aggregate demand in economies with more competitive goods and services markets (Mankiw, 1988). This holds true whether fiscal policy is implemented through elevated government spending, tax reductions, or a combination of increased government spending and higher taxes, ensuring a balanced government budget (Alesina and Perotti, 1995). In each scenario, the impact of fiscal policy on output expansion is more pronounced when the markup for goods and services is lower.

However, Pollitt (2020) contended that current mainstream neoclassicism and New Keynesian economics possess limitations that impede their effectiveness in analysing the ongoing COVID-19 pandemic. He argued against the suitability of Computable General Equilibrium and Dynamic Stochastic General Equilibrium models in adequately capturing the economic impact of a crisis or identifying potential recovery pathways. Therefore, there appears to be a consensus among both traditional and non-traditional economists on the necessity of integrating short-term supply policies with traditional Keynesian expansionism. This combined approach has been considered crucial for preventing a recession while promoting price increases during the current crisis (Eichenbaum et al., 2021; Pollitt et al., 2020; van Aarle, 2017).

2.2 Empirical Literature Review

2.2.1 *Economic impacts of COVID-19*

The global outbreak of COVID-19 has emerged as a dual challenge, giving rise to a profound healthcare emergency, and triggering an unprecedented economic downturn. As articulated by Susskind and Vines (2020), the scale of challenges faced is reminiscent of historical crises such as the Spanish flu pandemic and the Great

Depression, transpiring concurrently. This review's aim is to explore and synthesise existing literature related to the multifaceted impacts of the COVID-19 crisis on healthcare, economics, and labour markets.

The COVID-19 crisis has accelerated pre-existing economic trends, ushering in an era marked by a surge in both private and public debt, declining interest rates, and a diminishing capacity for fiscal and monetary policy adjustments. Scholars suggest that the pandemic may have hastened these trends, posing profound challenges to economic stability and resilience. Industries crucial for economic growth and employment, including tourism, hospitality, aviation, textile, agriculture, construction, gems/jewellery, and start-ups, have encountered substantial financial setbacks during the pandemic (Seetharaman, 2020). Further, the risk of poverty was heightened for informal workers, including those in daily wage jobs and agricultural sectors, as their activities often did not adhere to the security requirements mandated by COVID-19 legislation, thus increasing vulnerability to economic instability (Davidescu et al., 2021). This literature review is an analysis of the adverse impacts on these sectors, emphasising pronounced economic losses and the challenges faced in sustaining employment levels. The discussion underscores the pressing need for strategic interventions and recovery measures to reinstate economic vitality and promote employment growth (Mallah, 2021).

The decline in per capita GDP is explored through a complex interplay of factors, with a particular focus on the influence of COVID-19 mortality rates and underlying population demographics. Iluno et al. (2021) highlighted the remarkable prominence of COVID-19 mortality as the primary catalyst for the observed economic downturn. The literature suggests that this influence persists even when GDP per capita appears to maintain a relatively stable trajectory. The COVID-19 pandemic has precipitated significant shifts in labour markets, characterised by widespread job losses, furloughs, and changes in remote work dynamics (Lee et al., 2020). Coibion (2020) investigated the social and economic implications of these shifts, emphasising the disparities in impact across different demographic groups. This review is a critical assessment of the effectiveness of policy interventions in mitigating the consequences of these transformative shifts in the labour market.

On the other hand, the pace and nature of recovery from the pandemic will be delayed by both supply-side and demand-side challenges. On the supply side, many manufacturers and businesses depend on global supply chains to sustain their operations, leading to synchronization issues. Countries eager to resume production might find their efforts constrained if their international suppliers are unable to meet demand due to ongoing closures or reduced output caused by COVID-19 (Tisdell, 2020).

2.2.2 Economic policy responses to COVID-19

The aggregate demand and aggregate supply (AD-AS) model is one of the fundamental tools in economics. The macroeconomic impact of the COVID-19 pandemic is the result of a combination of 'aggregate demand' and 'aggregate supply' shocks in the economy. (Ataguba, 2020, Barua, 2020, Pinilla et al., 2021). The crisis is further exacerbated by a general decrease in demand, as a result of people's changes in consumer behaviour, and a general slowdown of economic activities (Martin et al., 2020).

Fornaro and Wolf (2020) reported the COVID-19 virus situation as causing a negative supply shock caused by the coronavirus gives rise to a fall in demand and involuntary unemployment worldwide. According to Baldwin and di Munro (2020), the pandemic affected all major economies, including the high-income countries, which account for 60 percent of global demand and supply and 65 percent of global production and exports. Meanwhile, Bekaert et al. (2020) found that in Quarter 1, 2020 real GDP growth shock in the USA had largely been due to an aggregate demand shock, while the staggeringly large shock in Quarter 2 was due to both aggregate demand and aggregate supply shocks.

Farayibi and Asongu (2020) found the COVID-19 pandemic to have had an insignificant negative impact on basic macroeconomic variables and GDP growth. On the other hand, medium-sized businesses and manufacturing firms found it challenging to endure the lockdown, resulting in the unemployment of numerous informal sector workers. Economic losses mounted due to reduced demand, movement restrictions, limited access to markets, and the impeded mobility of people and goods, all of which had a considerable impact on workers (Rasul et al., 2021).

Simultaneously, developing countries experienced a substantial surge in unemployment and underemployment attributable to COVID-19. The restrictions imposed by the pandemic brought a halt to significant economic activities, leading to the closure of many businesses, with only a few health-related enterprises remaining operational (Ataguba, 2020; Rasul et al., 2021).

As stated above, the COVID-19 pandemic has exercised dual impact involving a severe public health crisis and a substantial economic downturn. Efforts to contain the disease, provide treatment, and develop vaccines have been essential (Cutler and Summers, 2020; Gaffney et al., 2020; Varona and Gonzales, 2021). The pandemic, leading to labour shortages due to illness and increased fatalities, has forced workplace closures and imposed restrictions on production, trade, and travel. These circumstances have imposed policy limitations, exacerbating economic deceleration (Ibn-Mohammed et al., 2021).

Beyond demand management, the economic impacts of COVID-19 have necessitated comprehensive responses in monetary, fiscal, and healthcare policies (McKibbin and Fernando, 2020). Khan et al. (2020) found a positive correlation between fiscal policy, internal movements, and economic activity, with no significant relationship between confirmed COVID-19 cases and economic activity worldwide. In contrast, Li and Liang (2021) found that countries facing greater COVID-19-related uncertainty had higher levels of fiscal support, observing a positive correlation with the total population but no significant relationship with per capita income or development indicators.

To prevent fatalities and manage long-term consequences, governments faced the critical task of convincing politicians and the public of the necessity of stringent policy measures (Chisadza et al., 2021; Mintrom and O'Connor, 2020). Worldwide, governments implemented various measures to combat the pandemic's impact on public health and its economic consequences.

The effectiveness of these measures directly influences macroeconomic expectations (Binder, 2020), with health economists now becoming crucial to policymaking during current and future pandemics (Donaldson and Mitton, 2020). Countries responded swiftly, implementing policy measures to "flatten the curve" and

reduce daily new cases. South Korea, for example, introduced four financial stimulus packages and emergency relief measures, totalling 13 percent of its GDP (Subramaniam et al., 2021).

As Romer and Romer (2021) stated, a prudent approach to policy during a pandemic involves providing individuals with compensation equivalent to what they would have received if they could have insured themselves against pandemic-related effects. This targeted assistance should ideally extend to those who become unemployed as well as those who remain employed but face heightened exposure to risks due to the essential nature of their jobs. Channelling aid directly to those affected specifically addresses the issue of significant disparities in harms resulting from the pandemic recession. It also tackles the challenge that general stimulus measures may not uniformly permeate the economy during a pandemic. Varona and Gonzales (2021) emphasised the importance of promoting sustained and inclusive economic growth based on investment, accumulation of human capital, and social and human development policies in the long term.

Preliminary evidence indicates the effectiveness of these measures in mitigating the depth of the recession, particularly in advanced economies where fiscal multipliers are higher, and monetary policy transmission is more effective (Bayer et al., 2020; Faria-e-Castro, 2021; Jinjara et al., 2021). According to Ali et al. (2012), a positive correlation exists between fiscal expenditure and the Human Development Index. Countries with larger populations also tend to provide more substantial fiscal support (Li & Liang, 2021).

The global financial market encountered heightened challenges amid the COVID-19 outbreak, leading central banks in developed nations to implement unconventional measures to alleviate its adverse effects. It is imperative, both from an academic and policy perspective, to comprehend the consequences of the pandemic shock and evaluate the effectiveness of the implemented policies aimed at mitigating its impact (Karaman, 2022). While some economists argued that nonconventional monetary tools can offset the impact of the lower boundary of interest rates and create space for monetary policy (Bernanke and Yellen, 2020), others contend that, due to the evolving nature of macroeconomics, the ability of monetary policy to achieve much

when interest rates are at this lower boundary is limited (Corradin et al., 2021; DeLong et al., 2012; Eichenbaum 2019; Greenwood et al., 2014; Ortman and Tripier, 2021).

Ortmans and Tripier (2021) provided evidence that fiscal and monetary policy measures were effective in lowering bond yields for European economies. In contrast, Lepeti and Fuentes-Albero (2022) investigated the effects of an unexpected decline in interest rates and concluded that monetary policy was likely to be ineffective at the peak of the pandemic but should contribute to sustaining the recovery in economic activity once the virus started dissipating.

COVID-19 has affected economic growth by increasing the fiscal deficit, monetary burden, and risks of macroeconomic instability, and decreasing migration, remittances, and income from travel and tourism (Burger and Calitz, 2020; Hayat et al., 2021; Islam and Muyeed, 2020; King, 2015). The COVID-19 pandemic has created great uncertainty and heavy economic, fiscal, financial, and social pressure (Iluno et al., 2021). Hence, the COVID-19 pandemic experience suggests that building a more robust social safety net, including enhancing governments' ability to quickly mobilize public assistance to vulnerable households, will be essential for a timely and scaled-up response in future crises (Miguel et al., 2022).

2.2.3 *The cost of COVID-19*

The COVID-19 pandemic has prompted a growing body of empirical literature. Globally, the COVID-19 pandemic imposed substantial and escalating human costs, with protective measures having severely impacted economic activity. The projected contraction of the global economy by 3 percent in 2020 was markedly worse than the downturn observed during the 2008–09 financial crisis (Mishra, 2020).

Boissay and Rungcharoenkitkul (2020) proposed that the economic cost of the pandemic can be approximated by GDP forgone, representing the disparity between current forecasts and pre-COVID-19 projections. By the end of 2020, the annual output loss is estimated to range between 5 and 9 percent for the US and between 4 and 4.5 percent for the global economy. Meanwhile, Ghaffari Darab et al. (2021a) states that the high prevalence of COVID-19 has imposed a significant economic burden on countries and health systems, potentially necessitating rationing or stringent cost-control measures. Elevated healthcare costs also posed a threat to the well-being of

COVID-19-infected patients, with 14 percent of Americans expressing an intention to avoid medical care due to cost implications (Debata et al., 2020).

Eichenbaum et al. (2020) explored the equilibrium interactions between economic decisions and epidemic dynamics, utilising the SIR model. They indicated that while containment policies and decisions to reduce work and consumption mitigate the severity of the pandemic in terms of total deaths, they exacerbate the size of the ensuing recession. Yang et al. (2023) estimated prevented deaths; however, their figures were highly sensitive to under-reporting assumptions, potentially increasing by up to 2.1 million after employing a less conservative assumption. Additionally, their estimation suggests that \$155 billion in costs related to outpatient care and COVID-19-related productivity loss were saved through averted infections. Control measures for COVID-19, according to Jin et al. (2021), resulted in substantial costs from productivity losses, amounting to 2.7 percent of China's annual gross domestic product from January 1 to March 31, 2020. The monthly economic losses during the lockdown reached 177 billion yuan. In 2020, although the lockdown policy reduced COVID-19 infections by 180,000, saving approximately 20,000 lives and nearly 30 billion yuan in medical costs in China, the total GDP decreased by 37 percent in 2020. The private components of GDP, investment, consumption, export, and import, suffered losses of 82 percent, 30 percent, 36 percent, and 25 percent respectively (Debata et al., 2020). Marcolino et al. (2021) highlighted significant variability in acquisition costs and investments by institutions responding to the pandemic. McKibbin and Fernando (2021) noted a sharp decline in both consumption and investment caused by the COVID-19 pandemic.

In many countries, diverse attitudes toward vaccination exist within the public, as indicated by a cross-national study among Europeans (Rughiniş et al., 2022). To address vaccine hesitancy, promoting confidence in professional organizations such as the WHO and trust in domestic healthcare professionals has been shown to be effective. Therefore, it is crucial to persuade vaccine skeptics regarding the legitimacy of science-based recommendations and ensure successful delivery of information rather than dismissal (Hao, 2023).

2.2.4 *The impact of vaccination procedure on the economy*

Global and regional economies have been facing the potential of substantial economic and financial consequences due to the COVID-19 pandemic. LaBelle and Santacreu (2022) revealed an unprecedented imbalance between supply and demand, resulting in price hikes and subsequent inflation. The extensive transportation networks and economic interdependence stemming from globalisation made it challenging and costly to contain the virus and manage the risks of its spread across various regions. This emphasised the critical need for international collaboration and global investments in vaccine research and distribution. Additionally, there has been heightened importance placed on preventive measures, including the enhancement of real-time surveillance capabilities and the development of contact tracing systems at both national and international levels (Pak et al., 2020).

Vaccination has direct effects on economic behaviour because vaccinated individuals can safely engage in their economic activities and create indirect impacts like lower infection risk for non-vaccinated individuals (Gagnon et al., 2021, Foy et al., 2021). COVID-19 vaccination in low and middle-income settings is highly cost-effective and even cost-saving, when the vaccine is reasonably priced and efficacy is high (Pearson et al., 2021). Diagne et al. (2021) determined the critical vaccination threshold level and discovered that if vaccine efficacy was low and disease spread was high, the disease might not be eradicated even if a large proportion of the population was vaccinated. According to a UNDP analysis (2021), countries with higher vaccination rates are expected to recover faster, with a USD 7.9 billion increase in global GDP for every million people vaccinated. Unless urgent corrective measures are taken, the path to recovery for low-income countries with near-zero vaccination rates will be long and uncertain. Accelerated vaccination is likely to have net economic benefits, especially if less expensive vaccines are prioritised (Gagnon et al., 2021).

2.3 Gaps in the Literature

The predominant body of research on COVID-19 and its economic implications primarily comprises peer-reviewed journal papers employing descriptive data analysis. Despite some research on the economic repercussions of COVID-19, there remains

a notable scarcity of evidence and insufficient studies comprehensively examining changes in all macroeconomic factors due to the pandemic.

Within this context, numerous gaps persist in existing studies, presenting opportunities for further investigation. The economic consequences of COVID-19 exhibit variations contingent upon several identified factors: the current status of virus spread, changes in socioeconomic policies, fiscal support and monetary policy measures, and shifts in economic growth. Moreover, disparities have arisen in the impacts on the macroeconomic factors of export, import, foreign direct investment, government fixed capital formation, interest rates, exchange rates, inflation, and unemployment. Therefore, a comprehensive country or regional comparison taking into account all these influencing factors will contribute to a more robust estimation of the pandemic's economic impact.

To the extent of the researcher's knowledge, there is a comprehensive analysis of the economics of COVID-19 addressing both government policy responses and the impacts of macroeconomic factors during the pandemic. On one hand, a thorough evaluation is needed of the efficacy of government responses to COVID-19, with methods proposed to enhance their effectiveness. This would be, applicable not only to the current pandemic but also to future situations of comparable magnitude. On the other hand, while some researchers have provided estimates of direct health costs per day for a COVID-19-infected patient in a single country or a group of countries, comparisons across studies prove challenging due to variations in methodology, population, and healthcare costs.

There is a literature gap exists in evaluating the cost of COVID-19 in Australia and identifying its macroeconomic impact. Further research is also warranted to explore the effects of macroeconomic variables, comprehend the determinants of the economic policy changes, explore efficient methods for mitigating threats posed by the COVID-19 pandemic, and assess the impact of COVID-19 vaccination processes on real GDP and employment to measure the rate of progress of economic recovery. As Table 1 and Figure 1 indicate earlier in the Chapter 1, the research embodied in this thesis addresses these gaps. In the forthcoming chapters, each study will delve into the intricate details of the economics of COVID-19, comprehensively assessing its multifaceted macroeconomic impacts.

CHAPTER 3: PAPER 1 – THE ECONOMICS OF COVID-19: A SYSTEMATIC LITERATURE REVIEW

3.1 Introduction

This chapter comprises the first study that a systematic, PRISMA-guided literature review. This study provides a comprehensive review of the economics of COVID-19 using the literature published between March 2020 to August 2021. It mainly focuses on economic impacts, cost, and uncertainty. The changes in economic factors and containment health policies have been considerations in the decision-making process of nations. The review concentrates on macroeconomic factors, how they behaved during the pandemic, and their impact on entire economies, while also reviewing each country's policies concerning COVID-19 perspectives, gaps, and future venues for further research. This study's aim is to guide governments, firms, and households to make rational decisions and actions by reducing the impacts of any future pandemic.

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3.3 Links and implications

The significance of this study lies in its comprehensive examination of the most relevant research articles to gauge the economic consequences of COVID-19 using a systematic literature review. The study has focused on examining the behaviour of macroeconomic variables during the pandemic, with the goal of providing guidance to governments, firms, and households for making informed decisions and rational actions to mitigate the impacts of any future pandemics. The repercussions of lockdowns and containment measures have had significant effects on price levels, employment, and consumption patterns. This study has analysed the negative economic impacts and explored new measures for addressing short-term economic effects and formulating effective economic policies. It has also motivated an examination of the necessary policy decisions to mitigate the negative effects of such a pandemic. Therefore, the next chapter provides an in-depth analysis of the fiscal support implemented during the COVID-19 pandemic in response to the challenges posed by the crisis.

CHAPTER 4: PAPER 2 – FISCAL SUPPORT DURING THE COVID-19 PANDEMIC AND ITS DETERMINANTS: EVIDENCE FOR OECD COUNTRIES

4.1 Introduction

This chapter presents the second study of the thesis, examining fiscal support during the COVID-19 pandemic and the reasoning for it, based on the evidence from OECD countries. It identifies the determinants of fiscal support to enhance livelihoods and sustainable development amid the COVID-19 pandemic. This proactive approach not only enhanced economic development but also bolstered the healthcare sector's capacity to effectively respond to the COVID-19 pandemic. The primary aim of this research is to conduct an econometric analysis of the factors influencing governments' decisions concerning fiscal support. The implications of this study hold significant relevance for the attainment of SDGs.

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4.3 Links and implications

This study has been an examination of the factors influencing governments' fiscal support strategies during the pandemic. Using GMM regression analysis on data from 34 prominent economies, representative of OECD countries, up to the end of 2022, offers a challenge to conventional economic theory. The findings of the study help to identify the most influential factors that affected the determination of fiscal support packages during the pandemic. They also underscore the importance of fiscal responsibility and sustainability. Governments must manage debt carefully to ensure it remains at manageable levels and does not jeopardise the country's long-term financial stability.

While this has been an analysis of fiscal support during COVID-19 pandemic, monetary policy changes also need to be examined. The next chapter comprises an investigation of such changes and their impact on macroeconomic variables. This offers a better understanding of the changes to monetary policy during and after the pandemic period.

CHAPTER 5: PAPER 3 – EXAMINING MONETARY POLICY MEASURES AND THEIR IMPACTS DURING COVID PANDEMIC AND POST PANDEMIC: OECD PERSPECTIVES

5.1 Introduction

This chapter presents the third study, revealing the impacts of monetary policy measures on the key economic indicators of GDP, inflation, and unemployment. The study's aim is to investigate the impact of interest rates and exchange rate policies implemented in response to the COVID-19 pandemic from 2020 to 2023. This study employs panel data analysis, specially focusing on OECD countries. This study offers an explanation about the current global economic challenges and the role of COVID-19 in these challenges. It bridges a gap by examining the impact of monetary policy measures undertaken by OECD countries on the macroeconomy both during the pandemic and after it. The insights garnered from this investigation are intended to serve as a guiding framework for effectively addressing future pandemics or economic shocks of a similar nature.

5.2 Published paper

Examining Monetary Policy Measures and their Impacts during COVID pandemic and Post pandemic: OECD Perspectives

Abstract

Governments worldwide implemented various fiscal and monetary measures to address the adverse impacts of COVID-19 on their economies. The paper examines the changes in the monetary policy measures due to COVID-19 and their effects on macroeconomic variables. This study utilises fortnightly data from 2020 to 2023 of the OECD countries to explore this relationship. The study employs a Panel Autoregressive Distributed Lag (ARDL) model to analyse the effects of monetary policy responses of the OECD governments, and the obtained results reveal that within OECD countries, the prevailing trend of lower interest rate policy emerged during the pandemic. This policy approach yielded a dual effect: lowering both output growth and inflation rate while concurrently exacerbating the unemployment rate throughout COVID-19. Consequently, monetary policies have played a pivotal role in facilitating the recovery from a profound economic shock, such as the COVID-19 pandemic.

Keywords: COVID-19, Monetary Policy, Economic Growth, Inflation, Unemployment

JEL Code: F61, E31, E43

1. Introduction

The worldwide recovery from the COVID-19 pandemic is anticipated to continue throughout 2022 and 2023, driven by progress in global immunisation efforts, supportive macroeconomic policies in major economies, and favourable financial conditions. In response to the COVID-19 crisis, policymakers took significant legislative actions that involved providing substantial fiscal support to businesses and individuals, thereby preventing a deeper decline in employment, income, and productivity (Dörr et al., 2022). As a result of the successful implementation of effective vaccinations, continuous policy support, and the gradual resumption of various economic activities, global economic growth has witnessed an upturn this year (Oskam and Davis, 2023). On the other hand, in advanced economies, central banks and monetary authorities have implemented substantial measures to ease monetary policy, aiming to bolster the economy and attain their inflation targets. These measures include lowering interest rates and augmenting their government bond holdings as part of their reserve assets (Gertler and Karadi, 2011).

The primary objective of this research is to analyse the effects of monetary policy measures on key economic indicators, such as GDP, inflation, and unemployment, during the COVID-19 pandemic period and the post-pandemic period. This study is motivated by inconsistent macroeconomic situations, such as a heightened level of public debt, limited monetary policy flexibility, and lasting effects on specific segments of the labour market. Most OECD countries face an unprecedented economic situation in the wake of the profound aftermath of the COVID-19 pandemic. This predicament has been exacerbated by the surge in energy and food prices driven by Russia's invasion of Ukraine. Given these intricate circumstances, the necessity arises to meticulously identify both fiscal and monetary policy measures and their corresponding impacts.

Many researchers (Kritzinger et al., 2021; Naudé and Cameron, 2021; Deslatte et al., 2020) argue that governments and their economic policies have demonstrated an apparent mishandling of the COVID-19 pandemic from the very start. This fact has become increasingly clear over time. The concern lies in their current misinterpretation of the inflationary stage of the epidemic, which poses a significant risk of a recession.

On the other hand, to mitigate demand, governments can consider reducing their own expenditures. Central banks have increased the cost of borrowing money, thereby curbing demand, as evidenced by the recent interest rate hikes in the U.S., Australia, and Europe (Song and Zhou, 2020). Hence, examining how governments responded through monetary policy measures to address economic growth, inflationary pressures, and unemployment during both the COVID-19 period and the subsequent post-pandemic period becomes essential.

Since this study is based on panel data analysis, employing a Panel ARDL model for 33 OECD countries from 2020 to 2023, it is important to note that each country has different exchange rate policy regimes and interest rate policy decisions. This study does not account for these differences due to data availability and to avoid complexities. Therefore, it relaxes the conditions regarding exchange rate policy regimes and distinct interest rate rules for the monetary policies of each respective country.

A *pandemic* is defined as a widespread outbreak of a contagious disease, typically affecting a vast geographic area, and leading to profound societal and economic disruptions. Accurate policy decisions a country makes are paramount in shaping economic growth, controlling inflation, and managing employment levels, especially in the face of such significant economic shocks. Monetary policy is a critical factor in this equation, given that economic effects and challenges often persist even after the immediate health crisis subsides. Surprisingly, there has been a shortage of substantial discussion and focus on the specific question of how monetary policy should be conducted during a pandemic and in the post-pandemic recovery phase. Considering the significant economic ramifications of a pandemic and the pivotal role that monetary policy plays in maintaining economic stability, this lack of attention underscores the pressing need for further discussion on this critical topic.

This paper is structured as follows: Section 2 discusses the Role of COVID-19 in the current economic problems, Section 3 provides a literature review, and Section 4 describes the methodology. Section 5 evaluates the economic impact of the COVID-19 pandemic and the responses of monetary policy and discusses the deployment of fiscal policies during the COVID-19 crisis in OECD countries. Finally, Section 6 concludes the study by summarising the findings, presenting policy implications,

acknowledging the limitations of existing literature, and proposing avenues for future research.

2. The Current Global Economic Challenges during the COVID-19 Pandemic

The global economy has experienced a profound impact due to the COVID-19 pandemic, resulting in widespread disruptions to historical growth trends in countries across the globe. Nevertheless, as most COVID-19-related restrictions and health measures are being lifted, economic growth shows signs of recovering and aligning with longer-term patterns. However, it is crucial to acknowledge that the economic consequences of the pandemic were evident from the beginning, taking a toll on public health and human lives. Therefore, this unprecedented global crisis is widely acknowledged as the most significant economic shock witnessed in decades.

The COVID-19 pandemic underscored the urgency of taking immediate action to mitigate its health and economic consequences, safeguard vulnerable populations, and establish a foundation for long-term recovery. It was crucial for all the countries, many of which confront formidable vulnerabilities, to enhance their public health systems, tackle the issues arising from informal sectors, and implement reforms to foster robust and sustainable growth beyond the health crisis.

For many economies, real GDP has reached, or surpassed pre-pandemic levels observed in the fourth quarter of 2019. Nevertheless, there remains significant variation in economics across different countries (Jackson et al., 2020). The World Economic Situation and Prospects report underscores the continued repercussions of the COVID-19 pandemic, along with unattended macroeconomic structural challenges, which present substantial risks to the global economy. Projected for 2023, the global GDP growth is anticipated to be 2.6 percent, marking the lowest annual rate since the global financial crisis, excluding the influence of the 2020 pandemic. However, a slight recovery is expected in 2024, with growth predicted to improve to 2.9 percent (Seitzer et al., 2023). The economic consequences of the COVID-19 crisis vary across different regions. The extent of the impact is influenced by regional economic specialisation in sectors directly or indirectly affected by the crisis, as well as the level of involvement in global value chains (Boyce et al., 2023).

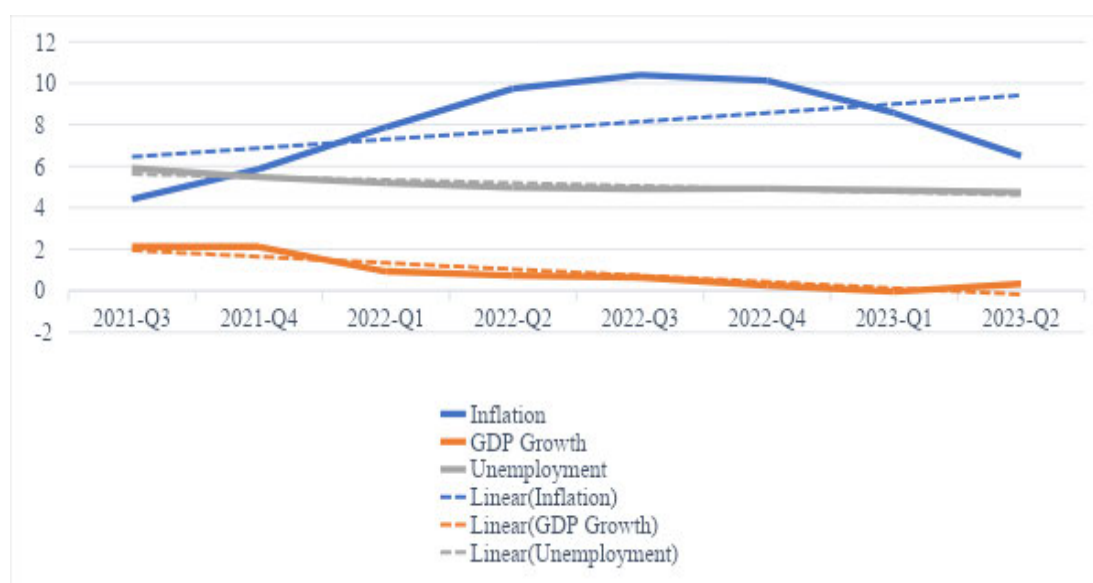
In 2022, the global economy witnessed a significant surge in inflation, affecting both developed and emerging economies. This increase in inflation was driven by a combination of global factors that contributed to and amplified the ongoing worldwide inflationary trend. The recovery of demand following the COVID-19 crisis, coupled with various supply challenges, played a crucial role in exerting pricing pressures on the economy (Hazakis, 2022).

The COVID-19 pandemic notably impacted the elevation of inflation rates in many countries. Sectors that experienced significant disruptions due to lockdown measures, including recreation, accommodation, and transportation, were significant contributors to the inflation surge in 2022. In the context of OECD countries, the inflation rate in the OECD area experienced a notable and considerable increase in December 2021 compared to the 12 months in 2020. This surge in inflation was partially driven by a significant rise in Turkey's annual inflation (OECD, 2023). Within the OECD area, energy prices witnessed a substantial increase of 25 per cent over the 12 months leading up to December 2021.

When excluding food and energy, OECD year-on-year inflation also rose sharply to 4.6 percent, significantly contributing to headline inflation in several major economies. Looking at the entirety of 2022, the annual inflation rate in the OECD rose to 4.0 percent, a significant increase compared to the 1.4 percent recorded in 2021, marking the highest annual average rate since 2000. These statistics indicate that the global economy faces many challenges, including high inflation, tightening financial conditions across most regions, Russia's invasion of Ukraine, and the COVID-19 pandemic. These factors are exerting significant pressure on economic prospects.

The normalisation of monetary and fiscal policies, which provided unprecedented support during the pandemic, is now dampening demand as policymakers aim to curb inflation and restore stability. Consequently, an increasing number of economies are witnessing a slowdown, and some even face contractionary growth. The future health of the global economy hinges critically on the precise calibration of monetary policy, the resolution of the Ukrainian conflict, and the potential for additional supply-side shocks stemming from the ongoing pandemic.

Figure 01: Changes in Major Macroeconomic Variables Across OECD Countries



Source: OECD statistics (2023)

The economic shocks of 2022 are exacerbating the ongoing economic scarring from the pandemic (Figure 01), particularly for OECD economies. At the start of 2022, the pandemic's severe impact on global GDP was already at a negative value of about -0.05 per cent by Quarter 1 2023. Inflation increased from 4.4 per cent in Quarter 3 2021 to 10.39 per cent in Quarter 3 2022 before declining to 8.56 per cent in Q1 2023. Prices in the third quarter of 2023 declined to 6.1 per cent lower than in the same quarter of 2022. Rising inflation with declining real wages and falling unemployment characterised the macroeconomic situation in 2021 in many economies. Therefore, the lasting reduction of inflation will depend significantly on the determination of monetary policymakers.

On the other hand, the tightening of labour markets coupled with reduced labour supply in contact-intensive industries due to health concerns, changing worker preferences, and limitations on cross-border movements has likely added to the inflationary pressures. Moreover, numerous service-sector businesses that are particularly vulnerable to these obstacles may face insurmountable challenges, leading to an escalation in the risk of job losses and bankruptcies—this could adversely impact overall economic demand.

3. Literature Review

This paper contributes to the rapidly expanding literature on monetary policy reactions to the COVID-19 pandemic and the effectiveness of the policy measures in response. The literature has two main strands: the first investigates the theoretical background, while the second examines the impact of the COVID-19 shock on GDP growth, inflation rates, and unemployment due to monetary policy interactions and their effectiveness.

According to Keynesian economic theory, swift government actions are vital to stimulate demand and facilitate economic recovery during crises, as highlighted in prior research (van Aarle, 2017). Keynes emphasised that a policy of government non-intervention would be a severe mistake, leading to a decline in economic output and prolonged suffering for millions of individuals (Alozie et al., 2020; Byrialsen et al., 2021). Consequently, both traditional and non-traditional economists seem to agree on the importance of combining short-term supply-side policies with traditional Keynesian expansionary measures to avert a recession and address price fluctuations during the current crisis (Eichenbaum et al., 2021; Godri Pollitt et al., 2020; van Aarle, 2017).

The unique nature of a pandemic leads to both a demand shock, as consumers curtail their activities, and a supply shock, as businesses either close or scale back their operations. Additionally, the sudden onset of these extreme shocks provides little to no pre-warning for consumers, businesses, or governments, resulting in a swift and pronounced shift in overall economic conditions (Wolf, 2014).

The global financial market faced intensified challenges due to the COVID-19 outbreak, prompting central banks in developed countries to implement unconventional measures to alleviate the adverse effects. From an academic and policy perspective, it is crucial to comprehend the consequences of the pandemic shock and assess the effectiveness of the implemented policies aimed at mitigating its impact (Karaman, 2022).

While some economists argue that nonconventional monetary tools may offset the effect of the lower bound and provide space for monetary policy (Bernanke and Yellen, 2020), others suggest that, due to the changing nature of macroeconomics,

the ability of monetary policy to accomplish much when interest rates are at their lower bound is limited (DeLong et al., 2012; Greenwood et al., 2014; Eichenbaum, 2019; Corradin et al., 2021; Ortmans and Tripier, 2021). Ortmans and Tripier (2021) present evidence that fiscal and monetary policy measures effectively lower bond yields for European economies. In contrast, Lepeti and Fuentes-Albero (2022) study the effects of an unanticipated decline in the interest rate to conclude that monetary policy is likely to be ineffective at the height of the pandemic but should help sustain the recovery in economic activity once the virus starts dissipating.

During pandemics, conventional monetary policy had a minimal impact on GDP, while unconventional monetary policy measures have the potential to mitigate the overall decline in GDP (Gertler and Karadi, 2011). Yilmazkuday (2020) examines the effects of U.S. monetary policy, specifically policy rates, on exchange rates in 21 emerging-market countries during the pandemic. The findings indicate that a negative shock in U.S. monetary policy resulted in currency depreciation in emerging markets. Bhar and Malliaris (2020) discovered that the Federal Reserve's unconventional monetary policies, implemented in response to the 2008 financial crisis, could effectively reduce longer-term interest rates. These findings hold valuable insights for central banks in addressing the financial and economic repercussions of COVID-19.

Existing research on monetary policy primarily focuses on assessing its effectiveness by examining its impact on stock markets in various regions, including North America, Africa, Asia, and Europe. However, there is a notable research gap in modelling optimal containment policies and determining the appropriate response of monetary policy during an epidemic. None of these studies have addressed the influence of COVID-19-induced interest rate uncertainty on the transmission of monetary policy in OECD countries (Narayan, 2020; Phan and Narayan, 2020). Therefore, this study aims to bridge this gap by examining the impact of monetary policy measures undertaken by OECD countries on the macroeconomy during both the COVID-19 pandemic and the subsequent post-pandemic period. The insights garnered from this investigation serve as a guiding framework for effectively addressing future pandemics or economic shocks of a similar nature.

4. Data and Methodology

4.1 Data Collection

This empirical analysis relies on an extensive database at the country level that combines information on monetary policy measures and macroeconomic variables. In particular, the GDP growth rate serves as a proxy for economic growth, and the consumer price index acts as a proxy for the inflation rate. In both equations, real GDP growth is computed by calculating the monthly year-on-year percentage growth rates. The inflation rate variable is derived from the year-on-year percentage change of the Consumer Price Index (CPI). Data were extracted from various sources, including the International Monetary Fund (IMF) Macroeconomic and Financial data, The Organisation for Economic Co-operation and Development (OECD), and the WHO Coronavirus Data.

Table 1: Brief Discussion About Selected Variables

Variable Name	Description	Source
Gross Domestic Product Growth Rate	Gross domestic product growth - expenditure approach	World Bank: World Development Indicators, Our World Data
Unemployment	Unemployment, total (% of total labour force)	World Bank: World Development Indicators, Our World Data
Interest Rate	Monetary Policy related interest Rate	International Financial Statistics (IFS)
Exchange Rate	A relative price of currency expressed in terms of USD	International Financial Statistics (IFS) -Currency exchange rates, monthly average
Economic Uncertainty	World Uncertainty Index	International Monetary Fund (IMF) Macroeconomic and Financial data
Gross Fixed Capital Formation	Gross fixed capital formation as a percentage of GDP	OECD Statistics
Government Expenditure	Total Government Expenditure as a percentage of GDP	OECD Statistics
Consumer Price Index	Consumer Price Index percentage change on the same period of the previous year	OECD Statistics

4.2 Sample Selection

The Organisation for Economic Co-operation and Development, abbreviated as OECD, is an international organisation of 38 countries committed to democracy and the market economy. We included all 33 countries based on data availability. The study's timeframe utilises fortnightly data, derived from the OECD statistics database, spanning from January 2020 to December 2023. Quarterly data was converted to a fortnightly basis using EViews software.

4.3 Methodology

The empirical literature has focused on three key aspects: the impact of interest rates on the money market through monetary policy and its effects on macroeconomic variables such as GDP growth, inflation, and unemployment.

This study employs a balanced panel dataset and a panel ARDL model to analyse the relationship between key macroeconomic policy targets. This model enables the differentiation between short-term and long-term effects. In other words, it allows for examining how variables adjust toward short-term and long-term equilibrium conditions. ARDL model allows intersection points, short-term coefficients, and error variances to change freely between groups but keeps the long-term coefficients the same. The PMG estimator enables us to investigate long-term homogeneity without imposing homogeneity of parameters in the short term (Pesaran et al., 1999).

The considered time period is sufficient to obtain meaningful results because the ARDL approach is suitable for generating both short-run and long-run elasticities from a small sample size (Duasa, 2007; Narayan, 2004).

As per the theory regarding the theory of monetary policy transmission mechanism, multiple channels exist to elucidate the impact of monetary policy on real sectors or the overall economic progress (Prabheesh and Kumar, 2021). These channels encompass mechanisms perceived to operate via the influence exerted by central bank monetary policy instruments, including but not limited to the interest rate, credit supply, exchange rate, and expectations (Chundakkadan and Sasidharan, 2020). Therefore, the model examines the impact of conventional monetary policy,

demand and supply shocks, inflation, and short-term growth dynamics. By separately accounting for GDP growth, inflation and unemployment, the study disentangles these factors from pure supply and demand shocks, respectively. This separation allows for a more precise analysis of their individual effects within the structural theoretical framework.

$$Y_{it} = \beta_0 + \beta_1 r_{it} + \beta_2 k_{it} + \beta_3 exe_{it} + X_{it} + \varepsilon_t \dots \dots \dots (1)$$

$$Y_{it} = \beta_0 + \beta_1 r_{it} + \beta_2 k_{it} + \beta_3 exe_{it} + \beta_4 (r * k * Covid_{Dum}) + X_{it} + \varepsilon_t \dots \dots (2)$$

Where Y_{it} indicates dependent variable, where it denotes Gross Domestic Product growth, Inflation, and Unemployment rate. similarly, β_1, \dots, β_4 are the parameters to be estimated. β_0 is the intercept, t denotes time, i denotes country, and ε_t is the error term. Likewise, “ r ” denotes the interest rate, “ k ” stands for an uncertainty measured by the volatility index (it is implied volatility as measured by the VIX index and can be interpreted as the market expectation of risk), and “ exe ” stands for the exchange rate. The study employs the above model by replacing the dependent variable (Inf_{it}) as the inflation rate (equation 2) to capture monetary shocks by incorporating both the interest and inflation rates.

Inflation is proxied by the consumer price index, and the interest rate is proxied by the lending rate. The exchange rate denotes the value of the country’s currency used for the conversion into US Dollar. The fundamental Equation 2 is augmented with two additional variables to analyse the actual impact comprehensively: cyclical unemployment (unp), denoting the disparity between unemployment and the natural rate, and expected inflation (Inf_Ex) as control variables.

The study uses the 3rd equation by replacing the dependent variable (unp_{it}) as a cyclical unemployment rate to identify the Short-term aggregate supply changes. Equation 3 incorporates GDP growth and inflation rate as control variables to ascertain the real impact accurately.

To examine the impact of COVID-19 uncertainty on monetary policy effectiveness captured by triple interaction term ($r*k*Covid_Dum$), where $Covid_Dum$ stands for a dummy variable, which takes value 1 for the COVID-19 pandemic period

and 0 for other periods. All variables in the models are expressed in logarithmic form (equations 3-6).

Firstly, the study examines Cross-sectional Dependency (CD) through the use of LM tests, namely, Pesaran (2004) and Breusch-Pagan (2004). These tests counteract panel data issues and ensure the robustness and consistency of estimators (Nathaniel et al., 2021).

In addition, the study performs stationary tests for both dependent and independent variables using unit root tests. The Augmented Dickey-Fuller test typically identifies non-stationarity in time series data. The panel unit root test allows for investigating mean-reversion in the panel. It is essential to determine the level of integration among variables to pursue time series based OLS regression and to avoid spurious regression models.

Next, optimal lag selections used the unrestricted model and an information criterion to decide the choice of lags for each group per variable. Then, the panel cointegration test determines the possibility of establishing a long-run equilibrium relationship between variables. This paper employs residual cointegration tests of Pedroni (1999, 2004) and Kao (1999). The panel cointegration test is conducted to determine the possibility of establishing a long-run equilibrium relationship towards which variables converge over time. The deviation of the system from equilibrium at any given point is referred to as the equilibrium error. The Pedroni and Kao tests are based on Engle and Granger (1987) two-step (residual-based) cointegration tests. The Engle and Granger (1987) cointegration test is based on an examination of the residuals, to check whether a spurious regression is performed using $I(1)$ variables. If the variables are cointegrated then the residuals should be $I(0)$. On the other hand, if the variables are not cointegrated then the residuals will be $I(1)$. Pedroni (1999, 2004) and Kao (1999) extended the Engle-Granger framework to test panel data. This paper employed Pedroni (Engle-Granger-based) and Kao Residual cointegration tests to assess the feasibility of producing a panel ARDL model. Finally, the study uses the Hausman test to indicate the null hypothesis of homogeneity by comparing the Mean Group (MG) and the Pooled Mean Group (PMG) estimators.

The testing of the ARDL approach consists of two steps. The first step is to check a long run cointegration relationship among variables. Following the establishment of cointegration, the second step is to estimate the long- and short-run coefficients. The second step only converges to estimate short-run coefficients if the cointegration is rejected. Then, as ARDL assumes no serial correlation, an appropriate lag length (m) should be considered. The study estimates the ARDL model based on Akaike's information criterion (Liu et al., 2020).

As a robustness test, this study uses the panel ARDL Pooled Mean Group (PMG) method as it allows constant term, error variance, and short-run parameters to vary among panel countries. However, it assumes that the coefficients of the long-run relationship are constant across countries. The PMG estimator considers both pooling due to the homogeneity constraints on the long-run coefficients and averaging across countries to obtain the means of the estimated values of the model's error correction coefficients and short-run coefficients.

Due to its incorporation of both pooling and averaging strategies, this model outperforms dynamic ordinary least squares and completely modified least squares methods. Further, this panel regression can be expressed using the ARDL (l and g) technique, according to Pesaran et al. (1999), where "l" is the lags of the dependent variable and "g" is the lags of regressors. Mathematically, this can be expressed as follows.

$$Y_i = \sum_{j=1}^{l-1} \alpha_{ij} \beta_{ij, -j} + \sum_{j=0}^{g-1} \mu_{ij} X_{i,-j} + \rho_i + \varepsilon_{it}$$

In the given context, where "i" represents the number of countries and "t" denotes the period, the vector "Y_t" consists of dependent variables, including GDP growth rate, inflation rate, and unemployment rate, represented as a (k x 1) vector. Meanwhile, X_i is a matrix of explanatory variables, with an order of (T x k), encompassing variables such as interest rate, uncertainty rate, exchange rate, an interaction term between interest rate and uncertainty index, and dummy variables. Additionally, the variable ρ_i represents fixed effects accounting for country-specific characteristics while ε_{it} is an error term, capturing the model's unexplained variations.

5 Results and discussions

5.1 Results

Table 2: Unit Root test

Null Hypothesis: Unit root (individual unit root process)		
	ADF - Fisher Chi-square	ADF - Choi Z-stat
CPI	101.957***	(4.10564)***
GDP	398.244***	(15.8024)***
GFCF	442.507***	(17.0582)***
K	83.1324*	(2.85658)**
R	94.5387**	(1.85428)**
D(EXE)	717.659***	(23.5183)***
D(GXP)	643.648***	(22.1348)***
D(UNP)	760.753***	(24.0456)***

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels

The results of the stationary tests (Table 2) indicate that variables such as GDP growth, rate of uncertainty, gross capital formation, interest rate, and inflation rate are stationary at levels. On the other hand, variables such as government expenditure, exchange rate, and unemployment are stationary at the first difference, with a significant P-result of 0.0000. This indicates that the ARDL cointegration method is required when modelling with a mix of I (1) and I(0) regressors (differed order of integration, that is, some variables are stationary at levels, and some are at first difference).

Pedroni (2004), Johansen Fisher (1995), and Kao residual panel cointegration tests do the robustness check in the cointegration analysis (Table 3). This paper employed Kao Residual cointegration tests to assess the feasibility of producing a panel ARDL model. The Kao test specifies cross-section-specific intercepts and homogeneous coefficients for the first stage regressors. Null and Alternative hypotheses about the Residual test are as follows.

H₀: No Cointegration

H_a: Cointegration

The results reject the null hypothesis and confirm the presence of cointegration in both the deterministic trend and no trend.

Table 3: Cointegration Test

	Model 01		Model 02		Model 3	
	t-Stat	Prob	t-Stat	Prob	t-Stat	Prob
ADF	-7.886526	0.0000	-3.39819	0.0003	-4.39843	0.0000
RESID (1)	-19.10875	0.0000	-9.70651	0.000	-10.9669	0.0000
D (RESID (-1))	8.146924	0.0000	2.790826	0.0053	1.61502	0.1060

Per Table 3, the Kao residual panel co-integration results revealed that Kao residual statistics significantly reject the null of co-integration.

The Pesaran CD, Breusch-Pagan LM, and Pesaran Scaled LM test statistics for all three equations are within the upper tail and strongly reject the null hypothesis of no cross-section dependence in residuals.

Table 4: Cross-Sectional Dependency test

Tests	Model 1	Model 2	Model 3
Breusch-Pagan LM	5156.590***	6818.900***	5664.752***
Pesaran Scaled LM	141.4195***	192.5736***	157.0571***
Pesaran CD	40.53911***	27.30785***	11.34433***

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels

The impact of cross-sectional dependence on estimates depends on several parameters, including the extent of cross-sectional correlations and the nature of cross-sectional dependence. The findings presented in Table 4 demonstrate that the null hypothesis of "no cross-sectional dependence" is rejected even at a 1 per cent significance level. Therefore, the study must proceed with tests and estimation techniques that can account for cross-sectional dependence. These findings call for adopting econometric methods that can produce reliable outcomes in the presence of

dependencies. The heterogeneity assumption was also examined using the test displayed in the table.

Observing the Variance Inflation Factor (VIF) for explanatory variables is crucial in statistical analysis. The VIF results indicate whether multicollinearity is present among the variables in the model. In this case, all three models show low VIF values, less than 5, indicating that multicollinearity is not a concern.

Table 5 presents the results of the long-term effects of monetary policy measures and macroeconomic variables in OECD countries. Selecting an optimal lag length before employing the ARDL model is vital. Various lag length criteria, such as the Akaike Information Criterion (AIC), Hannan Quinn (HQ) information, and Schwarz Bayesian Criterion (SBC), can determine the optimal lag length. Based on the AIC, this study selected a lag length of 3 for the analysis.

Table 5: Long-run Coefficient Estimates by the Panel ARDL Approach

Variables	Dependent Variable: GDP Growth Rate		Dependent Variable: Inflation Rate		Dependent Variable: Unemployment Rate	
	During COVID-19 Pandemic	Post Pandemic	During COVID-19 Pandemic	Post Pandemic	During COVID-19 Pandemic	Post Pandemic
Interest Rate	-0.0848** (0.04243)	-0.178*** (0.0109)	-0.266*** (0.0993)	-1.104*** (0.2319)	0.2202*** (0.0562)	-0.0067 (0.38006)
Exchange Rate	-0.00084*** (0.000175)	0.0020** (0.00099)	-0.0002** (0.00009)	0.0096*** (0.00079)	0.000029 (0.000056)	0.00016*** (0.000046)
Economic Uncertainty	-17.295*** (4.344181)	-0.16703 (0.38745)	1.78076* (1.04831)	-4.3937** (3.96042)	3.05343*** (0.64732)	1.1068** (0.44311)
Gross Fixed Capital Formation	0.28056** (0.09112)	0.0294*** (0.0072)	-	-	-	-
Government Expenditure	0.5396*** (0.10623)	0.0660 (0.0594)	-	-	-	-

Consumer Price Index	-	-	-	-	-0.3778*** (0.03676)	-0.01594 (0.02741)
Unemployment	-	-	0.07879 (0.1069)	-3.954*** (0.8216)	-	-
Mean dependent var	0.105491	0.061062	0.10316	0.04120	0.008311	0.040918
S.E. of regression	0.705765	1.792321	2.011197	1.54211	0.335036	0.407803
S.D. dependent var	3.605623	4.099626	2.637019	1.98451	1.054646	1.191612

*Note: p-values and any subsequent tests do not account for the model. Robust t-statistics are indicated in parenthesis. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. The white cross-section standard errors and covariance test rejected the null hypothesis of heteroscedasticity.

The results of the panel ARDL analysis are shown in Table 5. The selection of the most appropriate ARDL model was made by the EViews software, based on the Akaike information criterion and a maximum lag length of 3.

Table 5 summarises the results of the long-run elasticity of the GDP growth rate, inflation rate, and unemployment rate concerning monetary policy measures and other control variables. The findings of this study suggest a significant negative effect of the interest rate (r) on economic growth and inflation during the pandemic period. These results indicate that a 1 per cent increase in the interest rate decreases 0.08 per cent in GDP growth and 0.26 per cent in inflation within the economy during the COVID period. Conversely, a 1 per cent rise in the interest rate corresponds to a 0.22 per cent increase in unemployment.

According to these study findings, a 1 percent increase in exchange rate reduces the GDP growth and inflation rates by 0.0008 per cent and 0.0002 per cent, respectively, during the COVID period. A higher exchange rate (currency appreciation) makes foreign goods and services cheaper than domestically produced goods. This decreases exports and domestic production activities (Ramasamy and Abar, 2015).

Hence, the effects of the exchange rate on economic growth and inflation are consistent.

On the other hand, the 1 percent increase in the exchange rate increases the unemployment rate by 0.00002 per cent. A stronger domestic currency makes exports more expensive for foreign buyers, reducing demand for domestic goods and services abroad. This can harm export-dependent industries like manufacturing and tourism, leading to lower revenues. Some businesses may need to reduce their workforce to counter reduced income, resulting in higher unemployment in these sectors.

During the COVID period, a 1 percent increase in economic uncertainty decreased economic growth by 17.29 percent and increased the inflation rate and unemployment by 1.7 percent and 3.05 percent, respectively. The COVID-19 pandemic increased global economic uncertainty, which caused disruptions in supply, demand, and productivity. These findings are theoretically consistent.

However, starting in 2022, all countries faced various economic shocks, notably the aftermath of the COVID-19 pandemic. As presented in Table 5, models 2, 4, and 6 show monetary policy measures and their impacts on macroeconomic variables during the post-COVID-19 era. A 1 percent increase in the interest rate results in a 0.17 per cent reduction in GDP growth and a 1.1 percent reduction in inflation in the long run.

Consequently, a 1 percent increase in exchange rate results in a 0.002 per cent GDP growth, 0.009 percent inflation rate growth, and a 0.0001 percent unemployment growth rate in the long term. The impact of economic uncertainty on GDP growth is negative but insignificant, and the effects on inflation and unemployment are, respectively, negative and positive. The results were significant and consistent; hence, these outcomes echo the results of previous studies (Lucian, 2006; Saymeh et al., 2013; Carrera and Vergara, 2012).

6. Discussion

Findings from this study reveal a significant negative relationship between declining interest rates and increasing economic growth during the COVID-19 period. Notably, most countries aggressively lowered their interest rates during this time. A

decrease in interest rates can have several economic effects. It can reduce the cost of borrowing, thereby encouraging consumer spending, business investments, and housing purchases. Lower interest rates may also discourage foreign capital, resulting in a depreciation of the domestic currency, which, in turn, can boost exports. Consequently, many OECD governments proactively supported their local economies during the crisis by assisting households, businesses, and affected service sectors by reducing their interest rates.

It is noteworthy that the relationship between interest rates and GDP growth simplifies the complex and dynamic economic system, especially during the COVID-19 period when all economic sectors were affected due to lockdowns and social restrictions. Despite conventional economic IS-LM theory predicting that a slowdown in economic activity should increase interest rates, an intriguing deviation from this theory occurred, with savings rates continuing to rise. This phenomenon raises questions about the underlying factors driving this behaviour.

The interest rates decreased during the pandemic despite conflicting economic forces such as rising public debt and unprecedented savings. Local governments in many OECD countries played a pivotal role in providing comprehensive support, including financial aid, non-repayable grants, concessional loans at low or zero interest rates, liquidity loans, and facilitating access to external financing through guarantees. Additionally, they deferred loan instalments as part of their support measures (OECD, 2020).

Persistently low interest rates during the pandemic can raise concerns about potential inflation, as central banks may be concerned about overheating the economy. To counteract this, they may consider tightening monetary policy in the future, raising interest rates to control inflation. The concept of a negative relationship between interest rates and inflation is grounded in economic theory. Lowering interest rates makes borrowing more affordable and may increase consumer and business spending. This higher demand can put upward pressure on prices, potentially leading to an increased inflation rate.

Despite initially high values, interest rates experienced a gradual decrease by the end of 2020. An unintended consequence of this policy was a reduction in

unemployment rates. However, the slowdown in economic activity and reduced production output prompted companies to curtail their hiring efforts, affecting unemployment rates during the pandemic.

Furthermore, a country's monetary policy is closely related to its exchange rate policy. In a trade economy that engages with other countries, monetary policy can affect real output through the exchange rate channel, especially when nominal wages and prices remain relatively stable (Krylova, 2002). A higher exchange rate can also reduce inflation as cheaper imports become available in domestic currencies. This could lead to currency appreciation, making imports more affordable while reducing the competitiveness of exports, resulting in a drop in domestic demand. As a result, local companies may reduce costs and cut jobs, causing unemployment to rise. These findings align with those of Purfield and Rosenberg (2011) during the 2008-2009 global financial crisis.

High economic uncertainty levels can lead to decreased business and consumer confidence, which may reduce investments in capital, technology, and innovation. This, in turn, can slow down economic growth. Conversely, when people are uncertain about their financial future, especially during a pandemic, they may save more and spend less or delay non-essential consumption, thereby reducing overall economic activity. This situation aligns with the findings of Hepburn et al. (2020).

A noteworthy development in the post-COVID-19 era is the increase in interest rates, coupled with a high inflationary environment in OECD countries. These findings suggest that the impact of elevated interest rates on financial markets and economic activity may be more significant than initially anticipated. This strategic policy shift aims to stimulate economic growth and counter the economic slowdown in the post-COVID-19 era. As the economy recovers and inflationary pressures mount, some central banks may contemplate a gradual increase in interest rates, aligning with the broader policy normalisation process (Binici et al., 2022). The level of inflation is an essential factor shaping the interest rate policy in the post-pandemic era. If inflation persists (at high levels), central banks may need to raise interest rates to control it, even as the economy rebounds.

Additionally, a positive relationship exists between exchange rates and GDP growth rate. This indicates that a weaker currency can enhance a country's competitiveness in foreign markets, potentially boosting export-related industries and overall economic growth (Enu and Opoku, 2013). Moreover, exchange rates can impact a country's trade balance, with a depreciating currency potentially improving the trade balance, thereby contributing positively to economic growth. Nevertheless, it is crucial to acknowledge the volatility in exchange rate movements, making it challenging to predict their precise influence on economic growth during the post-COVID-19 era. Governments and central banks must diligently oversee and manage exchange rate dynamics to ensure they bolster, rather than hinder, their economic recovery endeavours.

Exchange rates play a significant role in determining the prices of imported goods and services. A depreciating domestic currency raises the cost of imports. Furthermore, exchange rate fluctuations can influence inflation expectations among consumers and businesses (Auboin and Ruta, 2013). If individuals anticipate a significant future currency depreciation, they may engage in behaviour that accelerates inflation, such as hoarding goods. Additionally, various other domestic and global factors influence inflation dynamics. Therefore, central banks and policymakers must carefully consider the interplay between exchange rates and inflation when making monetary policy decisions during the post-COVID-19 era.

Conversely, an appreciating domestic currency can erode the competitiveness of exports, potentially reducing the demand for domestically produced goods and services in global markets, with potentially negative repercussions for employment in export-oriented sectors. Further, an appreciating domestic currency can make imports more affordable, potentially intensifying competition for domestically produced goods. This can affect industries facing substantial import competition, leading to job losses.

Economic uncertainty can result in cautious investment decisions by businesses and reduced consumer spending (Hepburn et al., 2020). Uncertainty regarding the future can lead to businesses postponing capital expenditures and hiring, potentially decelerating economic growth. In the post-COVID-19 era, government policies aimed at reducing economic uncertainty and supporting recovery to impact GDP growth significantly. For instance, fiscal stimulus packages and

supportive monetary policies can mitigate the adverse effects of uncertainty and stimulate economic activity. Central banks often respond to inflationary pressures by tightening monetary policy.

Nevertheless, in the post-COVID-19 era, central banks may carefully balance the need to control inflation to support economic recovery, potentially adopting a more patient approach to interest rate increases to avoid stifling growth. Elevated economic uncertainty can prompt businesses to exercise caution when hiring new employees and, in some cases, initiate layoffs, contributing to higher unemployment rates.

There is a negative relationship between the inflation rate and unemployment rate during and after COVID-19. The Phillips curve often describes the relationship between inflation and unemployment, which suggests an inverse relationship: as inflation increases, unemployment decreases, and vice versa. This relationship is known as the *short-run Phillips curve*. The long-term Phillips curve relationship is not so straightforward, especially during a pandemic when demand is depressed (Lawler and Pavlenko, 2020). Policymakers must consider various factors, including the nature and duration of the crisis, the effectiveness of policy responses, and long-term expectations, when addressing unemployment and inflation during a pandemic.

7. Conclusion

Given the profound uncertainty brought about by the COVID-19 pandemic, this study closely examines the influence of monetary policy measures on GDP growth, inflation, and unemployment within 33 OECD countries significantly affected by the COVID-19 pandemic period and the subsequent post-pandemic era spanning from 2020 to 2023 using the Panel ARDL approach. The study findings suggest that during the COVID-19 pandemic period, monetary policy measures had a low level of interest rates, as the majority of OECD economies reduced the cash rate and interest rates on exchange settlement balances. This was primarily due to the fiscal policy of most OECD countries, which provided substantial support to their economies, creating a shift that posed a challenge for countries with low budget deficits and minimal public debt.

In contrast, the post-COVID-19 era witnessed the implementation of high-interest rates by countries aimed at fostering economic growth and concurrently

curbing unemployment. Introducing relaxed monetary policy measures carries some risks, such as public investment becoming an adjustment variable. Higher interest rates reduced the availability of credit, subsequently reducing consumer spending and thereby reducing economic growth.

These findings underscore the importance of swiftly transitioning patterns of monetary policy measures in response to economic shocks like pandemics. However, governments must manage inflationary pressures, a notable drawback of expansionary monetary policy. In the meantime, governments should announce significant recovery plans focusing on public investments, such as strengthening healthcare systems during a pandemic and accelerating the production process immediately after immunisation for the virus. Therefore, monetary policies must remain adaptive and responsive to evolving economic conditions. Central banks should maintain a balance between controlling inflation and supporting economic activity through interest rate adjustments and quantitative easing.

On the other hand, occupations in the industrial and services sector must be adaptable to remote working based on the nature of the work. The adaptability of occupations to remote working depends significantly on the industry's technological readiness and the nature of the job tasks. Employers may need to invest in training and technology to facilitate this transition, ensuring that employees have the tools and skills necessary to work effectively from remote locations.

Recognising that the COVID-19 pandemic may not be the last epidemic and anticipating future economic shocks, this study offers potential policy insights applicable to similar circumstances. Well-calibrated policy measures are required to mitigate the impact of the recent adverse shocks on the global economy, restore economic stability, and strengthen prospects for strong, inclusive, and sustainable improvements in living standards.

This study encounters several limitations primarily stemming from time constraints. The study's scope is confined to a relatively short period, but the long-term ramifications may differ. Furthermore, the study could not incorporate changes in energy prices in the fundamental models due to data limitations. Therefore, future research endeavours would be valuable, mainly through single-country analyses.

Such an approach would provide a more individualised understanding of the impact of monetary policy measures on macroeconomic variables both during and after economic shocks.

Declaration

The authors listed below certify that we have NO affiliations with or involvement in any organisation or entity with any financial or non-financial interest in the subject focus or materials discussed in this manuscript.

Availability of data

The data supporting this study's findings are available from the websites of the International Monetary Fund, the Australian Bureau of Statistics, and the Australian Institute of Health and Welfare.

Conflict of interest

The authors have no affiliations with or involvement in any organisation or entity with any financial or non-financial interest in the subject focus or materials discussed in this study.

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5.3 Links and implications

This paper revealed the changes in macroeconomic variables resulting from monetary policy measures during the COVID-19 pandemic and after. The reduction in interest rates implemented through monetary policy measures across numerous OECD economies during the COVID-19 pandemic presented both opportunities and challenges for the entire macroeconomic system. Balancing the benefits of low interest rates with the potential risks and challenges they entail remains a complex task for policymakers as they navigate the path to recovery and long-term sustainability. This trend was primarily driven by the fiscal policies of many OECD countries, which provided substantial support to their economies. This shift posed a challenge for countries with low budget deficits and minimal public debt. In contrast, the post pandemic period witnessed the implementation of higher interest rates by countries aiming to stimulate economic growth while concurrently addressing unemployment. The introduction of relaxed monetary policy measures carries certain risks, such as public investment becoming an adjustment variable. Higher interest rates reduced the availability of credit, subsequently decreasing consumer spending and leading to a contraction in economic growth.

While the previous paper focused on fiscal policy, this study has examined the macroeconomic changes resulting from monetary policy adjustments. The subsequent chapter provides a comprehensive exploration of the effectiveness of government policy responses, especially those implemented to mitigate the health and economic risks posed by COVID-19. This analysis is intended to contribute valuable insights that can inform future policy decisions and aid in fostering resilience against similar global crises.

CHAPTER 6: PAPER 4 – THE EFFICACY OF GOVERNMENT STRATEGIES TO CONTROL THE COVID-19 PANDEMIC

6.1 Introduction

This chapter presents the fourth study of the thesis: an investigation into the efficacy of government policy directions in mitigating the effects of the COVID-19 pandemic. This study relies on a panel of 22 countries from Quarter 1 of 2020 to Quarter 2 of 2022. It is motivated by the ongoing outbreaks and comprehensive policy responses taken by countries to mitigate the spread of COVID-19 and minimise mortality rates. An overview is given of government responses throughout the pandemic history. This study is an evaluation of the effectiveness of governments' decisions in mitigating the risks of COVID-19. Policy directions are proposed to reduce its impact. The contributes to the literature providing a comprehensive evaluation of the efficacy of government responses to COVID-19 with methods to enhance their effectiveness, which can be applied not only to the current pandemic and future situations of similar magnitude.

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6.3 Links and implications

This has been an investigation into the efficacy of government responses in controlling the spread and reducing fatalities during the COVID-19 pandemic. Government responses were categorized into four indices: containment and health, economic support, government response, and stringency. The study reveals that policymakers globally responded promptly to the COVID-19 pandemic, aiming to mitigate its risks. Economic support and stringency have emerged as the most effective interventions among the four, as the implementation of strict measures and financial support correlates with a reduction in infection and fatality rates.

This study has demonstrated that providing economic support for income and debt relief has played a crucial role in suppressing the rate of COVID-19 infections and fatality rates. In the following chapter, the analysis transitions to examining the cost of the COVID-19 pandemic on the economy. This comprises, approximate direct health cost expenditure, taking into account government funding, public or private health insurance, patient out-of-pocket expenses, or a combination of these. Such estimations assist policymakers in resource allocation and prioritising disease control activities. They are also essential for long-term planning, ensuring sustainable financing in similar future conditions.

CHAPTER 7: PAPER 5 – THE COST ANALYSIS OF COVID-19 IN AUSTRALIA

7.1 Introduction

This chapter introduces the fifth paper of the thesis, which focuses on a comprehensive analysis of the cost associated with COVID-19, particularly within the context of Australia. Notably, this paper stands out as the only study in the thesis that centres on a single country analysis. Recognising the variations in cost related to COVID-19 across different countries, contingent on their containment and health policies, this study pioneers an examination aimed at estimating the direct healthcare costs incurred by hospital admitted COVID-19 infected patients in Australia.

Beyond providing a mere cost estimate, the study ventures further by delving into the various factors influencing the determination of inpatient costs for COVID-19 in Australia, leveraging the WHO CHOICE model. The intricate relationship between inpatient unit cost and diverse explanatory variables is explored through multiple regression analysis employing the ordinary least squares method. Furthermore, the study broadens its scope to analyse structural changes that transpired during the COVID-19 pandemic period. This research serves not only as a crucial guide for comprehending the intricacies of healthcare costs associated with COVID-19 in Australia but also offers valuable insights for policymakers. By emphasising unprecedented macroeconomic changes, the study contributes significantly to shaping a comprehensive policy direction in response to the challenges posed by the COVID-19 pandemic.

7.2 Published paper

Cost Analysis of COVID-19 in Australia

Abstract

Access to accurate and reliable information on the cost of COVID-19 can help with economic policy decisions. This paper aims to analyse of the costs of the SARS-CoV-2. pandemic with a special focus on Australia. Costs include macroeconomic costs of foregone gross domestic product (GDP) attributable to the pandemic and direct and indirect costs. This is an examination of the direct and indirect costs of the COVID-19 pandemic on the Australian economy by employing the bottom-up costing approach and the WHO-CHOICE model. All models are estimated using quarterly and fortnightly data from 2020 to 2022 when the pandemic hit the economy the hardest in Australia. The results indicate that an inpatient's per day unit cost is estimated to be AUD 836, which may reveal the minimum direct health cost value. The WHO-CHOICE model identifies the factors that determine inpatient hospital costs per day. The changes in hospital bed occupancy, GDP per capita, and hospital admissions are more responsive to changes in inpatient costs. The findings of indirect impact GDP fell significantly to 1.9 percent below its No-COVID level in 2021 Quarter 1. The reduction continued to -1.8 percent by the 3rd quarter of 2021. Important policy recommendations are then suggested based on the empirical results.

Key Words: Covid-19, Inpatient Direct Cost, Macroeconomy, Economic Cost

JEL Code: C22, D61, O56

1. Introduction

The COVID-19 pandemic has affected households, industries, and governments over the globe and has resulted in an unprecedented increase in costs to the economy. In advanced and emerging economies, the escalated pandemic resulted in strict lockdowns and massive disruptions in economic activity (Baldwin and Mauro, Gopinath, 2020). This study is motivated by the ongoing coronavirus pandemic, and its cost on economies worldwide. In particular, the direct costs of the COVID-19 pandemic to the Australian economy are examined and policy directions are suggested to mitigate their magnitude.

The economic impacts of COVID-19 can be broadly classified as demand and supply shocks (Boissay and Rungcharoenkitkul, 2020). The pandemic affects the economy through the following channels: (1) the direct effect of a reduction in the workforce; (2) the increase in the cost of global trade; (3) the sudden decline in travel and transportation due to local and international border restrictions; (4) the decline in demand for services sector activities (Maliszewska et al., 2021, Pearson et al., 2021). Besides the impact through these channels, there existed a decline in consumer demand as millions of people stayed at home and postponed non-essential expenses, a contraction in foreign direct investment, and an expansion in government expenses with growing healthcare expenditure widening the economic costs associated with COVID-19 (Ajmal et al., 2021, World Bank, 2021). Therefore, it is crucial to identify country-specific economic cost factors to ensure stability and defend the economy from major breakdowns.

Based on the situation stated above, the research objectives are to (1) estimate the direct health costs of the COVID-19 pandemic, (2) identify country-specific cost factors and (3) analyse the macroeconomic impacts due to this pandemic in Australia.

However, estimating costs per patient is challenging in hospitals due to complex and insufficient data. There is no publicly available information on the input costs of testing and treatments for COVID-19 in Australia. Therefore, it is necessary to estimate the approximate direct health cost expenditure by government funding, public or private health insurance, patient out-of-pocket expenses, or a combination of all. This is because estimations of the cost of coronavirus disease in a country may not only

support policymakers in effectively allocating resources and prioritising disease control activities, but it is also paramount to the long-term planning for sustainable financing in similar future conditions.

Although the previous literature estimated the unit cost of specific health interventions, the transferability of such findings from one setting to another is limited (Adam, 2008; Beck, 2012). This study contributes to literature in the following ways. First, it is one of the first attempts to assess the direct health cost of the COVID-19 pandemic in Australia. Second, the impact of indirect cost factors is identified to determine the inpatient per day cost of COVID-19 in Australia. Third, this study can be used as a guide for a comprehensive policy direction in response to the COVID-19 by emphasising unprecedented macroeconomic changes.

This article is organised as follows. Section 2 presents the public health responses on COVID-19 in Australia. Sections 3 and 4 indicate empirical evidence on the cost of COVID-19 and the methodology for this study. Section 5 provides the estimated daily cost of inpatients of COVID-19 per person, and the macroeconomic impact of COVID-19. Finally, Section 6 concludes the study. It includes policy recommendations, the limitations of the existing literature, and future research directions.

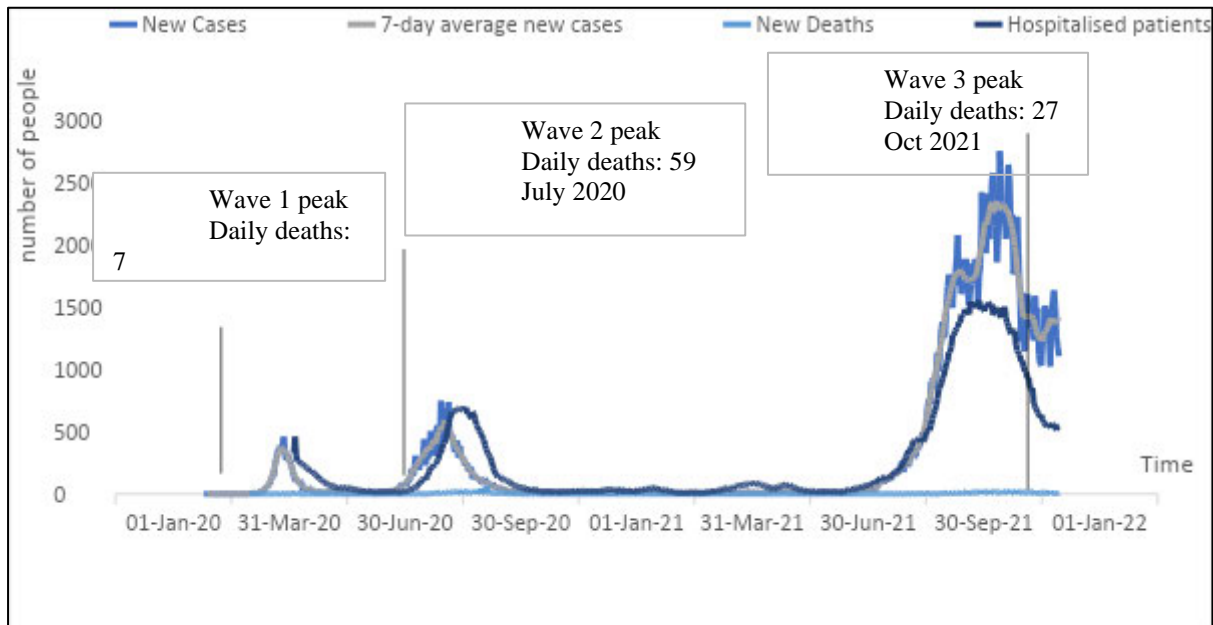
2. Public Health Responses to COVID-19 in Australia

Australia is a country with a population of 25.77 million people (2021). The population aged 65 and above is 16.21 percent of the total population. GDP per capita is estimated at USD 55,807. Total health spending in 2021-22 is USD 98.3 billion, accounting for 16.7 percent of total Australian government spending (The Commonwealth of Australia, 2022).

Since the start of the pandemic in 2020, Australia has experienced multiple waves of COVID-19 (Figure 1). The first wave occurred between March and April, with most Australian states recording active infected cases and deaths. The second wave began in June 2020, with the most active infections and deaths. Then, with the spread of the Delta variant, a third wave began in June 2021 and reached its peak in October. The Omicron variant was revealed in Australia in November 2021 and quickly spread

throughout the country, resulting in a fourth wave that lasted till the first quarter of 2022.

Figure 1: Waves 1-3 daily cases, hospitalisations, and peak deaths



Source: Department of Health and Aged Care, 2022a

Most COVID-19 patients can have mild to moderate symptoms and recover without treatments or hospitalisation. However, some people become severely ill and need medical attention. Since the outbreak of COVID-19, various countries have responded to the pandemic using different strategies. Australia has also followed several policies to suppress COVID-19 infection. The Australian government attempted to lessen the pressure on health services by lowering the number of illnesses and fatalities through shutdown procedures. It introduced voluntary mitigation restrictions such as self-isolation for those with symptoms and social distancing advice for those most at risk.

Table 1: Hierarchy of Control for COVID-19 Pandemic in Australia

Most Effective	Hierarchy of control ranking	Examples of control measures to prevent transmission
	Elimination	Vaccination
	Decrease the opportunities for the virus to be spread	Testing and quarantine at borders Travel restrictions
	Substitution	Physical distancing
Less Effective	Find different approaches to provide care that minimise the risk of transmission.	Symptomatic health worker and agency group to stay home and not come to work, remote working, telehealth
	Engineering controls	Ventilation and improved air changes
	Use physical barriers and other forms of hazard reduction	Registration of all people entering the facility (symptom check, QR code), negative pressure rooms, single room with ensuite, isolation of patients
	Administrative controls Implement effective and consistent policies & protocols	Audit and feedback, hand hygiene, cleaning and disinfection, signs, posters, information sheets, infection prevention and control guidance documents, training, and education of health workers
	Personal protective equipment	Symptomatic patients to wear surgical masks, correct transmission-based precautions, personal protective equipment worn when in contact with infectious patients

Source: Department of Health and Aged Care, 2022b

The Australian government enforced local and international border restrictions to control the immediate spread of the coronavirus (SARS- CoV-2) in Australia before the World Health Organisation (WHO) declared a Public Health Emergency in 2020. Therefore, the Australian economy recovered from COVID-19-related lockdowns from 2020 to 2021, completing the calendar year with successful and effective controls.

3. Literature Review

There is a growing body of empirical literature on the COVID-19 pandemic. This section is a review of past studies related to the cost of COVID-19 and includes macroeconomic factors such as GDP during the COVID-19 pandemic. The COVID-19 pandemic is inflicting high and rising human costs worldwide, and the necessary protection measures are severely impacting economic activity. As a result of the pandemic, the global economy is projected to contract sharply by 3 percent in 2020, much worse than during the 2008–09 financial crisis (Mishra, 2020). According to the Boissay and Rungcharoenkitkul, (2020) the economic cost of the Covid-19 pandemic can be proxied by GDP forgone, namely the difference between current forecasts and pre-Covid-19 outlook. The annual output loss ranges between 5 and 9 percent of pre-Covid-19 estimates for the US, and between 4 and 4.5 percent for the global economy by the end of 2020. In the meantime, Ghaffari Darab et al., 2021a stated that the high prevalence rate of COVID-19 has been imposing a heavy economic burden on the country and health system directly, which may result in rationing or painful cost-control approaches. High healthcare costs could also threaten the health of patients infected with COVID-19. 14 percent of Americans said they would avoid medical care due to cost if they developed symptoms consistent with COVID-19 (Debata et al., 2020).

Einchebaum et al. (2020) investigate the equilibrium interactions between economic decisions and epidemic dynamics using the SIR model. Their findings imply that while containment policies and agents' decisions to lower work and consumption mitigate the severity of the pandemic base on the total deaths, the size of the ensuing recession is exacerbated. According to the Jin et al., (2021), COVID-19 control measures prevent the spread of disease resulted in substantial costs from productivity losses amounting to 2.7 percent of China's annual gross domestic product during 1 January–31 March 2020. The total monthly economic losses during the lockdown reached 177 billion yuan. However, the lockdown policy has been considered to

reduce COVID-19 infections by 180,000, which saved about 20,000 lives, as well as nearly 30 billion yuan in medical costs in China (Debata et al., 2020). Therefore, the total GDP decreased 37 percent in 2020. The private components of GDP, investment, consumption, export, and import lost 82 percent, 30 percent, 36 percent, and 25 percent of their respective counterfactual values (Debata et al., 2020). Another part of the literature is devoted to the measurement of the macroeconomic impact of COVID-19. Marcolino et al., (2021) stated that a significant variability in acquisition costs and investments by institutions responding to the COVID-19 pandemic. On the other hand, McKibbin and Fernando (2020) mentioned that the COVID-19 pandemic caused a sharp drop in both consumption and investment.

The above literature review demonstrates that COVID-19 has created financial and economic costs of many kinds. Even though there are limited studies about direct health cost estimates per day at hospital for a COVID-19 infected patient, based in a single country or a group of countries, it is difficult to compare across the literature due to differences in methodology, population, and healthcare costs. Therefore, our contribution to the literature is precise to evaluate the cost of COVID-19 in Australia and identify its macroeconomic impact because such a research study is absent in Australia.

4. Data and Methodology

4.1 Data Collection

For this study, we use data from the Australian Bureau of Statistics (ABS), the Australian Institute of Health and Welfare (AIHW) database, the European Centre for Disease Prevention and Control Statistics, and WHO Coronavirus Data from 2020 to 2022 to evaluate the cost of the COVID-19 pandemic in Australia. For the direct health cost estimation, we follow the framework of bottom-up costing, for which we gather data from the ABS and AIHW. To identify the determinants of the cost of COVID-19 in six states of Australia, we use the WHO-CHOICE¹ model and collect data from the AIHW database. "EViews-09" econometric software is used for estimation purposes.

WHO-CHOICE (Choosing Interventions that are Cost-Effective) is an initiative started by the World Health Organisation in 1998 to help countries choose their healthcare priorities. (1)

Table 2: Brief description of the variables

Variables	Description	Source
GDP per capita (PPP) (000 USD)	Per capita values for gross domestic product (GDP) expressed in current international dollars converted by purchasing power parity (PPP) conversion factor.	Australian Bureau of Statistics
Bed occupancy rate	The percentage of available beds which have been occupied over the period	Australian Institute of Health and Welfare (AIHW) database
Average length of hospital stays	The average number of days COVID-19 infected patients spend in the hospital.	Australian Institute of Health and Welfare (AIHW) database
Inpatient admissions	The number of COVID-19 patients admitted to the hospital for medical treatment or a procedure.	Australian Institute of Health and Welfare (AIHW) database
Level of the facility	Admissions to Public Hospital and Private hospitals	Australian Institute of Health and Welfare (AIHW) database

5. Methodology

One of the objectives of this study is to estimate the direct and indirect costs of COVID-19. The direct cost includes the medical expenditure for diagnosis, treatment, and rehabilitation. Indirect costs include lost production due to premature deaths and missed workdays.

The direct health costs can vary with the number of infected patients, the severity of the illness, the mean length of stay in the hospital, and other variables (Warren et al., 2003). We estimate the direct health cost of a COVID-19 patient using the bottom-up approach. This method primarily relies on detailed records and observation to measure resource use (Ghaffari Darab et al., 2021b). Here, we prospectively include consecutive patients diagnosed with COVID-19 who were admitted to public or private hospitals in 2021.

WHO-CHOICE brings upon the prediction models describe cost estimation for all states of Australia. Furthermore, the WHO-CHOICE model is used to identify the factors that influence the cost of inpatient health services per day (WHO, 2021). This study uses state specific values where possible and other independent variables based on the representative “average values” which can be converted to normative values. All COVID-19 patients who had been referred to a primary referral medical facility in all states of Australia by July 2022 made up the research population.

The relationship between the inpatient unit cost and explanatory variables are explored using multiple regression analysis using the ordinary least squares method (Warren et al.,2003). Natural logarithms are used to transform the dependent and explanatory variables to make the coefficients interpretable as elasticities. The functional specification is formulated as follows (Stenberg, 2020):

$$\ln UIC_i = \beta_0 + \beta_i \sum_{i=1}^n \ln X_i + \varepsilon_i$$

Where $\ln UIC_i$ is the natural log (Ghaffari Darab et al.) of unit cost per inpatient day in Australian dollars in the i^{th} facility; β_0 and $\beta_{i, \dots, n}$ are the estimated parameters; X_i are the set of explanatory variables transformed into natural logarithms for continuous variables (GDP per capita in 2021, bed occupancy rate, ALOS, total inpatient admissions, dummy variable for public hospitals and dummy variable for private hospitals); and ε_i represents the error term. As in the WHO-CHOICE model, hospital bed cost per day does not include expenses for medications, medical supplies, caregiving appliances, and laboratory research. These are considered separately and factored into the treatment plan since a detailed vector of input prices is not available.

Furthermore, GDP per capita serves as a proxy for the level of technology (Adam et al., 2003). In terms of the output indicators that such models typically use, occupancy rate, total inpatient admissions, and ALOS provide a measure of capacity utilisation while controlling for facility size. An indicator of the level of the facility and of whether the hospital is public or private hospital has been considered for the study. Further, we gather sector-by-sector percentage change estimates of COVID-19’s economic impact based on data from the ABS to examine the indirect cost of COVID-19 on the Australian economy from mid-March 2020 to June 2022.

5. Results and Discussion

5.3 Direct Cost

The average inpatient cost of COVID-19 is used to determine the mean value of total direct health costs for each patient with COVID-19. According to the initial guidelines, the average expenses per patient, per day, and per stay can be determined based on the risk type of the illness.

Table 3: Risk type of the COVID-19

Risk Category	Treatment Method
Mild symptoms	Rest and recover at home.
Worsening symptoms	Contact a general practitioner (GP), GP respiratory clinic, or the National Coronavirus Helpline.
Severe symptoms	Immediate hospitalisation Authorise a drug, supplemental oxygen or mechanical ventilation as needed.

Source: Department of Health and Aged care, 2022

Unit cost estimates are much sensitive to the method used for cost allocation. The direct health costs of COVID-19 can be calculated separately for each of the three types of risks. These costs vary according to the treatment procedure, direct and indirect labour, types of medical consumables, COVID-19 test kits, laboratory tests, radiological examination costs, and accommodation. In this study, we only estimate the minimum daily healthcare cost of a hospital admitted patient based on possible assumptions and calculations.

Table 4: Estimated daily cost of inpatient of COVID-19 per person (without ICU admission)

Cost categories	Amount (Australian dollars)	Percentage of total cost per COVID-19 infected patient
Human capital cost (International_Labour_Organisation)	122.33	14.61
Medicinal consumables	342.50	40.92
Diagnostic test ((Polymerase Chain Reaction (PCR))	100.00	11.94
Laboratory tests	50.00	5.97
Radiological examinations (Computed Tomography scans)	222.00	26.52
Total cost per COVID-19 infected patient	836.83	
Total inpatient cost of COVID-19 (The total inpatient cost of COVID-19 in 2021, calculated as the product of the total cost (TC) and the number of patients for the year, amounted to 4473 patients.)	3,738,974.089	

Source: Author's construction based on Australian Bureau of Statistics, 2022

The direct costs of a COVID-19-infected inpatient in hospital wards are shown in Table 4. An inpatient's per day unit cost is estimated to be AUD 836. This is the minimum per day cost that is compensated for COVID-19 inpatients by government funding, public or private health insurance, patient out-of-pocket expenses, or a mix of all to cover the cost of treatments in Australia. The total cost is thought to constitute 40 percent of medicinal consumable expenditure and 26 percent of radiological examination expenditure. The estimated total cost of inpatients is AUD 3.7 million for 2021 in Australia.

Human capital and medical consumables are more expensive for inpatients than for other cost categories. We divide the total salary and wage expenditure per day for medical and supportive staff by the total admitted number of COVID-19

patients to calculate the direct human capital cost per day. The cost of medicinal consumables is calculated based on the several COVID-19 treatments that people with COVID-19 may be eligible for if they are in a healthcare facility. There are two types of COVID-19 treatment options in Australia. First, antiviral treatments help to prevent viruses from infecting healthy cells. The second type of treatment is monoclonal antibody therapy which works by attaching to the virus and preventing it from entering human cells. This facilitates the fight against the threatening virus (AIHW, 2021). Therefore, we include both COVID-19 antiviral treatment cost and monoclonal antibody treatment cost to calculate the cost of medicinal consumables. Further, radiology is identified as an indispensable part of COVID-19 inpatient primary care. It is essential to diagnose, manage, and treat many common conditions. Then we include the average upfront cost of radiology for this calculation.

5.2 WHO-CHOICE specific cost factors for inpatient health service delivery

Further, we attempt to identify the factors of country-specific costs related to health service utilisation with estimates for cost per inpatient day using the WHO-CHOICE model. The study conducts “Huber-white-Hinkley (HIC) heteroscedasticity test.

Table 5: Regression coefficient: natural log of cost per inpatient bed day

Variable	Regression coefficient	P value
Ln GDP per capita	0.278596 (0.09409)	0.04152
Ln occupancy rate	1.050608 (0.11725)	0.01200
Ln ALOS	-0.042187 (0.00458)	0.01687
Ln admissions	0.014049 (0.00168)	0.09981
Dummy H1- public hospital	-0.112456 (0.05068)	0.06982
Dummy H2- private hospital	0.110145 (0.07553)	0.21825
R2	0.698	
Adjusted R2	0.685	
F-stat	251.08 (0.004)	
Durbin-Watson stat	1.565	

Note: *, ** and *** represent statistical significance at 10%, 5% and 1% levels, respectively

Source: Authors' estimation (2022)

The final regression models for inpatient unit costs are shown in Table 6. Most of these are statistically significant under the probability value ($p < 0.05$). The inpatient cost model performs marginally better, with an adjusted R squared of 0.698. In this model, the hospital bed occupancy rate is a highly significant proxy for the price level or cost of a COVID-19 patient. When there is an increase in the bed occupancy rate of 1 percent, this directly increases the cost of inpatient by 1.05 percent. This confirms the measure of capacity utilisation as one of the important independent variables of cost analyse. The relationship between bed occupancy rate and inpatient costs suggests that as hospitals operate at higher occupancy levels, there is a proportional increase in the resources required to manage patient care. This may include additional staffing, medical supplies, and infrastructure maintenance, among other factors. Consequently, healthcare facilities may experience escalating costs as they strive to accommodate higher patient volumes

In the model, GDP per capita is a significant proxy for price level and level of technology. 1 percent increase in GDP per capita increase the inpatient per day cost by 0.2 percent. GDP per capita can also serve as a proxy for the overall level of technology and medical infrastructure within a country. As economies develop and technological advancements occur, healthcare systems may adopt more sophisticated and expensive medical technologies and treatments, contributing to higher healthcare costs.

Further, higher admissions make a significant and very small positive effect on cost. This small effect on cost can be said to result from mixed effects exerted on the cost. Higher admissions could lead to lower overhead costs per patient and greater efficiency. On the other hand, greater size could also indicate more specialist care, with a large proportion of complicated cases with a higher unit cost. Further, there is a negative relationship between cost of inpatients and length of stay. A 1 percent increase in hospital stay time increases the inpatient cost by only 0.01 percent per day. When increasing the length of the hospital stay days, the fixed costs per patient are spread over the days. Therefore, more hospital days lower the per day cost per inpatient. On the other hand, initial expenses might be substantial compared to the incremental costs of each additional day, which could include routine care, monitoring, and ongoing medication.

Inpatient unit cost per day is predicted to be lower in public hospitals. However, the results show that cost is higher in a private hospital, but this relationship has an insignificant impact on the COVID-19 inpatient cost.

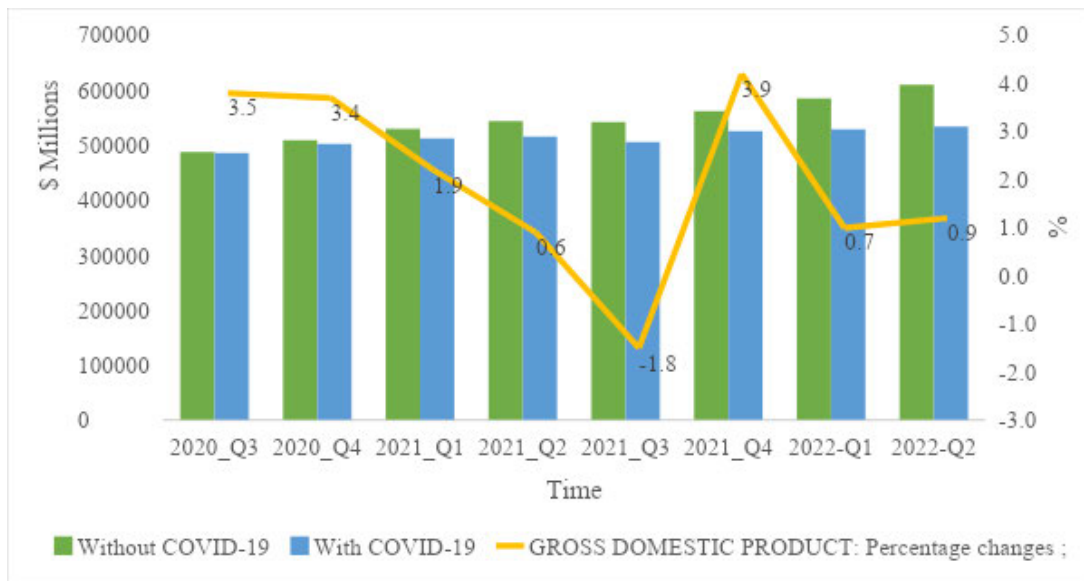
Inpatient unit cost per day is predicted to be lower in public hospitals. However, the results show that cost is higher in a private hospital, but this relationship has an insignificant impact on the COVID-19 inpatient cost. The analysis suggests a discrepancy between initial assumptions and observed outcomes regarding hospital costs. While the higher cost in private hospitals may initially seem counterintuitive, it's important to consider various factors that could contribute to this disparity, such as differences in treatment protocols, patient demographics, or hospital infrastructure. Furthermore, the statement emphasizes that despite the higher costs in private hospitals, this factor doesn't have a significant impact on the overall inpatient cost related to COVID-19 in Australia. This suggests that while there may be differences in costs between public and private hospitals, these differences may not substantially influence the financial burden of COVID-19 treatment on the healthcare system as a whole.

The regression coefficients are stored in a vector $c(1)$ to $c(k+1)$, where the number in parentheses indicates the order of appearance in the regression output. Therefore, Wald test result indicate the F-statistics of 209.1 and Chi-square value of 1045.57. P-value indicates that all variables are significant.

5.3 Indirect Cost

COVID-19 has left a significant imprint on the Australian economy since its onset. Measures to control the virus's spread have led to varied impacts on economic activities. This section delves into the shifts in sectoral contributions to the Australian economy brought about by the COVID-19 pandemic. It is divided into two parts. Firstly, it outlines the initial repercussions of COVID-19 containment measures from the first quarter of 2020 to the second quarter of 2022 across all economic sectors. The second part entails a closer examination of the primary macroeconomic variables, including consumption, investment, government expenditure, exports, and imports, along with their implications in both the COVID-19 scenario and a hypothetical scenario without COVID-19 (No-COVID).

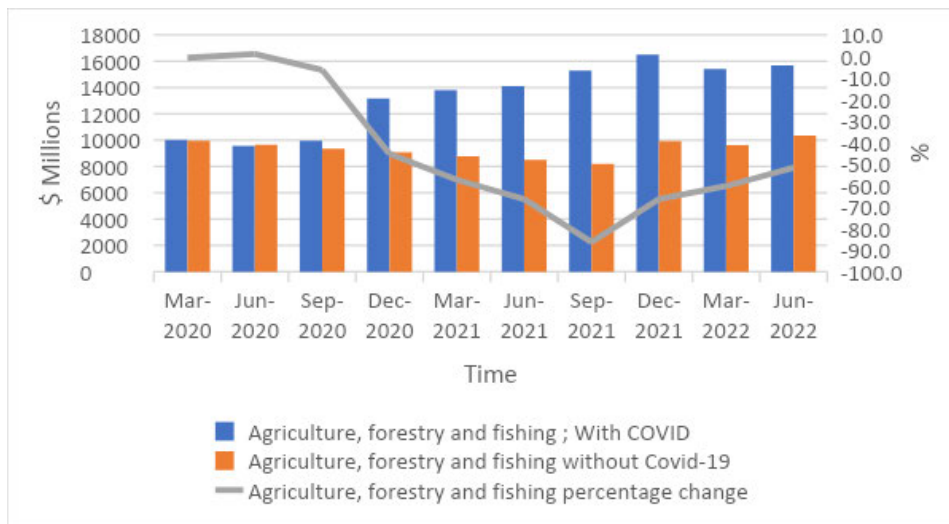
Figure 2: GDP changes due to the COVID-19 pandemic



Source: IMF, (2020) and Australian Bureau of Statistics, (2022a)

Figure 2 displays percentage deviations in GDP values away from No-COVID levels. In this figure, the blue columns represent the GDP (total for Australia, in Australian dollars, quarterly, and seasonally adjusted) between 2020 and 2022 in a normal situation. The green columns represent the IMF's predicted GDP values. The GDP value is closely related to demand shocks caused by physical distance and slowing international trade. Using that as a baseline, the green line shows that there will be a 5.28 trillion gap in GDP in the 4th quarter of 2021 under normal conditions when compared with conditions in the pandemic. In 2021 Quarter 1, GDP fell significantly to 1.9 percent below its No-COVID level. The reduction continued to -1.8 percent by the 3rd quarter of 2021. The L-strain and Delta outbreaks of COVID-19 had a massive impact on Australian GDP, resulting in two declines in GDP during the peak of restrictions across Australia. As the population emerged from lockdowns, there was a strong rebound in growth. While growth is returning to pre-pandemic levels, GDP is estimated to have suffered an AUD 158 billion cumulative loss, compared to its pre-pandemic trajectory (Australian Bureau of Statistics, 2022a).

Figure 3: Sectoral effects of COVID-19: Agricultural sector

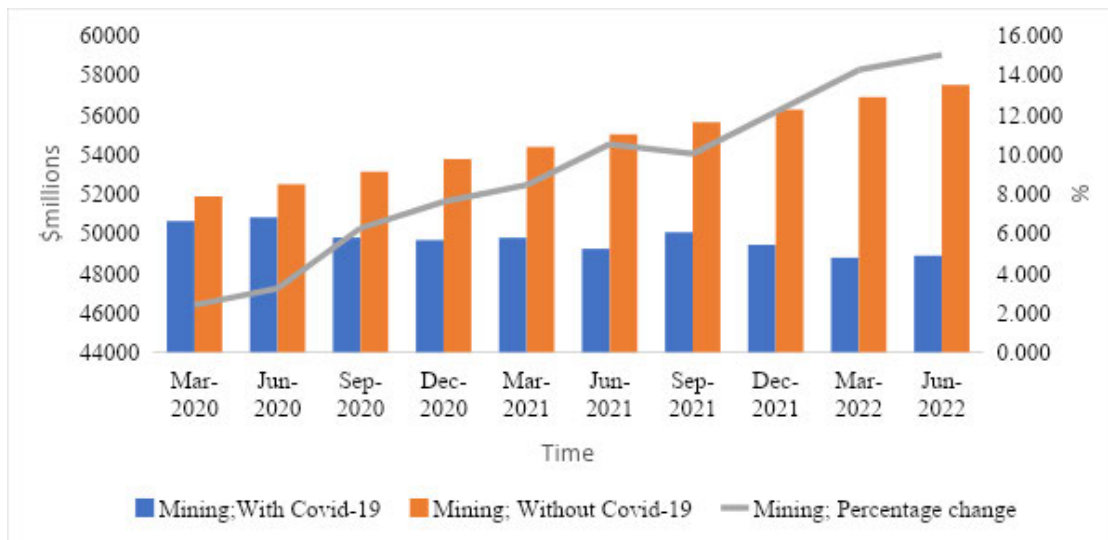


Source: Australian Bureau of Statistics, (2022a)

The agriculture sector, which was exempt from most social distancing restrictions, experienced a relatively small contraction (between 20 percent -1 percent). As a result of the knock-on effects of social distancing on forestry and fishing, the agri-food system contracted by 40 percent in the 4th quarter of 2020. All these downstream agri-food sectors have been suffering significant losses and contribute significantly to GDP. During the observed period, agriculture, forestry, and fishing fell in 2020 Q2 relative to No-COVID levels, reflecting the general downturn in world demand. Over time, the agriculture sector recovered after the 3rd quarter of 2020 and was back to No-COVID levels by 2021.

The initial effects of COVID-19 containment across all industries peaked 2020 Q4. Most industries are the most negatively impacted in 2020 Q4. Both internal physical barriers and global travel restrictions have an impact on these sectors. The deviations show a different outline to those for mining. The Australian mining sector is unlikely to return to No-COVID situations. It is significantly below the No-COVID scenario compared to other industrial activities. Recovery in electricity, gas, water, and waste services production starts to rise at the end of 2021, with output back to No-COVID values by the start of 2022.

Figure 4: Sectoral effects of COVID-19: Industrial sector (mining)



Source: Australian Bureau of Statistics, (2022a)

COVID-19 is anticipated to have a comparatively lesser impact on the mining sector compared to other segments of the Australian economy. Within the industry, the impact is projected to mainly revolve around significant shifts in commodity prices. Nevertheless, a notable decrease in oil and gas prices has led to reduced operating costs for many mining establishments, mitigating some of the disruptions. Australia's mining sector has experienced remarkable windfall profits over the past two years, attributed to substantially elevated prices for fossil fuel energy and other minerals (Jericho and Stanford, 2023).

The Australian services sector has grown at a 3.3 percent annual rate. This means that the services sector's growth continues to outpace that of the goods sector. The information, media, and telecommunications sector grew the fastest, with a compound annual growth rate of 5.8 percent in June 2021 before beginning to decline. Professional, scientific, and technical services grew after the 2nd quarter of 2021, while healthcare and social assistance fluctuated from -8.8 percent to 9.5 percent. Business activities in industries like hospitality, tourism, elective medicine, personal care services, and public entertainment experienced an unprecedented decline due to the demand shock brought on by the Australian government's social distancing policies and other measures (Australian Bureau of Statistics, 2022b).

The most impacted sectors in 2020 Q2 are accommodation and food services, arts and recreation services, transportation, postal services, and warehousing, owing to domestic physical barriers and international travel restrictions. Rental, hiring, and real estate services, administrative and support services, and other services declined due to the travel bans and mobility restrictions. Rental, hiring, and real estate services were reduced directly by physical distancing restrictions and indirectly through being connected to the construction sector, traveling, and dwelling investment. The decline in healthcare and social assistance is relatively small in 2020 Quarter 2. Overall, service sectors have recovered since the 3rd quarter of 2021, with the exception of a few minor drops. However, this only makes up a small proportion of the services sector.

6. Conclusion and Policy Recommendations

The economic toll of the COVID-19 pandemic is incalculable. However, estimates and evaluations would indicate how global GDP might have evolved if COVID-19 had been absent. The COVID-19 pandemic had a significant impact on the Australian economy. At the same time, economic activities have been affected differently by measures to reduce the spread, such as social distancing, commercial trading restrictions, and stay-at-home orders. Therefore, in this article we have aimed to evaluate the direct and indirect costs of the COVID-19 pandemic on the Australian economy from 2020 to 2022, a time when the pandemic hit the economy the hardest. Such an evaluation of economic costs and the burden of a pandemic are crucial in developing resource allocation and prioritisation strategies for public health and economic resilience.

According to the findings, the unit cost of inpatients per day is estimated to be AUD 836, and 40 percent of the total cost is for medicinal consumables. The estimated total inpatient cost of COVID-19 in 2021 based on 4473 patients is AUD 3.7 million for 2021 in Australia.

Moreover, the relationship between the inpatient unit cost per day and explanatory variables is explored using multiple regression analysis using the ordinary least squares method (Warren et al., 2003) based on the WHO-CHOICE model. Inpatient costs across six states of Australia are significantly associated with the type of hospital, gross domestic product, bed occupancy rate, average length of stay, and

total number of inpatient admissions. The hospital bed occupancy rate is a highly significant proxy for the cost of a COVID-19 patient. A 1 percent change of GDP per capita for a state increases the inpatient costs by 0.24 percent. The higher number of admissions has a significant but minor cost-saving effect on per day hospital cost. Furthermore, the direct cost of inpatient units per day in public hospitals is expected to be lower than in private hospitals. The magnitude of costs necessitates health policy coordination to respond to the pandemic. We conclude that the accurate estimation of health costs is a necessity to boost policy responses to COVID-19. In the context of cost minimisation efforts at the national level, health policy coordination among all states could effectively reduce the economic effects of COVID-19.

This study has several policy recommendations. Indeed, the efficient use of resources decreases cost, which reduces the economic burden of health, which, in turn, leads to higher health security. The government and policymakers should consider the current macroeconomic transmission channels and causalities to monitor the impact of the macroeconomy by using available policy instruments, such as monetary and fiscal policies.

Like many other studies, this study is not beyond some limitations. For example, we do not estimate the outpatient cost of COVID-19 and do not explicitly address the major macroeconomic factors of inflation, unemployment, international trade flows, and the financial performance of Australia. Finally, this study offers a pathway for policymakers to confront the health crisis or to correct the macroeconomic issues posed by COVID-19.

Declaration

The authors whose names are listed below certify that we have NO affiliations with or involvement in any organisation or entity with any financial or non-financial interest in the subject focus or materials discussed in this manuscript.

Availability of data

The data that support the findings of this study are available from the websites of the International Monetary Fund, the Australian Bureau of Statistics and the Australian Institute of Health and Welfare.

Conflict of interest

The authors have no affiliations with or involvement in any organisation or entity with any financial or non-financial interest in the subject focus or materials discussed in this study.

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7.3 Links and Applications

This chapter has provided an analysis of the cost incurred by a COVID-19 infected patient in Australia, revealing an average daily cost of AUD836. The estimated total inpatient cost of COVID-19 in 2021 in Australia, derived from a sample of 4473 patients, amounted to AUD 3.7 million. To identify the determinants of the inpatient unit cost per day, a comprehensive exploration has been conducted through multiple regression analysis, employing the ordinary least squares method, and anchored in the WHO-CHOICE model. Various explanatory variables, encompass the type of hospital, gross domestic product, bed occupancy rate, average length of stay, and total number of inpatient admissions across six states of Australia.

A pivotal contribution of this work lies in furnishing an accurate approximate estimation of health costs, critical for well-informed policy responses to the challenges posed by COVID-19. The findings suggest that, to minimise cost at the national level, synchronised health policy efforts among all states could effectively alleviate the economic impact of COVID-19.

This study has focused on evaluating healthcare cost due to the COVID-19 in Australia. The subsequent chapter comprises an analysis of the macroeconomic impacts of COVID-19 vaccination rollouts, crucial in step in reducing health risks associated with this disease. This offers insight into the broader economic consequences of such vaccination delivery.

CHAPTER 8: PAPER 6 – THE IMPACT OF COVID-19 VACCINE ROLLOUTS ON THE ECONOMY: EVIDENCE FROM OECD COUNTRIES

8.1 Introduction

This chapter presents the final study of the thesis. It is an examination of the impact of the COVID-19 vaccination process on the key macroeconomic factors: economic growth, inflation, and unemployment. A sample of 37 OECD countries from Quarter 4 2020 to Quarter 4 2022 was used. A panel dataset encompassing multiple countries and quarters was employed, utilising a panel random effect model for the analysis of the economic impact of COVID-19 vaccinations.

Notably, this study is distinctive in its investigation the effects of vaccinations on major macroeconomic variables, offering evidence of how the vaccine rollout may have shaped economic changes across OECD countries. Consequently, this study contributes to the existing literature by delving into the relationship between COVID-19 vaccination and economic growth, inflation, and unemployment. The analysis contributes to the ongoing discourse on public health and offers valuable insights for policymakers and stakeholders navigating the intricate intersection of healthcare and the economy in the context of the COVID-19 pandemic.

8.2 Published paper

The Impact of COVID-19 Vaccine Rollouts on the Economy: Evidence from OECD Countries

Abstract

This study examines the effects of COVID-19 vaccine rollouts on the macroeconomy by analysing a panel of data from OECD countries between 2020 and 2022. The study uses a random effects model to explore the relationship between vaccination rates and three key economic indicators: economic growth, price levels, and unemployment. The motivation behind this research stems from the multifaceted effects of ongoing COVID-19 vaccine rollouts on global economies, including widespread unemployment, reduced economic growth, widened inequality, and social unrest. This study reveals that COVID-19 vaccinations are associated with increased economic growth, reduced price levels, and unemployment. Our results imply that national authorities should prioritise the accessibility and affordability of COVID-19 vaccines as a public health commodity to help counter the pandemic threat to global public health.

Keywords: Covid-19 Vaccination, Economic Growth, Inflation, Unemployment

JEL Code: B22, C23, I18

1. Introduction

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is a highly infectious virus that caused a global pandemic resulting in significant illness and death. This pandemic took advantage of the vulnerabilities and instability present worldwide. The scale of the pandemic makes it the most widespread infectious disease since the 1918-1919 influenza pandemic. This global public health crisis has highlighted the shocking social inequalities that persist in many high, middle, and low-income countries. These inequalities directly and indirectly affect health and economic outcomes (Rodrigues and Plotkin, 2020). Introducing COVID-19 vaccines has led to a worldwide effort to achieve community immunity and ease containment measures to support economic recovery.

COVID-19 vaccines are crucial in responding to the pandemic as they protect against severe illnesses and death. The World Health Organisation (WHO) is committed to maintaining the momentum of increasing access to COVID-19 vaccine rollouts. It will continue to assist countries in accelerating vaccine delivery to save lives and prevent serious illness. The global effort to develop safe and effective COVID-19 vaccines has yielded remarkable results, thanks to significant investments in clinical discovery (Deb et al., 2022). Within this context, this study aims to explore the multifaceted impact of ongoing COVID-19 vaccine rollouts on economies worldwide.

Vaccines are crucial in resolving the health and economic crises caused by COVID-19. To end this pandemic, a significant portion of the global population must become immune to the virus—hence, the most effective solution is through vaccination (Deb et al., 2022). Despite the approval of several vaccines, the enormous challenge of producing adequate and distributing them to the global population persists. Therefore, the World Health Organisation and the World Bank have focused on financing and manufacturing COVID-19 vaccines for global use to ensure equitable distribution among all countries. Massive COVID-19 vaccination is an effective and economical measure to mitigate the pandemic. Many countries began implementing COVID-19 vaccination programs by the end of 2020 (Viana et al., 2021).

Over thirty vaccines have been approved for general or emergency use, with over 13 billion doses administered globally and 1.1 million doses administered daily.

As of the end of 2023, 56 percent of the world population has been vaccinated with a complete primary series of a COVID-19 vaccine (WHO, 2023). The first approved vaccines were the Pfizer–BioNTech (BNT162b) and Moderna (mRNA-1273) mRNA vaccines. The Pfizer–BioNTech vaccine received EUA on December 11, 2020, and the Moderna mRNA vaccine received EUA on December 18, 2020. Several other vaccines have been approved in different parts of the world, including OECD countries, such as CoronaVac, BBIBP-CorV, CoviVac, Covaxin, the Oxford–AstraZeneca vaccine (ChAdOx1 nCoV-19), Sputnik V, the Johnson & Johnson vaccine, Convidicea, RBD-Dimer, and EpiVacCorona (Chakraborty et al., 2023; OECD Data, 2021).

At the onset of the COVID-19 pandemic, countries were compelled to follow strict non-pharmaceutical interventions to limit the virus spread. However, these containment measures have enormous economic costs, resulting in unprecedented economic impacts. With the introduction of vaccines, countries have shifted their focus to vaccinating their populations against SARS-nCoV-2 to boost immunity, ease containment measures, and achieve economic recovery (Pearson et al., 2021). Consequently, several questions arise: (1) What is the impact of COVID-19 vaccination on economic activities? (2) What policy decisions must be taken to ensure economic stability while accelerating vaccine rollouts during a pandemic?

The main objective of this research is to analyse the relationship between the GDP growth rate, inflation rate, unemployment rate, and COVID-19 vaccination rates in a sample of 37 OECD countries from Quarter 4 2020 to Quarter 2 2023. The study also emphasises policy aspects in response to the COVID-19 vaccine rollouts. It utilises a panel dataset spanning multiple countries and quarters, employing a panel random effect model to analyse the economic impact of COVID-19 vaccinations. The research is unique in that it investigates the effects of vaccinations on major macroeconomic variables, providing evidence of how the vaccine rollout may have influenced economic changes across 37 countries worldwide. This study adds to the existing literature by exploring the relationship between COVID-19 vaccination and economic growth, inflation, and unemployment.

This paper is structured as follows: Section 2 provides a literature review, Section 3 describes the methodology, and Section 4 examines the impact of COVID-

19 vaccine rollouts on macroeconomic variables. Finally, Section 5 concludes the study by summarising the findings, presenting policy implications, highlighting limitations of the existing literature, and suggesting future research directions.

2. Literature Review

This paper contributes to the literature by assessing the macroeconomic impact of COVID-19 vaccination programs. The COVID-19 pandemic has presented a unique scenario characterised by simultaneous decreases in supply and demand, reduced production and employment, and trade density (Loayza and Pennings, 2020; Marquez et al., 2020). Furthermore, the pandemic has significantly disrupted consumer and business purchasing patterns, resulting in market anomalies and further delaying global economic activity (Ababulgu Abasimel and Wana Fufa, 2021). The COVID-19 pandemic significantly impacted employment worldwide. The outbreak has resulted in reduced job opportunities and increased unemployment rates. Particularly hard-hit industries, such as construction, manufacturing, and services, are expected to experience job losses due to global value chain disruptions, business closures, and the failure of small enterprises during prolonged shutdowns (LaBelle and Santacreu, 2022).

The COVID-19 pandemic had significant economic and financial ramifications for both regional and global economies. The findings of LaBelle and Santacreu (2022) illustrate an unprecedented mismatch between supply and demand, which has led to price increases and, consequently, inflation. The high level of transportation connectivity and economic interconnectedness brought about by globalisation made containing the virus and mitigating importation risks complicated and costly once the disease began to spread in multiple locations. This underscores the importance of international cooperation and global investment in vaccine development and distribution, as well as preventive measures such as real-time surveillance capacity building and developing contact tracing capabilities at national and international levels (Pak et al., 2020).

Traditional economic evaluations of vaccination often overlook health-related productivity gains and macroeconomic benefits resulting from improvements in health status (Quilici et al., 2015). The impact of COVID-19 vaccination is significant, and it

can save millions of lives during the first year of immunisation (Watson et al., 2022). Using an epidemiological model, Sandmann et al. (2021) investigated vaccination's health and economic impacts in the United Kingdom. Their study estimates the financial costs of vaccine rollouts based on COVID-19 epidemiological outcomes.

Deb et al. (2021) studied the effect of COVID-19 vaccinations on economic activity, measuring it through high-frequency emissions and mobility. Diagne and co-workers (Diagne et al., 2021) established the critical vaccination threshold level. They found that even after vaccinating a large portion of the population, the disease could not be eradicated if vaccine efficacy is low and disease spread is high.

According to Guo et al. (2022), the county-level per capita income is negatively associated with the COVID-19 vaccination rates in counties with higher proportions of certain groups. On the other hand, the county-level unemployment rate is negatively associated with the vaccination rates in counties with higher proportions of non-Hispanic White individuals. Hence, it is crucial to implement policy interventions to increase vaccination rates among racial and ethnic minority communities to foster economic recovery.

On the other hand, vaccination not only directly affects economic behaviour by enabling vaccinated individuals to engage in economic activities safely but also has an indirect impact by reducing the risk of infection for non-vaccinated individuals (Foy et al., 2021). Successful vaccine programs' decrease in morbidity and mortality has reduced disease incidence, healthcare costs, and treatments through direct and indirect protection (Deogaonkar et al., 2012).

Vaccines are highly beneficial and cost-effective compared to other public health interventions (Lee et al., 2009; Foy et al., 2021; Bloom et al., 2017). Therefore, fast vaccine deployment should be a key priority in future public health management. This is particularly important in limiting the health and economic damage caused by the coronavirus, as noted by Deb et al. (2021).

Ensuring equitable access to vaccines through contributing to their production, waiving intellectual property rights, and establishing manufacturing hubs are crucial measures for reducing illness and mortality rates and enhancing the quality of life for people worldwide (Rackimuthu et al., 2022). To reduce disease morbidity and

mortality, governments and public health officials must prioritise the most effective approaches to mass vaccination rollouts. Tracking vaccination rates and prioritising strategies within specific countries over time is crucial to achieving this need. It is equally important to compare vaccination rates and strategies across different countries (Mathieu et al., 2021). Antonini et al. (2022) highlighted that effective coordination between governance levels, the ability to ensure a large supply of doses, and trust in health authorities were among the determinants for successful vaccination campaign outcomes based on the experiences in France, Israel, Italy, and Spain during the first eleven months following the initial COVID-19 vaccine approval. The strengths and weaknesses of COVID-19 pandemic crisis management, along with the various strategies employed in vaccination roll-out campaigns, may provide valuable lessons for policymakers in making informed decisions, especially in the context of future pandemics.

Several significant factors contribute to ineffective vaccine distribution in countries, including myths, religious beliefs, and mistrust. Widespread hesitancy surrounding vaccination, particularly among marginalized groups in developed countries, exacerbates the issue. Therefore, it is imperative for OECD governments to implement region-specific policies and facilitate seamless vaccine distribution to expedite the vaccination process. Future research could delve into the determinants of vaccination rates in OECD countries, shedding light on strategies to enhance vaccine uptake and efficacy (Xu et al., 2022).

The literature review above demonstrates that the COVID-19 vaccination has created various financial and macroeconomic effects. However, differences in methodology, population, and healthcare investments make it challenging to compare the limited studies about the health and economic impacts of COVID-19 vaccination based on a single country or a group of countries. Therefore, our contribution to the literature is to analyse the effect of COVID-19 vaccine rollouts on macroeconomic factors such as economic growth, inflation, and unemployment, reducing global vulnerabilities and instability through the rapid transmission of COVID-19 vaccinations.

3. Data and Methodology

3.1 Data Collection

This empirical analysis relies on an extensive database at the country level that combines information on COVID-19 vaccination rates and macroeconomic variables. In particular, the Real GDP growth rate serves as a proxy for economic growth, while the percentage change in the consumer price index is used as a proxy for the inflation rate. Data were extracted from various sources: the International Monetary Fund (IMF) Macroeconomic and Financial data, the Oxford COVID-19 Government Response Tracker data (OxCGRT), the WHO Coronavirus Data, and the OECD data. Table 1 summarises the data used in this study.

Table 1: Summary of data sources

Variables	Description
People fully vaccinated per hundred (Vac)	Total number of people who received all doses prescribed by the initial vaccination protocol per 100 people in the total population
GDP Growth Rate (GDP_gr)	The rate of increase of a country's real Gross Domestic Product (GDP). The growth rate is based on seasonally adjusted volume data, percentage change on the same quarter of the previous year base year 2015
Consumer Price Index (INF)	Consumer Price Index: all items
Unemployment	Rate of Unemployment as a percentage of labour force
Population growth (POP_gr)	Total population growth based on the definition of population growth with mid-year estimates
Government Expenditure (GE)	Government Expenditure as a percentage of GDP
Trade-GDP ratio (TR)	Trade openness

Gross fixed capital formation (GCF)	Net inflows, expressed as a percentage of GDP, which indicates the value of net investment outflows from the national economy from foreign investors
Money Supply (MS)	Money Supply (M3) 2015=100
Interest rate (INT)	Short-term interest rates, Per cent per quarter
Household Consumption Expenditure (CON)	Household Consumption Expenditure as a percentage of GDP
Exchange rate (EXR)	Exchange rate of the local currency against USD

3.2 Sample Selection

The study targets a diverse sample of countries, including economies ranging from low to high income and low to high human development, as rated by the World Bank. Based on data availability, we derived a list of 37 organisations for Economic Corporation and Development (OECD) sample countries. The time frame for the study is quarterly data between Q4 2020 and Q2 2023, capturing the period of COVID-19 vaccination.

3.3 Methodology

In this study, we conducted a panel data analysis to examine the relationship between COVID-19 vaccination and macroeconomic variables. Panel data refers to a type of data that tracks specific variables regularly over a period. The basic equation for panel regression is based on the following relationship:

$$Y_{it} = \beta_0 + \beta_1 Vac_{it} + \beta_2 X_{it} + \dots + \beta_k X_{it} + \varepsilon_{it}$$

Y_{it} alternatively denotes the economic growth rate, inflation rate, and unemployment rate of country i at time t . β_0 represents the level constant, and β_1, \dots, β_k are estimated regression parameters. Vac_{it} represents the COVID-19 vaccination rates, and X is a set of explanatory variables in time t and cross-section i . ε_{it} is a random error term in the time t and i^{th} cross-section. Based on the above equation, a general

notation of the functional dependence of 15 variables has been arranged in the four equations based on the four different dependent variables.

i. Model building: Impact of COVID-19 Vaccination on Economic Growth

Economic growth is a primary economic objective for every country. Governments worldwide are currently facing the challenge of determining how to provide COVID-19 vaccinations in a way that ensures sustained economic growth. To realise this requirement, the researchers selected multiple control variables, typically chosen based on theoretical notions, earlier literature, and data availability in the chosen countries.

$$GDPgr_{it} = \alpha_0 + \beta_1 GCFgr_{it} + \beta_2 TR_{it} + \beta_3 INF_{it} + \beta_4 lnGE_{it} + \beta_5 FDI_{it} + \beta_6 Vac_{it} + \varepsilon_{i,t} \dots \dots \dots (i)$$

The study generated the above equation following the findings of Rahman et al. (2019), where the GDP growth rate ($GDPgr_{it}$) is the dependent variable. The key independent variables are Gross Capital Formation ($GCFgr_{it}$), trade openness (TR_{it}), inflation rate (INF_{it}), government consumption expenditure (GCE_{it}), Fixed Direct Investment (FDI_{it}), and the rate of COVID-19 vaccination (Vac_{it}).

Theoretically, an increase in investment is expected to provide more jobs or increase employment levels. A higher growth rate of the economy has been argued to stimulate domestic investments. A theoretically established causal relationship exists between trade and productivity, which can occur in two ways. Proponents of export-led growth argue that exports can stimulate productivity growth, while advocates of import-led growth contend that imports can enhance productive efficiency (Kim et al., 2007; Krueger, 1990). Therefore, trade openness should be considered a crucial variable in growth analysis.

The relationship between inflation and economic growth has been a topic of debate among policymakers and researchers for a long time. While structuralists argue that inflation is necessary for economic growth, monetarists view it as harmful to economic progress (Bruno and Easterly, 1998). However, the impact of inflation on growth can vary significantly across countries due to differences in macroeconomic conditions (Eggoh and Khan, 2014). Numerous empirical studies examined the impact of government consumption spending on economic growth, including Grossman and

Miller's work in 1988. Recent studies in developing countries have also revealed a relationship between these two variables, as Wu et al. (2020) demonstrated. FDI's contribution to economic growth is not straightforward. While countries with well-developed financial markets benefit significantly from FDI, some researchers have identified a negative impact of FDI, such as the studies of Hausmann and Fernandez-Arias (2000) and Alfaro et al. (2004). Thus, the relationship between these two variables remains subject to further examination.

ii. Model building: Impact of COVID-19 vaccination on Inflation.

The global economy has encountered unprecedented challenges due to the unforeseen peril brought about by the COVID-19 pandemic. These challenges include rising inflation and disruptions to supply chain management, which have contributed to various unexplored disturbances that keep the market unstable. Therefore, it is essential to identify the impact of COVID-19 vaccination on the economy's inflation rate. When estimating the determinants of inflation through the use of both theoretical and empirical sources, Lim and Sek (2015) specify the general model as follows:

$$INF_{it} = \alpha_0 + \mu_t + \beta_1 MS_{it} + \beta_2 GE_{it} + \beta_3 INT_{it} + \beta_4 CON_{it} + \beta_5 Vac_{it} + \varepsilon_{i,t} \dots\dots(ii)$$

The equation specifies that the inflation rate (INF_{it}) is a function of money supply ($M3$), government expenditure as a percentage of GDP (GE_{it}), interest rate (INT_{it}), and household consumption as a percentage of GDP (CON_{it}), and rate of COVID-19 vaccination per 100 population (Vac_{it}).

In this study, "Inflation" refers to an increase in the general price levels of goods and services over a period and is used as the dependent variable. This study also considers three economic variables as control variables, categorised into five groups: cost-push, demand-pull, inflation expectations, monetary policy, and fiscal policy.

Government spending can drive up the production cost through the crowding-out effect, leading to cost-push inflation (Kinlaw et al., 2023). As a result, government expenditure is a crucial factor to consider in the context of inflation. In most countries, household consumption expenditure accounts for around half to two-thirds of the GDP (Öner, 2010). Peterson (1980) argued that, in a growing and evolving economy, prices of some goods must rise, and others must fall in response to changes in consumer

preferences, national needs, and supply. Therefore, household consumption expenditure can also be regarded as an essential variable.

iii. Model building: Impact of COVID-19 Vaccination on Unemployment

The equation to measure the impact of vaccination on the unemployment rate is given below.

$$UNR_{it} = \alpha_0 + \mu_t + \beta_1 GDP_{it} + \beta_2 INF_{it} + \beta_3 GovEx_{it} + \beta_4 POP_{it} + \beta_5 FDI_{it} + \beta_6 Vac_{it} + \varepsilon_{i,t} \dots\dots\dots iii$$

Unemployment rate (UNR_{it}) is the dependent variable. The independent variables are GDP growth rate, inflation rate (INF), government expenditure (GovEx), population growth (POP) and foreign direct investment net inflows as a percentage of GDP (FDI).

Traditionally, an inverse association existed between the inflation rate and unemployment. The Phillips curve describes the trade-off between inflation and unemployment. According to the Phillips curve, a negative relationship is expected between the inflation rate and the unemployment rate (Li and Liu, 2012). According to Keynesian employment theory, an expansionary fiscal policy framework stimulates aggregate demand, increasing employment. Hence, a negative relationship is expected between government expenditure and the unemployment rate. The works of Fedderke et al. (2006) and Holden et al. (2018) showed a negative relationship between government expenditure and the unemployment rate. This study used general government final consumption expenditure as a percentage of GDP as a proxy for Government expenditure.

Arslan and Zaman (2014) argued that population growth significantly affects the unemployment rate. According to Malthus's theory of population (1798), there is a positive relationship between population growth and the unemployment rate. Asif et al. (2013), Bakare (2011), Folawewo and Adeboje (2017), and Mahmood et al. (2011) have empirically demonstrated that population growth has a positive relationship with the unemployment rate.

Foreign Direct Investment (FDI) is an investment made in another country by individuals or citizens of one country. An increase in FDI would grow an economy's GDP while lowering unemployment (Eldeeb, 2015). As a result, all the above factors are control variables to consider when assessing the impact of COVID-19 vaccinations on a country's unemployment rate.

4. Results and Discussion

This section presents the results of the inferential test outlined in the methodology and given hypotheses. The results were obtained using the EViews statistical software. The panel data analysis consisted of several sequential steps that led to the final model. First, a correlation matrix was constructed to determine the correlation coefficients between variables and their statistical significance. Second, the intensity of dependence between variables was investigated by examining multicollinearity.

The study examines Cross-sectional Dependency (CD) through the use of LM tests, namely, Pesaran (2004) and Breusch-Pagan (2004). These tests are performed to counteract panel data issues and ensure the robustness and consistency of estimators (Dogan et al., 2020; Nathaniel et al., 2021). In addition, the study performs stationary tests for both dependent and independent variables using unit root tests. Specifically, the Augmented Dickey-Fuller test is used to identify non-stationarity, which helps determine the integration level among the variables and avoid spurious regression models. Next, the panel cointegration test determines the possibility of establishing a long-run equilibrium relationship between variables. This paper employs Pedroni's (1999, 2004) and Kao's (1999) residual cointegration tests. Finally, the study uses the Hausman test to indicate whether cross-section fixed, or random effects are most suitable for econometric models.

Hypothesis 1 (H1): There is a significant positive relationship between gross domestic growth rate (GDP) and COVID-19 vaccinations.

Hypothesis 2 (H2): There is a significant negative relationship between the inflation rate and COVID-19 vaccinations.

Hypothesis 3 (H3): There is a significant negative relationship between unemployment rate and COVID-19 vaccinations.

5.4.1 Descriptive Statistics

Table 2: Descriptive Statistics

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Pr ob
GDP	0.807	0.647	9.36	-7.577	1.781	0.424	7.056	291.34	***
CPI	2.117	1.4	28.28	-1.472	3.08	4.46	28.66	10176.86	***
UNR	6.891	5.4	34.9	2.3	5.347	3.379	16.242	2721.57	***
GE	42.35	44.2	75	6.85	10.8	-0.73	3.8	38.11	***
POP	0.45	0.45	2.2	-1.81	0.62	-0.23	4.21	23.11	***
Vac	8.42	2.3	57.69	0	12.6	1.83	5.64	280.69	***
INT	1.4	0.34	16.25	1.19	2.82	1.96	8.87	686.86	***
MS	268.31	182	1988.9	25.37	311.86	4.15	21.61	5763.14	***
GFCF	1.68	1.04	99.02	-50.45	10.19	4.15	50.91	32609.77	***
CON	2.09	0.9	38.37	-13.75	6.77	4.09	22.61	6229.55	***
FDI	-0.05	0.9	31.08	-44.19	7.81	-2.29	20.34	4435.64	***
TR	0.58	-0.43	70.96	-11.96	7.854	3.46	24.59	827.84	***
EXR	500.88	12.84	15563.73	0.715	2366.54	5.73	34.23	15265.55	***

Note: *** indicates significance at a 1% level.

Table 2 presents the descriptive statistics. The average value of new individuals who received all doses prescribed by the initial vaccination protocol per 100 people in the total population is 8. The range of new vaccination numbers recorded spans from 0 to 58 people, indicating the maximum and minimum newly vaccinated individuals during the COVID-19 period. The standard deviation of newly vaccinated individuals is 12.6, suggesting the average deviation of each vaccination from the mean.

All variables exhibit a right-skewed distribution, with kurtosis values exceeding the threshold of three, indicating a leptokurtic distribution. Additionally, the Jarque-Bera test indicates that none of the variables follows a normal distribution at a significance level of 1 percent.

4.2 Correlation Matrix

Table 3 presents a correlation matrix displaying the correlation coefficients between individual variables with their corresponding levels of statistical significance.

Table 3: Correlation Matrixes

Model 1	GDP_Gr	GFCF	EXR	CPI	GE	FDI	VAC
GDP_Gr	1						
GFCF	0.1769	1					
EXR	0.038	0.0077	1				
CPI	-0.065	-0.031	-0.058	1			
GE	-0.085	-0.065	-0.378***	-0.127**	1		
FDI	0.138**	-0.018	0.033	0.046	-0.245***	1	
VAC	0.252***	-0.004	-0.035	-0.116*	0.070	0.019	1
Model 2	CPI	MS	GE	INT	CON	VAC	
CPI	1						
MS	0.125**	1					
GE	-0.127**	0.125**	1				
INT	0.078	-0.116**	-0.323***	1			
CON	-0.063	0.002	-0.137**	0.0498	1		
VAC	-0.121**	0.004	0.069	-0.268***	0.049168	1	
Model 3	UNP	GDP	GE	POP	FDI	VAC	
UNP	1						
GDP	0.075	1					
GE	-0.091*	-0.083	1				
POP	0.196**	0.048	-0.332***	1			
FDI	0.121**	0.137**	-0.245***	-0.17***	1		
VAC	0.050***	-0.118**	0.068	-0.07	0.019	1	

Note: *, **, and*** indicate significance at the 10%, 5%, and 1% levels

A positive and statistically significant correlation ($r=0.190$) was observed between the GDP growth rate and COVID-19 vaccinations per 100 population and between unemployment and COVID-19 vaccination ($r=0.025$). In contrast, a significant but relatively low negative correlation ($r=-0.115$) was noted between unemployment

and COVID-19 vaccinations per 100 population. Table 3 indicates that all other correlations exhibited low to moderate levels.

4.3 Cross-Sectional Dependency Test

The Pesaran CD, Breusch-Pagan LM, and Pesaran Scaled LM test statistics for all three equations are within the upper tail and strongly reject the null hypothesis of no cross-section dependence in residuals (Table 4).

Table 4: Cross-Sectional Dependency test

Tests	Model 1	Model 2	Model 3
Pesaran CD	6.09098***	30.358***	38.087***
Breusch-Pagan LM	945.9658***	1539.784***	2567.144***
Pesaran Scaled LM	6.7274***	22.9215***	51.0819***

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels

4.4 Multicollinearity test

Observing the Variance Inflation Factor (VIF) for explanatory variables is crucial in statistical analysis. The VIF results indicate whether multicollinearity is present among the variables in the model. In this case, all three models show low VIF values, less than 5, indicating that multicollinearity is not a concern.

Table 5: Multicollinearity test

	Model 1 Cantered VIF	Model 2 Cantered VIF	Model 3 Cantered VIF
CPI	1.07857	-	1.03295
TR	1.06081	-	-
FDI	1.06361	-	1.17865
GFCF	1.01621	-	-
VAC	1.02784	1.06044	1.06028

GE	1.10988	1.14465	1.27225
EXR	-	1.11874	-
CON	-	1.02417	-
INT	-	1.18277	-
MS	-	1.02485	-
GDP	-	-	1.06765
POP_gr	-	-	1.23204

4.5 Stationary test

The results of the Stationary tests indicate that certain variables such as COVID-19 vaccinations per 100 population, GDP growth, rate of unemployment, interest rate, gross capital formation, government expenditure, exchange rate, and consumption are stationary at levels. On the other hand, variables such as CPI, FDI, MS, population growth, and trade openness are stationary at the first difference, with a significant P-result of 0.0000.

4.6 Residual Cointegration Test

Based on the Kao (Engle-granger-based) and Pedroni (Engle-granger-based) tests, the null hypothesis is rejected, and the presence of cointegration is confirmed in both cases with and without a deterministic trend.

4.7 Hausman's Test

The study employed Hausman's test to determine whether cross-section fixed effects or cross-section random effects would be the most appropriate for each of the three econometric models.

Table 6: Hausman's test

	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Test Summary - Model 1			
Period random	10.26661	6	0.1147
Test Summary - Model 2			
Period random	10.12792	7	0.1831
Test Summary - Model 3			
Period random	8.186601	5	0.1471

Hausman's test results (Table 6) indicate that the P-values (Prob chi2) for model 1, model 2, and model 3 are 0.1147, 0.1831, and 0.1471, respectively. Based on Hausman's test, the null hypothesis cannot be rejected ($p > 0.05$), and therefore, the study proceeds with the three models with random effects. All three final models utilise the least square method for control, and Table 7 presents their results.

Table 7: Econometric Models with cross-section random effects

Variables	Model 1 GDP	Model 2 Inflation	Model 3 Unemployment
Inflation	0.003229* (0.10107)	-	0.11502 (0.04265)
Trade Openness	0.003613* (0.23666)	-	-
FDI	0.025876** (2.06934)	-	0.0983** (2.3988)
Gross Fixed Capital Formation	-0.001417 (-0.15141)	-	-
Covid-19 Vaccination rate	0.022668** (0.008921)	-0.017683 * (0.001623)	-0.0117 * (1.4854)
Government Expenditure	0.012873 (1.40427)	0.053808 ** (0.007621)	-0.01449* (-0.0020)
Exchange Rate	-	-0.000180** (0.000016)	-
Consumption	-	0.041411 * (0.000016)	-

		(0.01124)	
Interest rate	-	0.038043 (0.32654)	-
Money Supply	-	0.001317 *** (0.00042)	-
GDP	-	-	-0.111477 * (0.02142)
Populating	-	-	1.291165 ** (0.19005)
Constant	4.057194 *** (4.85393)	1.38463*** (3.2203)	6.3777*** (4.3724)
R-squared	0.3685	0.4220	0.4013
F statistics	2.7990 **	2.3942**	2.7254 ***

Note: Robust t-statistics are in parenthesis. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. The white cross-section standard errors and covariance test rejected the null hypothesis of heteroscedasticity.

According to the first econometric model, 37 percent of the variance in GDP is explained by the model ($F = 2.79$, $P < 0.05$). The two variables that are not significant are gross fixed capital formation and government expenditure, which had a positive impact on GDP. An increase of 1 percent in COVID-19 vaccination rate leads to a 0.02 percent increase in GDP growth. Countries with higher vaccination rates may experience faster economic recovery. Vaccination programs can help reduce the spread of COVID-19, leading to fewer cases, hospitalizations, and deaths. This, in turn, can alleviate the strain on healthcare systems, allowing businesses to operate more freely and consumers to feel more confident in resuming economic activities. This aligns with the findings of Basek et al. (2022) and Roghani (2021), which indicate a strong linear association between per capita income and the proportion of people vaccinated in countries with populations of one million or more.

In addition, a 1 percent increase in the inflation rate, trade openness, and foreign direct investment (FDI) net inflows results in GDP growth increases of 0.0032 percent, 0.0037 percent, and 0.0259 percent, respectively. When inflation is predictable and moderate, it can encourage consumption and investment, as people prefer to spend or invest rather than hold onto cash, which might lose value over time. This behavior can stimulate economic activity and contribute to GDP growth.

Additionally, countries that are more open to trade often attract more FDI, which can further stimulate economic growth.

This model investigates the effect of COVID-19 vaccination on GDP growth rate during the pandemic period by utilising various control variables. The results show that the COVID-19 vaccines significantly and considerably effect on the GDP growth rate, which is in line with Deb et al. (2022) regarding the impact of COVID-19 vaccines on economic activity. A high level of vaccination coverage creates an environment conducive to the smooth resumption of production processes. Manufacturing plants, supply chains, and other critical infrastructure can function without the threat of sudden shutdowns due to outbreaks. This stability is vital for economic growth and the restoration of consumer and investor confidence

The second econometric model examined the relationship between the inflation rate and various factors in 37 countries, finding that 42.2 percent of the variance in the inflation rate was explained ($F=2.3942$, $P<0.05$). The results specify that a 1 percent increase in COVID-19 vaccination is associated with a 0.01 percent decrease in the inflation rate. The pandemic has caused significant disruptions to global supply chains. High vaccination rates can mitigate these disruptions by reducing illness-related absenteeism and enabling smoother operations in production and logistics. Improved supply chain efficiency can lead to a stabilization or reduction in costs of goods and services, contributing to lower inflation rates (Benchimol et al., 2022).

Additionally, when the money supply (broad money), household final consumption, and government expenditure increase by 1 percent, the inflation rate decreases by 0.001, 0.046, and 0.049, respectively. An appreciation of 1 percent in the exchange rate is followed by a decrease of 0.0001 percent in the inflation rate. Purchasing vaccines from international manufacturers can affect a country's trade balance. For countries with large-scale vaccine imports, this could initially lead to a deterioration of the trade balance, impacting the exchange rate. The study found no other significant relationships between the inflation rate and the other variables.

The findings suggest that a mass vaccination campaign can significantly reduce the need for non-pharmaceutical interventions, such as lockdowns and restrictions on economic and social activities. Achieving high vaccination coverage levels can lead to

herd immunity and eliminate the need for subsequent restrictions and lockdowns while creating an environment that facilitates a smooth resumption of production processes. While the benefits of mass vaccination campaigns are clear, several challenges must be addressed to achieve high vaccination coverage. These include vaccine hesitancy, logistical issues, equitable distribution, and maintaining public trust. Addressing these challenges requires comprehensive strategies, including public education campaigns, robust healthcare infrastructure, and transparent communication from health authorities. The success of the global vaccination effort hinges on building and maintaining trust in both the vaccines and the institutions overseeing their distribution. By promoting public confidence through transparent communication, efficient logistics, and inclusive engagement, governments can address vaccine hesitancy and ensure a smooth and effective immunization campaign (OECD, 2021).

A workforce highly immune to COVID-19 is more productive, which leads to increased production of goods and services at a lower unit cost. This increased productivity results in an increased supply of goods and services, which puts downward pressure on prices and lowers inflation.

According to the third econometric model, 40.13 percent of the variance in the unemployment rate can be explained ($F=2.7254$, $P<0.05$). All explanatory variables were significant at 10 percent, 5 percent, and 1 percent. Specifically, COVID-19 vaccination rates, FDI as a percentage of GDP, and population growth had a positive effect, while GDP growth and government expenditure negatively affected the unemployment rate.

Interestingly, a 1 percent increase in the COVID-19 vaccination rate per 100 population decreased the unemployment rate by 0.011 percent. However, from an economic perspective, a high vaccination rate allowed countries to reopen and spurred stronger growth prospects, reducing unemployment rates. This is because higher vaccination rates improve physical safety, which helps workers return to work, ultimately contributing to the recovery of the labour market. This finding is consistent with Gou et al. (2022), which indicates that the county-level unemployment rate is negatively associated with county-level vaccination rates.

5. Conclusion

COVID-19 vaccine rollouts are essential for resolving the health and economic crises caused by the pandemic. This paper provides an empirical assessment of the impact of COVID-19 vaccines on selected macroeconomic factors. The study analyses the effects of COVID-19 vaccinations on economic growth, inflation rates, and unemployment rates. To the best of our knowledge, this is the first empirical assessment of the macroeconomic effects of COVID-19 vaccinations using these key economic factors on a large-scale sample of OECD countries.

The findings suggest that COVID-19 vaccines significantly affect macroeconomic factors. Specifically, a 1 percent increase in vaccinations per 100 population is associated with a 0.02 percent increase in GDP growth rate. However, the study further revealed that COVID-19 vaccines negatively impact inflation and unemployment rates. The primary goal of COVID-19 vaccination programs is to prevent the spread of the virus and end the pandemic to save millions of lives. Additionally, the study suggests that vaccination programs can help economies recover by instilling confidence in consumers and workers to resume their previous routines. Therefore, the study shows that the successful rollout of COVID-19 vaccines has played a pivotal role in restarting the economy, as evidenced by higher production, lower inflation, and reduced unemployment claims.

To maintain this status quo, it is imperative that the health and economic costs of vaccination decrease. New, effective products against emerging variants should be developed to achieve this goal while maintaining the manufacturing capacity to produce both existing and new products quickly and at scale. Additionally, measures must be taken to ensure these products remain accessible and affordable.

This study has several limitations. Higher vaccination rates can bring economic spill over benefits beyond economic growth, inflation, and unemployment. The current study could not explore this aspect fully due to data limitations. Future studies should address this issue once the necessary data becomes available. Nonetheless, the present study still provides valuable insights for governments and policymakers in making informed decisions regarding vaccination and minimising the economic impact

of future pandemics. Therefore, the contribution of this study remains significant

Declaration

The authors listed below certify that they have NO affiliations with or involvement in any organisation or entity with any financial or non-financial interest in the subject focus or materials discussed in this manuscript.

Availability of data

The data supporting this study's findings are available from the International Monetary Fund, the Australian Bureau of Statistics and the Australian Institute of Health and Welfare websites.

Conflict of interest

The authors have no affiliations with or involvement in any organisation or entity with any financial or non-financial interest in the subject focus or materials discussed in this study.

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8.1 Links and implications

The primary goal of COVID-19 vaccination programs has been to reduce the spread of the virus and bring the pandemic to an end with the potential to save millions of lives. This paper has been an empirical assessment of the impact of COVID-19 vaccines on selected macroeconomic factors: economic growth, inflation rates, and unemployment rates. Notably, this study stands as the first empirical assessment of the macroeconomic effects of COVID-19 vaccinations using these key economic factors within a large-scale sample of OECD countries. This study has suggested that successful vaccination programs play a vital role in economic recovery by instilling confidence in consumers and workers, encouraging a return to previous routines. Consequently, it has been demonstrated that the effective rollout of COVID-19 vaccines has significantly contributed to restarting the economy, as evidenced by higher production, lower inflation, and reduced unemployment claims.

This thesis has encompassed six studies across four thematic macroeconomic areas of the impact of COVID-19: (a) the macroeconomic impact of COVID-19 (Chapter 3), (b) policy responses including economic policy changes due to the pandemic (Chapters 4, 5 and 6), (c) a cost analysis of COVID-19 (Chapter 7), and d) the macroeconomic impact of COVID-19 vaccinations (Chapter 8). In the following chapter, the concluding discussion and policy implications are presented based on the findings of these studies.

CHAPTER 09: DISCUSSION AND CONCLUSION

9.1 Overview

This is a thesis by publication. It comprises several empirical investigations into the economics of COVID-19, with a focus on evaluating its macroeconomic impact. This consists of examining macroeconomic changes, policy responses, a country-wide analysis of cost due to the COVID-19 pandemic, and an evaluation of COVID-19 vaccination. The main objective of this thesis has been to examine the macroeconomic impacts of COVID-19 pandemic to address and mitigate economic challenges.

Within this framework, specific objectives were delineated. These included an examination of the impacts of the COVID-19 pandemic on key macroeconomic factors using a Systematic Literature Review (SLR). Additionally, the study aimed to investigate the determinants of fiscal support to guide future economic decisions. Another specific objective was to examine of the impact of monetary policy measures on macroeconomic variables during and after the COVID-19 period. The thesis also included an analysis of the efficacy of governments' epidemic prevention responses to mitigate the risk of COVID-19. The study aimed to analysis of the costs associated with COVID-19 in one country (Australia). Finally, an assessment of the impact of COVID-19 vaccination rates on economic recovery was also part of the specific objectives.

In Chapter 1, an introductory overview was presented to elucidate the background, problem statement, research questions, and research objectives. Chapter 2 was a review of the theoretical and empirical literature, highlighting existing research gaps. To accomplish the research objectives, this study employed a quantitative analysis based on various macroeconomic settings. In total, six studies were conducted under four broad research themes using distinct econometric models.

Study 1 was consolidated as a systematic literature review, investigating the impact of COVID-19 on the macroeconomy (Chapter 3). The findings of Studies 2, 3, and 4 involved a discussion of economic policies. Study 2 focused on fiscal support during the COVID-19 pandemic (Chapter 4), while Study 3 analysed monetary policy

changes during and after the COVID-19 pandemic (Chapter 5). Study 4 involved an assessment of the effectiveness of government responses during the COVID-19 pandemic (Chapter 6). Study 5 was an analysis of the cost of COVID-19 under the theme of pandemic-related cost to the economy (Chapter 7). Study 6 was an explication of the macroeconomic impact of COVID-19 vaccinations (Chapter 8). Finally, Chapter 9, this chapter, provides a summary of all six studies and an outline of the research contributions, along with a conclusion outlining policy implications and, discussion of study limitations, suggestions for future research directions.

9.2 Summary of the key findings

Six study objectives and six research questions were identified, as mentioned in Chapter 1. The findings are grouped under each research objective, and they respond to the six research questions as summarised below based on the study themes.

9.2.1 *The Macroeconomic Impact of COVID-19*

The first objective of this thesis was to investigate the macroeconomic impacts of the COVID-19 pandemic. The most relevant research articles were identified to measure the economic consequences of the COVID-19 pandemic from 2020 to 2021. Study 1 examined the economic impacts of COVID-19 focusing on the behaviour of macroeconomic variables during the pandemic (RQ1). This SLR's aim was to guide governments, firms, and households to take rational decisions and actions to reduce the impacts caused by any future pandemic.

The economic effects of COVID-19 vary depending on various parameters, such as the status of the virus spread, socioeconomic policy changes, fiscal support policies and economic growth changes. On the other hand, the impacts differ of macroeconomic factors such as exports, imports, foreign direct investment, financial development, interest rates, and inflation. A country- or regional-level comparison of all these factors yields a more reliable estimate of the pandemic's economic impact.

Although this study attempted to cover both macroeconomic and household sector economic situations, there are some broad areas that cover microeconomic aspects, health financing, and efficiency of health resource utilisation, and a wide

range of heterogeneous methods and measures have been used. The analysis did not include studies of the ecological, demographic, and social impacts of the COVID-19 pandemic. The review was limited by the JBI summary quality framework of the underlying studies.

9.2.2 Economic policy responses to COVID-19

The second theme of this study was to assess and examine government policy responses during the COVID-19 pandemic. Specifically, it comprised an evaluation of fiscal support measures to recover the economy with the goal of achieving sustainable development, and of the impact of monetary policy measures on macroeconomic variables in the context of the pandemic.

Chapter 4 was an investigation into the impact of fiscal support policies in concurrently advancing progress across multiple SDGs. This study focused on assessing the impact of COVID-19 on SDG progress in OECD countries, specifically examining the role of fiscal support in sustaining the trajectory of SDGs (RQ2). The analytical method employed for this evaluation was the generalised method of moments. The study's findings underscore the crucial role of fiscal policy in stabilising the economy during crises. Governments in high per capita GDP countries likely aimed to prevent a severe economic downturn and maintain overall stability by injecting funds into various sectors. The positive relationship between unemployment and fiscal support signifies a fundamental aspect of how governments responded to the economic repercussions of the COVID-19 pandemic. On the other hand, as unemployment rates increased, it became evident that the pandemic led to significant job losses and economic hardship for individuals and families.

Theoretically, tax revenue and fiscal support exhibit a positive relationship. When increases tax revenue, governments have more capacity to expand their fiscal expenditure. However, in practice, governments may exercise caution in raising taxes during period of economic uncertainty, as this could potentially hinder economic recovery. Notably, public debt showed a positive effect on fiscal support during the pandemic in OECD countries. Contradicting theoretical predictions, this may be recognised as a unique condition during a crisis of pandemic proportions. Faced with the economic challenge of the COVID-19 pandemic, or similar challenges,

governments may choose to incrementally increase their public debt, either from domestic or foreign sources, to fund fiscal initiatives.

Chapter 5 consisted of an investigation of how monetary policy measures affect macroeconomic variables during and after the COVID-19 period (RQ3). This was a close examination of the influence of monetary policy measures on GDP growth, inflation, and unemployment across 33 OECD countries that were significantly affected by the pandemic. It covered the COVID-19 period and the subsequent post-pandemic era from Quarter 1 2020 to Quarter 4 2022, utilising the panel auto regressive distributed lag approach.

Findings suggest that during the pandemic period, monetary policy measures primarily manifested as a reduction in interest rates. The majority of OECD economies lowered the cash rate and interest rates on exchange settlement balances. This trend was largely influenced by the fiscal policies of most OECD countries, which provided substantial support to their economies. This support created a shift that posed a challenge for countries with low budget deficits and minimal public debt. In contrast, in the post pandemic period, countries implemented high interest rates with the aim of fostering economic growth and addressing unemployment. However, the introduction of these relaxed monetary policy measures carried some risks, including public investment becoming an adjustment variable. The higher interest rates reduced the availability of credit, subsequently impacting consumer spending and resulting in a reduction in economic growth.

Chapter 6 presented research into this question: what government epidemic prevention responses are effective in mitigating the risk to the economy? (RQ4). This supported some proposed policy directions to reduce its impact. This study utilised data from 22 countries from Quarter 2 2020 to Quarter 2 2022. The study revealed that policymakers around the world responded promptly to the COVID-19 pandemic to mitigate its risks. Essentially, there were four types of government policy interventions: Stringency indicator, Government response indicator, Containment and Health Indicator, and Economic Support. Among these, economic support and stringency have proven to be the most effective. Providing financial support and implementing strict measures has resulted in a reduction in infection and fatality rates.

Government responses have supported the reduction of infection rates, but unfortunately, they have also led to an increase in deaths. This latter finding, while surprising, can be attributed to instances where the public in certain countries disregarded the social distancing norms set by their governments. Variations in population age demographics could also contribute to this outcome.

The results demonstrate that providing economic support for income and debt relief has played a crucial role in suppressing the rate of COVID-19 infections and fatality rates. Additionally, although containment efforts and healthcare improvements have effectively reduced death rates, they have also been accompanied by a moderate increase in infection rates, contradicting some theoretical expectations. This outcome may be attributed to health inequality and the sluggish pace of vaccination rollouts. The findings suggest that implementing containment health practices without a connection to tracing and individual-level quarantine is ineffective. Policy implications derived from containment health measures should be accompanied by targeted, aggressive, and rapid containment strategies to substantially reduce the number of individuals infected with COVID-19.

9.2.3 Cost Analysis of COVID-19

Chapter 7 of this thesis comprised an estimation of the direct health costs of the COVID-19 pandemic, identifying country-specific cost factors, and analysing the macroeconomic impacts due to this pandemic (RQ5). While there are limited studies about direct health cost estimates per day at hospital for a COVID-19-infected patient, based on a single country or a group of countries, it is difficult to compare across the literature due to differences in methodology, population, and healthcare costs. Therefore, this paper was written as a single country analysis.

Findings indicate that, in Australia an inpatient's per day unit cost was estimated to be AUD 836. This was the minimum per day cost to cover the cost of treatments in Australia for COVID-19 inpatients and takes into account government funding, public or private health insurance, patient out-of-pocket expenses, or a mix of all. Of the total cost, 40 percent constituted expenditure on medicinal consumables and 26 percent on radiological examination expenditure. The estimated total cost of inpatients was AUD 3.7 million for 2021 in Australia.

Further, the factors were identified which comprise country-specific costs related to health service utilisation, with estimates for cost per inpatient day using the WHO- CHOICE model. The inpatient cost model performed marginally better, with an adjusted R squared of 0.698. In this model, the hospital bed occupancy rate was a highly significant proxy for the price level or cost of a COVID-19 patient. When there was an increase in the bed occupancy rate of 1 percent, this directly increased the cost of the inpatient by 1.05 percent.

This confirmed the measure of capacity utilisation as one of the important independent variables of cost analysis. In the model, GDP per capita was a significant proxy for price level and level of technology. A 1 percent increase in GDP per capita increased the inpatient per day cost by 0.2 percent. Further, higher admissions had a significant and very small positive effect on cost. This small effect can be said to result from mixed effects. Higher admissions could lead to lower overhead costs per patient and greater efficiency. On the other hand, a greater size could also indicate more specialist care, with a large proportion of complicated cases with a higher unit cost. Further, there was a negative relationship between the cost of inpatients and length of stay. A 1 percent increase in hospital stay time increased the inpatient cost by only 0.01 percent per day. When increasing the length of the hospital stay days, the fixed costs per patient are spread over the days. Therefore, more hospital days lower the per day cost per inpatient.

9.2.4 The Economic Impact of COVID-19 Vaccination Procedure

Chapter 8 comprised an investigation into the profound impacts of the emergence of COVID-19 vaccines on the economy (RQ6). This was an empirical assessment to provide a comprehensive understanding of how the introduction of COVID-19 vaccine influenced key macroeconomic factors: economic growth, inflation rates, unemployment rates.

The compelling findings reveal that COVID-19 vaccines wielded a substantial influence on these macroeconomic factors. Notably, the analysis indicates that a mere 1 per cent increase in vaccinations per 100 population correlated with a noteworthy 0.02 per cent rise in the GDP growth rate. However, intriguingly, the research reveals a negative impact on inflation and unemployment rates attributed to the vaccine rollout.

This nuanced perspective offers a more holistic understanding of the multifaceted effects of the COVID-19 vaccine rollout. In essence, the study demonstrated that the successful rollout of COVID-19 vaccines played a pivotal role in recovering the economy. This was evidenced not only by the discernible uptick in production but also by the concurrent trends of lower inflation and reduced unemployment claims.

9.3 Policy implications

All six papers in this thesis have discussed policy implications based on their individual study findings. Overall, this thesis provides systematic evidence concerning the macroeconomic impacts of the COVID-19 pandemic.

According to the Study 1, governments may choose to adopt additional development policy tools to ensure that post-pandemic recovery fosters greater long-term resilience. Emphasising the need for international collaboration in addressing global challenges, Study 2 proposes the utilisation of public debt for fiscal support during economic challengers, allowing governments to implement targeted interventions addressing inequality through the funding of social programs, education, healthcare, and infrastructure projects that benefit marginalised or disadvantaged communities. Further, it recommends progressive tax reduction to contribute to reducing inequality while ensuring a fair distribution of tax burden. This approach aims to strike a balance between promoting economic growth and compiling with sustainable development goals (SDGs) in reducing inequality. Study 3 underscores the importance of governments' effective management of inflationary pressure, a notable drawback associated with expansionary monetary policy. Simultaneously, it emphasises the necessity for governments to announce substantial recovery plans with a focus on public investments. This includes strengthening healthcare systems during pandemic periods and expediting the production process immediately after virus immunisation. Based on the findings of Study 4, it recommends that public health authorities and policymakers adopt targeted, aggressive, and rapid containment strategies to effectively reduce COVID-19 infections. The implementation of containment health practices without a connection to tracing and individual-level quarantine is deemed ineffective, and therefore, efforts should focus on a comprehensive approach that integrates these elements. Moreover, recognising the economic challenges faced by individuals during containment and quarantine, it is

recommended to provide substantial economic support for income and debt relief. This support should be directed towards affected individuals and businesses, ensuring that financial concerns do not hinder compliance with health guidelines.

Study 5 advocates for governments and policymakers to prioritise initiatives promoting the efficient use of healthcare resources, emphasising the optimisation of medical supplies, personal, and infrastructure for both affordable and maximum impact on public health. This involves streamlining administrative processes, negotiating favourable procurement deals, and integrating innovative technologies to enhance operational efficiency while preserving the quality of healthcare services. The study emphasizes the critical need for macroeconomic monitoring, particularly in understanding the interplay between economic factors and the healthcare sector. By actively assessing the macroeconomic transmission channels and causalities, government agencies can make more informed and strategic decisions, thereby fostering a resilient and efficient healthcare system.

As highlighted in Study 6, the successful implementation of these policy implications requires a coordinated effort between governments, healthcare providers, the private sector, and communities. By addressing both the health and economic aspects of the COVID-19 pandemic, these policies can help mitigate the impacts of the virus, promote recovery, and build more resilient and equitable societies for the future. Simultaneously, it is essential to launch comprehensive public health campaigns to educate the population about the benefits of vaccination and dispel myths and misinformation. Utilize multiple platforms, including social media, traditional media, and community outreach. Enhance the efficiency of vaccine distribution systems by investing in infrastructure improvements, such as cold chain logistics, storage facilities, and transportation networks.

9.4 Study limitations and recommendations for future research

While the six studies presented in this thesis offer valuable insights into the COVID-19 pandemic and its macroeconomic impact, certain limitations are acknowledged. These primarily arise from constraints related to data accessibility during the study, offering scope for future research.

A comprehensive overview of the existing body of literature on the economics of COVID-19, encompassing an examination of multidimensional aspects, may provide an understanding about mitigating the pandemic's adverse economic impacts. This review did not explicitly delve into the financial impacts of COVID-19, despite the inherent connection between financial health and a country's overall economic performance.

Moreover, several limitations were encountered in the cost analysis of the COVID-19 pandemic. Firstly, there was no estimation of the outpatient cost of COVID-19, nor major macroeconomic factors: inflation, unemployment, international trade flows, and the financial performance of countries. Notably, this study focused on a single country.

One of the primary limitations of examining the effectiveness of government responses during the COVID-19 pandemic lies in its reliance on the four main indexes of government responses, thereby overlooking other crucial contributors to mitigating risks associated with the pandemic. Future researchers should broaden their scope to include factors such as socioeconomic status, geographical variations, population density, financial capacity, and health systems, all of which play pivotal roles in shaping the overall impact of the pandemic.

While priority factors in determining fiscal support were examined, there was no exploration of fiscal financing methods, such as debt management, countries' public debt management and each country's credit rating. Further research should aim to fill this gap, providing a more comprehensive understanding of the financial strategies employed by different nations to navigate the economic challenges posed by the pandemic.

On the other hand, monetary policy measures are dependent on both domestic and foreign economic policy decisions. Therefore, in this study, the conditions regarding

exchange rate policy regimes and distinct interest rate rules for the monetary policies of each respective country were relaxed. Given that the study's scope was confined to a relatively short period, long-term ramifications may differ. Furthermore, changes in energy prices could not be incorporated into the fundamental models due to data limitations.

Finally, the thesis has provided an analysis of the impact of COVID-19 vaccinations on macroeconomic variables. However, data limitations impede a thorough examination of how vaccination rates influence outcomes beyond economic growth, inflation, and unemployment. Additionally, the scope of the thesis did not encompass an exploration of investment in the healthcare sector for developing COVID-19 vaccines.

Overall, the current study faced limitations in terms of accessibility of some statistical data. Despite the availability of data for the entire two-year pandemic period, constraints prevented a time series analysis. It is important to note that this study solely focused on macroeconomic impacts related to COVID-19 and did not delve into microeconomic aspects.

Future research endeavours are imperative to achieve a more comprehensive understanding of the effects of the pandemic on individual consumption patterns and the pricing dynamics of goods and services. Exploring these microeconomics aspects would shed light on how the pandemic has influenced consumer behaviour, market trends, and overall economic dynamics at the individual level.

Additionally further studies are essential to examine the impact of COVID-19 on international trade and foreign exchange markets. The global interconnectedness of economics and unprecedented disruptions caused by the pandemic make it crucial to explore how trade patterns have been altered, the challenges faced by international markets, and the fluctuations in foreign exchange rates. A nuanced analysis of these aspects would contribute significantly to understanding the pandemic's far-reaching implications on the global economic landscape.

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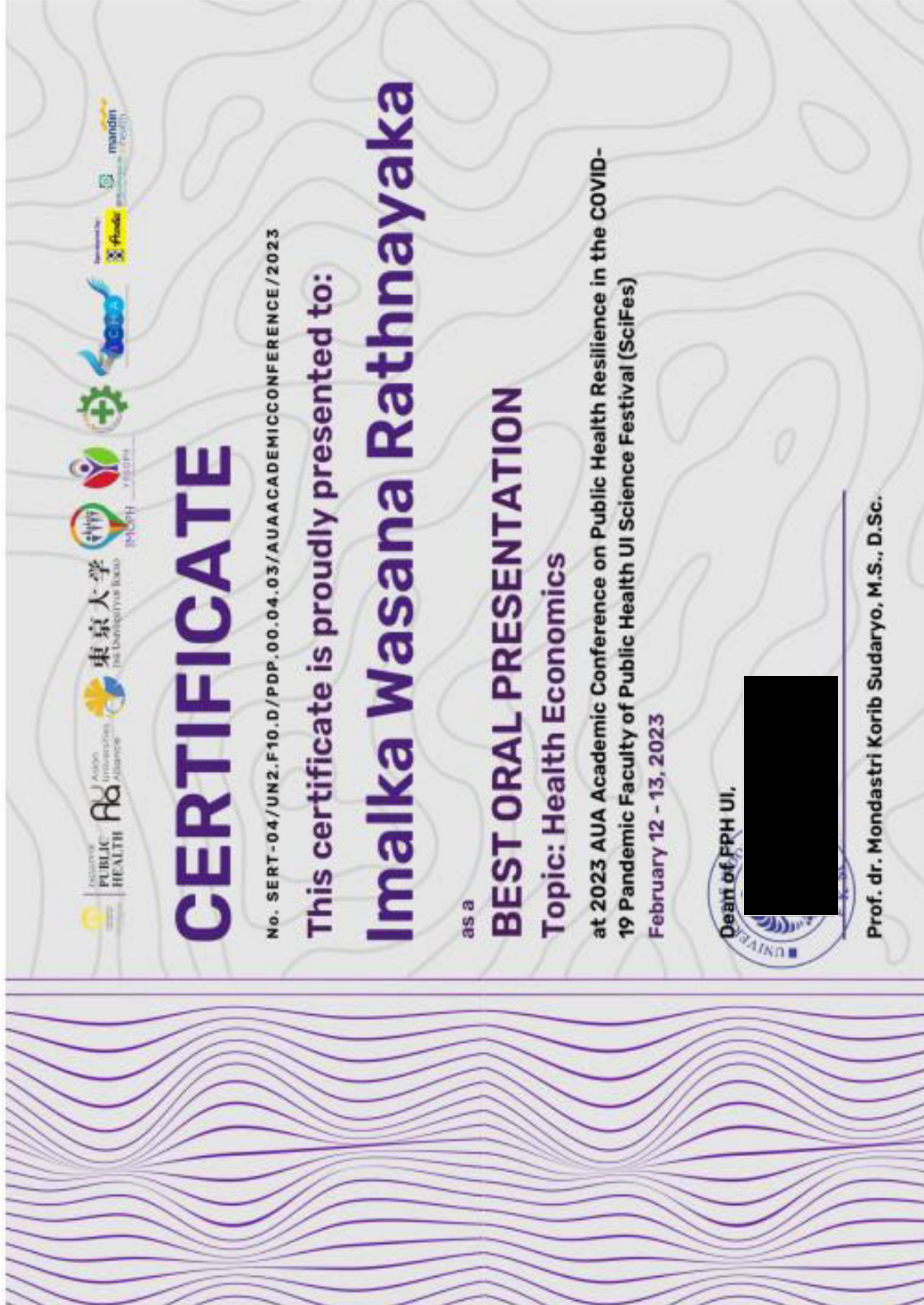
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APPENDICES

APPENDIX 1



APPENDIX 2



University of
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PGECR Organising Committee
(07) 46312223
PGECRSymposium@unisq.edu.au

6 October 2023

Re: 30th Postgraduate and Early Career Researcher (PGECR) Symposium – Confirmation of Participation

Dear Imalka,

This letter is to confirm that you presented at the 30th Postgraduate and Early Career Researcher Symposium. Details of this can be found below.

Symposium: 30th Postgraduate and Early Career Researcher Symposium

Date: 8 September 2023

Presentation title: The Macroeconomic Impact of COVID-19 Vaccines: Evidence from 37 Countries

Presenter: Imalka Wasana Rathnayaka

Yours sincerely



Douglas Eacersall PhD
Senior Lecturer Researcher Development
Co-chair PGECR Symposium Organising Committee

AHES

Australian Health Economics Society

44th Annual AHES Conference
Adelaide, 21-22 September 2023

Conference Abstracts Booklet

Conference twitter hashtag: #AHES2023

AHES twitter handle: @AusHealthEcon

APPENDIX 4

Room C Healthcare Costs 2

Cost Analysis of COVID-19 in Australia

Imalka Rath, University of Southern Queensland

Co-authors: Rasheda Khanam, Mohammad Mafizur Rahman

Severe Acute Respiratory Syndrome (SARS-COV-19) can be categorised as an outlier, which has severe health impacts with macroeconomic implications. This paper aims to evaluate the direct and indirect costs of the COVID-19 pandemic in Australia with an analysis of the macroeconomic impact from 2020 to 2022. Access to accurate and reliable information on the cost of COVID-19 can help with economic policy decisions. Therefore, this study is motivated by the ongoing coronavirus pandemic and its cost to economies worldwide. In particular, the direct costs of the COVID-19 pandemic to the Australian economy are examined and policy directions are suggested to mitigate their magnitude. Evaluation of economic costs and the burden of a pandemic are crucial in developing resource allocation and prioritisation strategies for public health and economic resilience. There is no publicly available information on the input costs of testing and treatments for COVID-19 in Australia. It is necessary to estimate the approximate direct health cost spend by government funding, public or private health insurance, patient out-of-pocket expenses, or a combination of these. These estimations of the cost of coronavirus disease in a country may not only support policymakers in effectively allocating resources and prioritising disease control activities, but it is also paramount to the long-term planning for sustainable financing in similar future conditions. (1) A micro-costing approach is performed using historical cost data for one year. All direct medical inputs were determined in quantities and monetary values for Covid-19 inpatients in the hospital. (2) The WHO CHOICE model is used to estimate the factors that affect determine inpatient hospital costs per day. (3) The impact of COVID-19 on various macroeconomic variables is evaluated using macroeconomic data. Based on different treatment methods for COVID-19, the study calculates the direct cost by narrow down cost factors and establishing possible assumptions. As a result, an inpatient's per-day unit cost is estimated to be AUD 836. It is the minimum cost per day that is compensated for COVID-19 inpatients by government funding, public or private health insurance, patient out-of-pocket expenses, or a combination of all be used to cover the cost of treatments in Australia. The hospital bed occupancy rate is a highly significant proxy for the cost of a COVID-19 patient. The GDP per capita for a state has a positive effect on inpatient costs. Higher admissions have small positive effects on cost. The findings of indirect impact GDP fell significantly to 1.9% below its No-COVID level in 2021 Q1. The reduction continued to -1.8% by the 3rd quarter of 2021. Important policy recommendations are then suggested based on the empirical results. This research is critical for national and local governments to strengthen efforts to collect, analyse, and use data on health system resources use and efficiency.

APPENDIX 5

AHES inc

Australian Health Economics Society Inc.
Incorporated in NSW
ABN number 62 310 470 803

President

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29-Sep-23

To whom it may concern,

Re: Attendance at the 44th AHES Annual Conference 2023, Adelaide, South Australia

This is to confirm that Ms. Imalka Wasana Rathnayaka attended the 44th Annual Australian Health Economics Society Conference in Adelaide, South Australia, on 21st & 22nd September 2023. Imalka presented a paper titled "The cost analysis of COVID-19 in Australia" in the Parallel session 7 on 22 September 2023.

Yours sincerely

[REDACTED]

Professor Julie Ratcliffe

President

APPENDIX 6

PSC Global Observatory



Australian Government
Australian Research Council



University of
South Australia

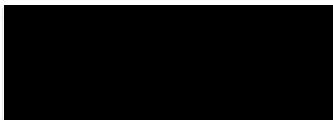
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The Kathleen Fitzpatrick ARC Laureate Fellowship PhD Thinkers Program

Congratulations

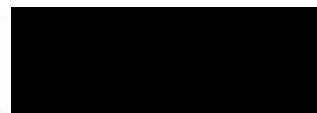
Imalka Rathnayaka

On being selected as a 2023 PhD Thinker



Professor Paula Geldens

Executive Dean, Justice and Society
UniSA Justice & Society



Professor Maureen Dollard

ARC Laureate Fellow
UniSA Justice & Society

APPENDIX 7



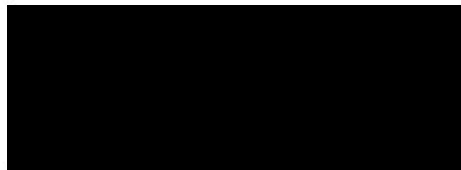
Graduate Research School

Runner Up, GRS Virtual Poster Competition and Showcase

Presented to

Imalka Wasana Rathnayaka

For your entry in the GRS Virtual Poster Competition and Showcase
Competition, *The Economics of COVID 19: Assessing Macroeconomic
Impact*.



Professor Charlotte Brownlow
Dean, Graduate Research School

uniso.edu.au

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APPENDIX 8

SRL: Source	Countries examined	Method	Objective	Main finding
Ataguba, J..E. (2020)	Africa	Qualitative	To discuss the economic burden or cost of the COVID-19 pandemic, especially in Africa.	Full economic impact of COVID-19 on the economies of countries in Africa cannot be ascertained now as the situation unfolds.
Gupta, A., et al. (2020)	India	OLS	To estimate the impacts of India's COVID-19 lockdown on household income, food security, welfare, and access to local loan markets	Weekly household local income fell by INR 1,022 (US\$ 13.5), an 88% drop compared to the long-term average with another 63% reduction in remittance.
Varona, L. and J. R. Gonzales (2021)	Peru	Time Series-ARDL Model	To analyses the dynamics of the short-term behavior of economic activity/ To explain the causal relationships in a Pandemic context based on the basic number of spread (Re) of COVID-19 per day.	A negative and statistically significant impact of the COVID-19 shock was found on the level of economic activity and a long-term Cointegration relationship with an error correction model (Dogan et al.), with the expected sign and statistically significant at 1%.
Pinilla, J., et al. (2021)	Spain	Time Series - Quarterly Frequency- Robust Statistical Bayesian Model	To analyses macroeconomic impact of the COVID-19 Pandemic in 2020 using key indicators of the Spanish economy	Adverse impact of the COVID 19 on the GDP was 11.41% in 2020/Immediate decrease in Demand- Families reduce consumption and began to save more, it leads to losses of jobs and reduced activity/ National Unemployment rate increases of 11.%

SRL: Source	Countries examined	Method	Objective	Main finding
Donaldson, C., and C. Mitton (2020).	United Kingdom and Canada	Qualitative	To study trade-offs with respect to enhancing health system capacity and the impact of the mix of private-public financing.	Health economics, it may be argued, should play a much bigger role in policymaking when it comes to current and future pandemics.
McKibbin, W. and R. Fernando (2020)	Argentina Australia Brazil Canada China France Germany India Indonesia Italy Japan Mexico Other Asia Other oil producing countries Republic of Korea Rest of euro zone Rest of OECD Rest of the world Russia Saudi Arabia South Africa Turkey United Kingdom United States of America	DSGE/CGE general equilibrium model.	To provide guidance to policymakers regarding the economic benefits of globally coordinated policy responses to tame the virus.	Consumer and investor confidence reinforce negative multiplier effects in a downward spiral between labor and output markets. The three potential “shapes” for the macroeconomic recovery: the highly optimistic yet implausible “V” path, the somewhat favorable “U” path, and the pessimistic yet more likely “L” path.

SRL: Source	Countries examined	Method	Objective	Main finding
Alhassan, G. N., et al. (2020).	Nigeria	time-series data - ARDL	To assess the regional economic impact of the lockdown measures ordered by the national government to prevent the spread of COVID-19.	Health expenditure has negative impact on economic growth./ The significant positive effect of life expectancy on economic growth/ Impact of death rate on economic growth is negative and significant
Hayat, M. A., et al. (2021).	Pakistan	time-series data - ARDL - Monthly data	To understand the impact of inflation and the interest rate on output growth in the context of Pakistan using the wavelet transformation approach.	Inflation growth and interest rate growth are out of phase, indicating the negative relationship between variables. Keeping the inflation rate at a low level is very essential for growth in Pakistan in these tough economic times due to the COVID-19 pandemic
Burger, P. and E. Calitz (2020)	South Africa	Markov-switching model- Qualitative	To explore the past efforts of government to maintain or restore fiscal sustainability by estimating a fiscal reaction function using a Markov-switching model.	Need to establish the deficit financing, expenditure, and revenue adjustments that the government will have to make to restore fiscal sustainability
Ngepah N. (2021).	196 counties	Poisson pseudo-maximum-likelihood (PPML) and the quantile regression techniques - Panel Data	To examines the different socio-economic determinants of the fatalities associated with the COVID-19 pandemic globally in social determinants of health frameworks.	An improved adequate health infrastructure for both testing and treatment is necessary, but not sufficient.

SRL: Source	Countries examined	Method	Objective	Main finding
Boissay, F and Rungcharoenkitkul, P.(2020)	USA and Global Economy	Descriptive Statistics	To review studies on past epidemics, and then turn to the latest quantitative estimates of Covid-19's impact on global growth.	A better understanding of the transmission channels of the Covid-19 shock to the economy, the interaction between economic decisions and the epidemic, and the policy trade-offs is therefore needed.
Jesús, F.V .and Charles I. J, (2020)	USA	Descriptive Statistics	To study time-varying contact rate to capture behavioral and policy-induced changes associated with social distancing	The mortality rate of SARs-CoV-2 in Spain is between 1% and 1.1%. Because many of the early deaths in the epidemic were linked with mismanagement of care at nursing homes in Madrid and Barcelona that could have been avoided, we pick 1% as our benchmark value.
Djurovic, G et al. (2020)	Montenegro	OLS - SVARX model of GDP	To diagnoses and assesses appropriate macroeconomic policy responses of the Montenegrin Government to the outbreak of COVID-19.	Forecasted reduction of the GDP_GAP is to-3.2% and-7.0%, respectively, from January 2020 to December 2020.
Van der Wielen, et al. (2021).	27 EU members	Panel Data	To document the changes in households' economic sentiment in the EU following the outbreak of the COVID-19 pandemic and ensuing lockdown.	The labour market impact of this crisis is more pervasive, at least in the people's minds.

SRL: Source	Countries examined	Method	Objective	Main finding
Ke, X. and C. Hsiao (2021)	China	Panel Data	To evaluate the economic consequences of the drastic lockdown policy in the epicenter of COVID-19 --- the Hubei Province of China during worldwide curbs on economic activity.	The total GDP decreased 37% in 2020. / Private components of GDP, investment, consumption, export, and import lost 82%, 30%, 36%, and 25% of their respective counterfactual values.
Rasul, G., et al. (2021).	Afghanistan Bangladesh Bhutan India Maldives Nepal Pakistan Sri Lanka	Descriptive Statistics	To analyze existing and prospective impacts, risks, and challenges of Covid-19 on key social and economic sectors including migration, tourism, informal sector, agriculture, and rural livelihoods.	COVID-19 affected to economic growth, increase of fiscal deficit and monetary burden, increase the risks of macroeconomic instability, decrease migration and remittance, reduce income from travel and tourism, and result in dwindling micro-small and medium industries and informal businesses.
Binder, C. (2020).	USA	OLS	To study the formation of consumer expectations and response to information or Fed communication	Job insecurity and job loss, illness, school and business closures, and future fiscal and monetary policy responses may have notable effects on expectations and beliefs. Possible increases in consumer inflation expectations in the next few months of the COVID-19 crisis might best be interpreted as increases in pessimism rather than as improved expectations of aggregate demand.

SRL: Source	Countries examined	Method	Objective	Main finding
Sarkodie, S. A. and P. A. Owusu (2021).	Global	Descriptive Statistics	To analyze global environmental, health and economic dimension of the effect of COVID-19 using qualitative and empirical assessments	COVID-19 global pandemic uncertaintyFootnote1 ranks the UK (128.36 index) as the country with the highest uncertainty level among 143 countries towards COVID-19 pandemic. The highest total economic stimulus occurs in Bahrain (31.30% of GDP) across 162 countries
Martin, A., et al. (2020).	Global	Descriptive Statistics	To analyze the socio-economic impacts of the COVID-19 containment at the household level.	Household savings and consumption drop significantly, the long recovery time after the crisis will be further exacerbated by a general decrease in demand, people's change in consumption behavior, and general slowdown of economic activities. government benefits, decrease the amplitude and duration of the crisis.
Keogh-Brown, M. R., et al. (2020).	UK	Sensitivity analysis	To assess the potential macroeconomic impact of COVID-19, together with policies to mitigate or suppress the pandemic by means of home quarantine, school closures, social distancing and accompanying business closures.	The total cost to the economy is £308bn (13.5% of GDP); £66bn (2.9% of GDP) of which is attributable to labour lost from working parents during school closures, and £201bn (8.8% of GDP) of which is attributable to business closures.

SRL: Source	Countries examined	Method	Objective	Main finding
Iluno, C., et al. (2021).	Nigeria	Regression Analysis - Gaussian polynomial, other non-linear, and Gamma generalized polynomial models	To model the effect of COVID-19 mortality per population (CMP), a proxy for COVID-19 on the Gross Domestic Product (GDP) per capita per COVID-19 cases (RGDPC), a proxy for the economic wellbeing of a nation.	There is a non-linear relationship between COVID-19 mortality and the economic wellbeing of Nigerians.
Béland, L.-P., et al. (2020).	USA	OLS	To explore the short-term economic consequences of COVID19 on employment and wages in the United States.	COVID-19 increased the unemployment rate, decreased hours of work and labor force participation, and had no significant impacts on wages. The negative impacts on labor market outcomes are larger for men, younger workers, Hispanics and less educated workers.
Bitanhirwe, B. K. Y. and D. Sewanyana (2021).	sub-Saharan Africa	Qualitative	To analyze health and economic burden associated with COVID-19 in SSA	Sub-Saharan Africa (SSA), remain tenuous and will require context-appropriate interventions. Control measures to tackle COVID-19 in SSA should therefore be informed through lessons learned from past outbreaks and emergencies on the continent.

SRL: Source	Countries examined	Method	Objective	Main finding
Li, Z., et al. (2021).	USA	Descriptive Statistics	To examine the impact of the global financial crisis, and the COVID-19 pandemic on the macroeconomic variables of the US economy	The impact of the crisis on the recession probabilities in the current pandemic is lower than that at the time of the global financial crisis.
Lim, G., et al. (2021)	Australia	Descriptive Statistics	To describe the economic growth and labour market ramifications associated with COVID-19, and the fiscal and monetary policies implemented to help counter its effects.	COVID-19 lockdowns and the closure of borders have had a massive negative and pervasive impact of Australia's performance in 2020.
Islam, M.R., et al. (2020)	Global	Descriptive Statistics	To find out the crucial impacts of Coronavirus pandemic on the global economy and predicting the scenario which will face the world economy	The countries are decreasing from the early month of this year, 30% to 40% foreign investment has been decreased and unemployment rate will rise to more than 25% all over the world. Findings also exhibited that this crisis could cost 2.7 trillion US dollar which is about 3.06% of the global GDP.
Amewu, S., et al. (2020)	Ghana	Social Accounting Matrix (SAM) multiplier models	To estimate the economic costs of COVID-19 policies and external shocks in a developing country context, with a focus on agri-food system impacts.	Heavy economic costs will impose. National GDP is estimated to fall by 27.9% while agri-food system GDP losses are estimated at 19.8%. poverty, and assuming the production slowdown during lockdown.

SRL: Source	Countries examined	Method	Objective	Main finding
Rowthorn R and Maciejowski J	United Kingdom	SIR Model	To quantify the benefits of early intervention to control the disease and examine how the government's valuation of life influences the optimal path.	Under the Baseline scenario, the value of life is £2m and the optimal lockdown lasts for 5.3 weeks. Holding other parameters constant, it becomes optimal to dispense with the lockdown altogether once the value of life drops below £1.68m.
Natuhoyila, A. N., et al. (2021)	Congo	cross-sectional	To measure the impact of the COVID-19 pandemic on the living conditions of households.	Approximately 85% households surveyed had a significantly socioeconomic impact due to the pandemic which highlights the need for more longitudinal studies to be conducted on this age group.
Parveen, T., et al. (2021)	Pakistan	Descriptive Statistics	To examine the medical, socio-economic challenges facing during the COVID-19 pandemic.	Due to health, social, economic, and political structure, the Pakistani government will not be able to take any action against COVID-19.
Argente, D. O. (2020)	South Korea	SIR Model	To quantify the effect of public disclosure on the transmission of the virus and economic losses in Seoul.	The daily economic welfare loss for the young (old) is 0.04 (0.05) percent under partial disclosure and 0.14 (0.17) percent under no disclosure.