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Economic Consequences of Covid-19 Pandemic: An Analysis of Exchange Rate Behaviour

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Abstract. *This paper examines the effect of Covid-19 on currency exchange rate behaviour by taking a sample of 37 countries over a period from 4th January 2020 to 30th April 2021. Three variables, such as daily confirmed cases, daily deaths, and the world pandemic uncertainty index (WPUI), are taken as the measure of Covid-19. By applying fixed-effect regression, the study documents that the exchange rate behaves positively to the Covid-19 outbreak, particularly to daily confirmed cases and daily deaths, which implies that the value of other currencies against the US dollar has been depreciated. However, the impact of WPUI is insignificant. On studying the time-varying impact of the pandemic, the study*

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reveals that the Covid-19 has an asymmetric impact on exchange rate over different time frames. Further, it is observed that though daily confirmed cases and daily deaths show a uniform effect, WPUI puts an asymmetric effect on the exchange rate owing to the nature of economies.

Keywords: *Covid-19 pandemic; economic disruption; uncertainty; exchange rate; asymmetric effect*

1. Introduction

It was 31st December 2019 when the World Health Organization (WHO) became aware of the spread of pneumonia-like disease in the Wuhan city of China. On 7th January 2020, the Chinese authority identified such a disease as Novel Corona Virus (Covid-19). WHO declared it as a pandemic on 11th March 2020. As of 30th April 2021, the virus had already reached more than 200 countries with 150,125,783 confirmed cases and 3,159,547 death cases globally[1]. The effect of the virus has been severely felt by countries such as China, France, Russia, South Africa, Brazil, Italy, India, the United Kingdom, Spain, and the United States. Though the world has witnessed many epidemics like the Plague, Ebola, Zika, Lassa fever, etc., the scale and growth speed of Covid-19 makes it unique among them. WHO has termed it the most severe pandemic in the last 100 years, and in line with this, Gates (2020) also termed it "the once-in-a-century-pathogen".

The pandemic has created not only a health crisis but also an economic and social crisis across the globe. The economic activities at the national and global level are at a standstill as the spread of the virus disrupted the movement of people and goods. The imposition of lockdown and social distancing norms encompassing suspension in the movement of people and goods within the national boundaries has led to demand-supply mismatch and has disrupted the national supply chain. Many enterprises have also been negatively affected by government restrictions such as the imposition of lockdown and social distancing (Ceylan et al., 2020). The major socio-cultural events and their supporting events have been suspended in the social sphere, further affecting economic activities. At the global level, the suspension of economic activities such as international travel, tourism, export, import, etc., has dramatically affected the global supply chain resulting in economic damage. As a consequential effect, Covid-19 has significantly affected the extent of social behaviour, income, consumption, spending pattern, travel habits, supply chains with a sequential impact on lifestyle, markets, and economy across the globe. These chains of effects show how the Covid-19 emanated as a health hazard and spiralled into the economic sphere of the countries.

The consequence of the global financial crisis in 2009 was so severe that it led to massive structural changes in the financial and commodity market, causing an asymmetric effect on portfolio allocation, market efficiency, and volatility (Rapach & Strauss,

[1] https://covid19.who.int/

2014). While Nwosa (2021) documents that Covid-19 has a more adverse effect on the market than the 2009 global recession. The Covid-19 pandemic disrupted all spheres of human beings creating uncertainty around the globe as it is unprecedented, and there is no definite solution available till now to mitigate such crisis. As per ILO (International Labour Organisation) report, global working hours were lost at 8.8 percent in 2020 relative to the 4th quarter of 2019. This working hour loss is equivalent to 255 million full-time jobs and approximately four times greater than during the global financial crisis in 2009. With the experience of these severe fallouts in economic, social and health fronts, the uncertainty among people compounded further. As per the world uncertainty index database[2], the WPUI (World Pandemic Uncertainty Index) has reached its all-time high during Covid-19 (See Figure 1).

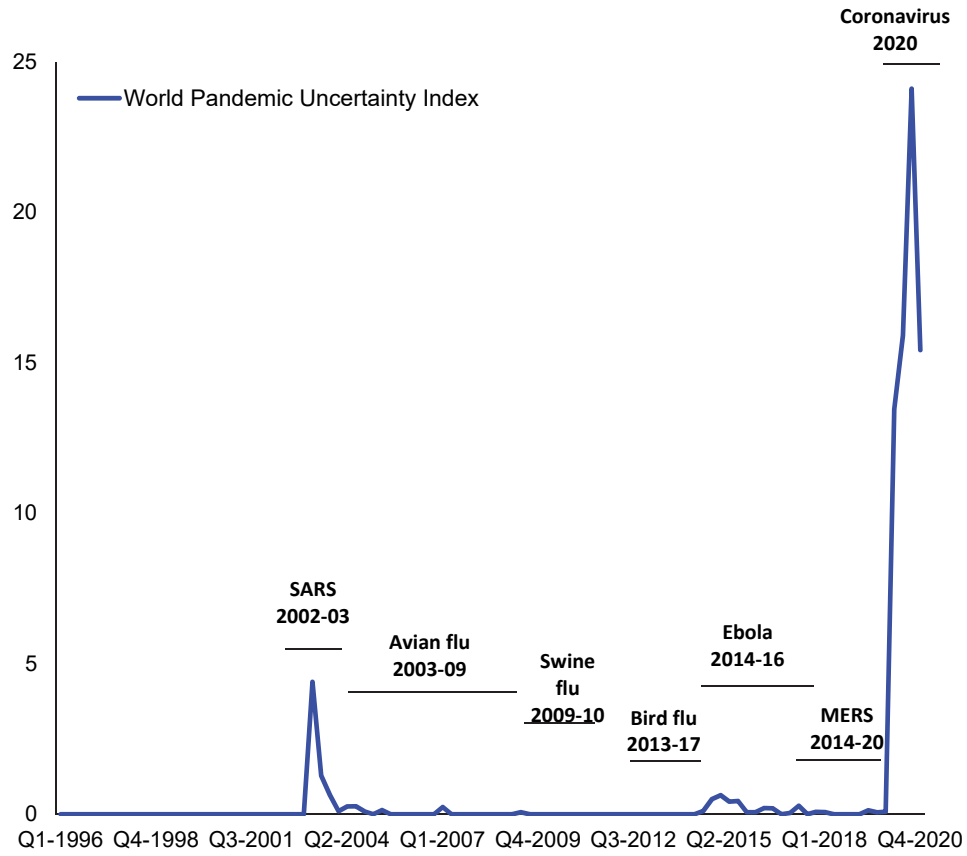

FIGURE 1. **Trend of WPUI in various Epidemics and Pandemics**

Source: World Uncertainty Index. https://worlduncertaintyindex.com/data/

[2] https://worlduncertaintyindex.com/data/

Realizing the severity of the Covid-19 pandemic, researchers around the globe have tried to explore its influence on various dimensions of business and economy, such as global supply chains (Bonadio et al., 2020; Qin et al., 2020), employment (Montenovo et al., 2020; Yu et al., 2020), industrial production (Altig et al., 2020; Appiah-Otoo & Issac, 2020), household consumption (Binder, 2020; Liu et al., 2020), innovation ability (Han & Qian, 2020), financial markets (Hoshikawa & Yoshimi, 2021; Ashraf, 2020; Baker et al., 2020; Iyke, 2020b; Lan et al., 2020; Liu et al., 2020; Mishra et al., 2020; Narayan, 2020; Prabheesh, 2020; Salisu & Sikiru, 2020; Yan & Qian, 2020), oil prices (Nwosa, 2021) and government intervention on economic activities during Covid-19 (Feng et al., 2021, Ertuğrul et al., 2020; Haldar & Sethi, 2020; Phan & Narayan, 2020; Song et al., 2020). However, the exchange rate is one of the crucial aspects of financial markets, and it plays a significant role in the economic development of every country, stability of the country's external environment, and foreign trade. Hence, the exchange rate needs considerable attention from researchers and policymakers to assess the impact of Covid-19 on it.

The Covid-19 ridden supply chain has created a change in demand and supply for currencies of all the countries across the globe for international trade and settlement, which in turn has created a fluctuation in the exchange rate of the currencies against the US dollar. As per the CNBC report dated 14th April 2020[3], when the value of some of the emerging markets' currency against USD was under stress due to oil price shock created by overproduction, the outbreak of Covid-19 dampened it further as the virus made shrinkage in the oil demand. Such risk has affected emerging markets and other economies as they have knock-on impact due to regional trade links. Hence, given the severe impact of Covid-19 on every economy across the globe, there is sufficient reason to believe that the impact of Covid-19 has certainly touched the exchange rate of the economies. So, at this juncture, the analysis of exchange rate behaviour is a matter of study. In this context, researchers such as Narayan (2020), Iyke (2020b), Nwosa (2021), Ozturk and Cavdar (2021), Sharma et al. (2021), Feng et al. (2021), Aloui (2021), Konstantakis et al. (2021), Hoshikawa and Yoshimi (2021), Aslam et al. (2020) and Camba and Camba (2020) have paid their attention to the impact of Covid-19 on exchange rate. Given the above scenario, the present work aims at analyzing the impact of Covid-19 measured in terms of confirmed cases, deaths, and uncertainty created by the pandemic on the exchange rate. This paper contributes to the existing literature on the exchange rate in various ways. Firstly, unlike other studies being limited to a specific country, this paper depicts the effect of the Covid-19 pandemic on the exchange rate from a large sample of 37 countries. Secondly, it provides insights on the impact of the pandemic on the exchange rate owing to the time frame and the level of

[3] https://www.cnbc.com/2020/04/14/emerging-market-currencies-have-been-hammered-by-covid-19.html

economic development of the country, i. e., emerging and developed economies. Thirdly, this is the first paper to assess the impact of the WPUI on the exchange rate.

The remainder of the paper continues in the following manner: the second section deals with the literature review, the third section describes the empirical methodology, the fourth section depicts the empirical results, and the final section concludes the study.

2. Literature Review

2.1 Theories of Exchange Rate and Covid-19

A natural disaster is considered as an important factor having potential to disrupt the economic fundamentals of the national as well as global economies (Farhi & Gabaix, 2016). Among all the economic fundamentals, one of the most affected assets price is the exchange rate (Iyke, 2020b). Though Covid-19 is considered to be the most severe disaster in the last 100 years, the world has seen many others and witnessed their economic implications in real markets as well as financial markets. Such low-frequency-high-impact (LFHI) disasters put a significant threat to the supply chain (Hosseini et al., 2019; Ivanov et al., 2017; Kinra et al., 2020). The effect of such events cascades to other aspects of the economy through the supply chain, which is called a ripple effect (Ivanov et al., 2014). The 2011 earthquake at Fukushima (contributor of metallic paint to global supply chain) and 2011 flood in Thailand (contributor of computer chips to global supply chain) disrupted production within a small geographic and economic area but put its magnified and rippling effect on other economies as such production was highly critical to the global supply chain. Hence, Wuhan, being a crucial industrial centre in the global map, has affected the global supply chain. Further, as the spread of the contagion has covered almost the entire world, it is presumed to have affected the global supply chain, which in turn must have affected the real markets and financial markets around the world. Goodell (2020), in his recent study, presented extensive literature on the economic consequences of natural disasters such as nuclear war and local disaster or climate change and reported that Covid-19 pandemic is creating a never experienced global economic losses. In this regard, a thorough analysis of the economic consequences of the Covid-19 pandemic in terms of exchange rate behaviour is the context of this study.

The analysis of exchange rate behaviour requires establishing the link between the effect of the Covid-19 pandemic and the theoretical underpinnings of the exchange rate behaviour. There are several theories that explain the behaviour of the exchange rate. The rational expectation theory of Muth (1961) states that people's expectations of what will happen in the future cause a change in the value of the underlying assets. So, the current expectation of the people about the exchange rate movement has the potential to drive the exchange rate in the future (MacDonald & Taylor, 1992). The

happening of unprecedented events alters the people's expectations and the exchange rate (Frenkel, 1981). So, Covid-19 being an unprecedented and unexpected event is presumed to affect the global exchange rate.

The efficient market hypothesis of Fama (1970) states that in an efficient forex market, the exchange rate reflects all the information concerning the exchange rate. In line with this, Firoj and Khanom (2018), Makovský (2014), Wickremasinghe (2008), and Frenkel (1981) suggest that the exchange rate behaviour is sensitive to available information that determines the efficiency of the forex market. So, the information on the Covid-19 infection and government intervention in terms of the shutdown, lockdown, etc. across the globe influence the people's expectations regarding economic activities, which in turn can affect the exchange rate of the economies. Further, information plays a pivotal role in the construction of optimal portfolios. In this regard, McKinnon's (1969) portfolio balance theory postulates that any economic event has a direct bearing on the asset return, which compels the agents to revise their asset portfolio for optimising the risk-return trade off. This behaviour creates a flucation in the demand and supply of currencies in the international market, which in turn causes varition in the value of currencies (Dooley & Isard, 1983; Khan & Abbas, 2015). In an open economy, the value of a currency is greatly influenced by capital flows (Gelman et al., 2015), and any increase and decrease in the interest rate cause a change in capital flow, leading to exchange rate fluctuation, which is termed as 'interest rate parity' (Aref-Adib & Martin, 2020). Further, the inflow of capital causes appreciation of home currency under a flexible exchange rate system. However, under a fixed exchange rate system, the inflow of capital translates into an inflationary rise of the money supply via the central bank's intervention (Islami & Welfens, 2013). During Covid-19, the governments of many countries have increased the money supply by changing monetary policy to counter the negative consequence of Covid-19 (Aref-Adib & Martin, 2020). But the change in money supply and the change in the prices in the goods market do not move at the same pace, and such mismatch is immediately reflected in the forex market (Aslam et al., 2020). It is because the exchange rate reacts much faster in the short run than goods market, and such overreaction of exchange rate fades out in the long run as promulgated by Dornbusch (1976) in the exchange rate overshooting hypothesis. So, the exchange rate is expected to witness more fluctuation in the initial stage of Covid-19 infection than in later stages. Phan and Narayan (2020) revealed that Covid-19 represents a greater global shock disrupting the economic fundamentals of nations across the globe leading to variation in demand and supply of currencies and exchange rate. Such variation in demand and supply of a particular country's currency emerges from the balance of payment (BOP) condition as proposed in the BOP theory of exchange rate of Allen and Kenen (1980). The above discussion concerning theories of exchange rate and Covid-19 scenario provides a detailed understanding as to how the shocks brought about by the Covid-19 pandemic have led to economic disruption and the channels though which Covid-19 can affect the exchange rate.

2.2 Empirical Studies on Covid-19 and Exchange Rate

Since the introduction of the floating exchange rate system in 1973, the currency value of any economy depends on its macroeconomic fundamentals. In the world of globalization, every economy is interconnected, thereby creating inter-dependency and a network of economies. This inter-connectivity among the economies creates an interplay between the demand and supply of currency in the foreign exchange market, which determines the exchange rate among the currencies (Bhanumurthy, 2006). In this context, a good number of works are available on factors affecting the exchange rate of the economies. The factors like net trade, the balance of payment, productivity growth, net capital flow, net foreign assets position, relative price level, interest rate, output, money supply, national income, portfolio preference, assets supplies, current account developments, and oil prices, among several other relative economic variables, are the prominent factors affecting the exchange rate (Bacchetta & Wincoop, 2006; Frankel, 1992; Stockman, 1980; Bhanumurthy, 2006; Tronzano, 2001; Heller, 1978; Bergstrand, 1991; Chinn, 2006). So, the exchange rate of a country is a function of the state of the countries' economy in relation to its global counterparts (Devpura, 2021; Duro et al., 2020). Prior studies by Narayan et al. (2018) have documented a plausible impact of unforeseen events like the terrorist attack on the economy and the exchange rate of various countries where some countries' currencies appreciated, while some currencies depreciated in response to such an event. In line with this, Covid-19 being an unforeseen event has drawn the attention of many researchers to gauge its economic consequences. Nwosa (2021) documents that Covid-19 has more adverse effects on the economy and market than the 2009 and 2016 global recession. Gietel-Basten (2020) find a more significant effect of Covid-19 on the global economy in the form of distortion in the international labour migration that affects the remittance flow among the countries. Venkatachary et al. (2020) report severe economic fallout across the globe due to Covid-19 pandemic. Zekra (2020) documents that Covid-19 has destroyed the global economy. In Romania's context, Serbanel (2020) demonstrates that the Covid-19 pandemic has severely affected the Romanian economy, particularly the health business, labour market, and households. Further, due to its massive effect on a large segment of the European economy and disruption in global supply and trade balance, there is a likely global recessionary situation. Akinsanmi (2020), in a study on China, Germany, UK, and US, reports that Covid-19 has negatively affected the ability of the people to contribute to the economic activities, which in turn has created economic instability and economic distortions.

The economic distortions caused by the pandemic can be broadly categorized into demand shock, supply shock, and financial shock. All these shocks have the potential to affect the macroeconomic fundamentals of the economy, including the exchange rate. De and Sun (2020) opined that the exchange rate serves as both a shock absorber and a source of shock. The empirical result of Camba and Camba (2020) reveals that Co-

vid-19 daily infection has a negative impact on the peso/dollar exchange rate in the Philippines, and Iqbal et al. (2020) report a negative impact of the Covid-19 breakout on the exchange rate of China. Rietz (1988), Barro (2006), Berkman et al. (2011), and Farhi and Gabaix (2016) have developed different models of the exchange rate in which the possibility of rare but extreme disaster is a prominent factor affecting the movements of exchange rates. Sharma et al. (2021), and Ozturk and Cavdar (2021) identified that exchange rate fluctuation tends to increase due to shutdowns amid Covid-19. Covid-19 has changed the determinants of the Euro/USD exchange rate and made the exchange rate more volatile (Konstantakis et al., 2021). There is a co-movement between Covid-19 cases and the exchange rate, and the impact of the pandemic on the exchange rate is significant and long-term in nature (Sharma et al., 2021). Iyke (2020b) identifies Covid-19 as a new determinant of the exchange rate. Narayan (2020) reveals that the Covid-19 pandemic has a temporary effect on the shock to the Yen-US exchange rate. However, Sharma et al. (2021) find a significant and long-term impact of the pandemic on the exchange rate, suggesting a contradiction and asymmetric effect of Covid-19 on the exchange rate. Hence, there is a strong reason to appreciate the fact that the pandemic has directly affected the economic fundamentals, financial markets, and exchange rate of the affected economies.

Hacche (1983) opined that the demand and supply condition in the foreign exchange market depends on the state of financial and real markets, which in turn are affected by the exchange rate. However, fluctuation in exchange rate raises the chances of financial market risks and foreign investment uncertainty (Byrne & Davis, 2005; Devereux, 2004), and the exchange rate affects the stock market performance during the pandemic period (Nwosa, 2021). Exchange rate uncertainty creates inflation uncertainty, which affects individuals' consumption decisions (Alexander, 1952; Iyke & Ho, 2020). So there is a complex and vicious circle among the various other macro-economic variables and exchange rates. The efforts of the government to contain the spread of the Covid-19 virus like lockdown, shutdown, suspension of movement of people and goods became more intensive and stringent with the increase in daily confirmed cases and deaths, which made the economic distortion more aggravated at national as well as the global level (Gopinath, 2020). The government's intervention in terms of policy response such as income support fiscal measures, international aids, etc. has resulted in exchange rate volatility but not the rise of Covid-19 confirmed cases (Feng et al., 2021). Farhi and Gabaix (2016) opined that the country's exposure to the disaster risk is different and time-varying. Aloui (2021) reveals that during Covid-19, the effect of monetary policy intervention by the Eurozone government in the form of Quantitative Easing on the Euro/USD exchange rate varies over time.

Islami and Welfens (2013) show that stock market dynamics also affect exchange rate because domestic stock market performance in comparison to other stock markets causes inflow and outflow of capital, leading to the fluctuation in the exchange rate. In this regard, on studying how the real effect of Covid-19 gets amplified through financial

channels, Ramelli and Wagner (2020) document that investors remain bearish to US stocks with exposure to China and the international market. However, with improvement in the situation in China as compared to Europe and the US, investors turned positive to US stocks. Ashraf (2020) studied the stock market response of 64 countries to the Covid-19 and established an adverse and asymmetric reaction of stocks across the globe to Covid-19, which is a fundamental reason for investors to reconstruct their portfolios. As a result, there is fluctuation in the demand and supply of currencies in the foreign exchange market resulting in variation in the exchange rate. Hoshikawa and Yoshimi (2021) demonstrate that an increase in Covid-19 infection leads to a rise in stock market volatility and a decrease in foreign investors' holdings, which gives rise to a reduction in the value of the domestic currency. The increased attention of investors to Covid-19 influences stock return and volatility (Iyke & Ho, 2021). Rai and Garg (2021) opine that the volatility spillover between the stock market and exchange rate return is dynamic and negative during Covid-19 in BRIICS economies. It implies that a decrease in stock market return translates into an increase in the exchange rate. Further, such an effect is more prominent during the initial lockdown period than the later periods.

The above literature clarifies that though several studies have been undertaken to reveal the impact of Covid-19 on various aspects of the economy, the literature on the effect of Covid-19 on the exchange rate is very scant, and the existing shreds of evidence are limited to a specific country. Further, the impact of Covid-19 on exchange rate due to change in time and level of economic development of countries is unheeded in prior works. Hence, in the above backdrop, this study aims to examine the exchange behaviour amidst the Covid-19 situation by revealing the effect of daily Covid-19 confirmed cases, death cases, and WPUI created due to Covid-19 on the exchange rate with a sample of 37 countries over a period from 4th January 2020 to 30th April 2021.

The study is unique and adds to the existing knowledge base in three ways: Firstly, we provide more insight into the studies, like Rietz (1988), Barro (2006), Farhi and Gabaix (2016), and Iqbal et al. (2020), examining the effect of the different disaster on the exchange rate of the countries. Secondly, we add to the recently evolving literature examining the impact of Covid-19 on the economy, such as J. Abel and Gietel-Basten (2020), Venkatachary et al., (2020), Zekra (2020), Cerami et al., (2020), Serbanel (2020), and Akinsanmi (2020). Thirdly, we contribute to the existing stock of literature in terms of the asymmetric effect of Covid-19 on the exchange rate owing to time and economies.

3. Methodology

3.1 Data and Sample

We constructed the sample by gathering data on the number of daily Covid-19 confirmed cases and death cases from the website of WHO. The data set starts from 4th

January 2020 and ends on 30th April 2021. We also collected data on WPUI[4] over the sample period constructed by Ahir et al. (2018). We included such an index as *pandemic has impacted societies both in terms of economic and psychological front and created many uncertainties such as trade, social, cultural, and financial market uncertainties* (Lazzerini & Putoto, 2020; Ho & Gan, 2021; Iyke, 2020a). The daily confirmed cases, daily deaths, and WPUI of respective sample countries are taken as independent variables, while the daily confirmed cases, daily deaths, and WPUI of the USA are considered as control variables to capture the impact of the USA Covid-19 situation on the exchange rate. Further, we collected data on the nominal effective exchange rate for each country against the US dollar from the website of IMF (International Monetary Fund). We took the exchange rate of each sample country against the US dollar as the US dollar plays a special role in international financial markets for international payments and settlements (Rebucci et al., 2021).

We adopted several criteria to filter the data. We removed those countries for which daily Covid-19 confirmed cases, death cases, WPUI data, and exchange rate data were not available. Lastly, we gathered data on the globalization index as a country-level control variable from the KOF Index of Globalization published by the KOF Swiss Economic Institute. It counts for the cross-country difference in the level of economic, social, and political integration with the rest of the world. After applying the filter criteria, we ended up with a sample of 37 countries. Further, we removed days with missing figures because though Covid-19 confirmed and death cases data are available for each day, the exchange rate data are unavailable for weekends and holidays. Finally, our dataset consists of 37 countries with 10,002 observations from 4th January 2020 to 30th April 2021.

TABLE 1. **Information on Sample Countries**

Sl. No.	Country	Status of Economy*	Date of 1st Covid-19 Confirmed Case**
1	Algeria	Emerging	25-02-20
2	Australia	Advanced	25-01-20
3	Botswana	Emerging	01-04-20
4	Brazil	Emerging	26-02-20
5	Brunei Darussalam	Emerging	10-03-20
6	Canada	Advanced	26-01-20
7	Chile	Emerging	03-03-20

[4] https://worlduncertaintyindex.com/data/
"The WPUI is formulated by taking the number of times the word uncertainty is written within a proximity to a word related to pandemic in the Economist Intelligence Unit country reports. A higher value of the index implies higher uncertainty due to pandemics and vice versa".

Sl. No.	Country	Status of Economy*	Date of 1st Covid-19 Confirmed Case**
8	China	Emerging	04-01-20
9	Colombia	Emerging	06-03-20
10	Czechia	Advanced	02-03-20
11	Denmark	Advanced	27-02-20
12	India	Emerging	30-01-20
13	Israel	Advanced	22-02-20
14	Japan	Advanced	14-01-20
15	Republic of Korea	Advanced	19-01-20
16	Kuwait	Emerging	24-02-20
17	Malaysia	Emerging	25-01-20
18	Mauritius	Emerging	18-03-20
19	Mexico	Emerging	28-02-20
20	New Zealand	Advanced	28-02-20
21	Norway	Advanced	26-02-20
22	Oman	Emerging	24-02-20
23	Peru	Emerging	07-03-20
24	Philippines	Emerging	30-01-20
25	Poland	Emerging	04-03-20
26	Qatar	Emerging	29-02-20
27	Russian Federation	Emerging	02-03-20
28	Saudi Arabia	Emerging	02-03-20
29	Singapore	Advanced	23-01-20
30	South Africa	Emerging	05-03-20
31	Sweden	Advanced	31-01-20
32	Switzerland	Advanced	24-02-20
33	Thailand	Emerging	13-01-20
34	Trinidad and Tobago	Emerging	13-03-20
35	United Arab Emirates	Emerging	29-01-20
36	The United Kingdom	Advanced	01-02-20
37	Uruguay	Emerging	15-03-20

*Source: *International Monetary Fund, **World Health Organization.*

3.2 Model Specification

To study the effect of confirmed Covid-19 cases, death cases, and WPUI on exchange rate behaviour, we performed a panel data analysis. We resort to panel data analysis technique over event study technique as first; the spread of Covid-19 is not a one-point happening, rather, it spreads over days in a country. Second, panel data has the edge of capturing the time-varying effect of the independent variable on the dependent variable. Third, panel data considers the variation in variables arising from cross-sectional units and time, and minimizes multicollinearity (Koop & Steel, 2001), unobservable heterogeneity (Hsiao, 2003; Moulton, 1986), heteroscedasticity, and estimation bias (Baltagi, 2008; Wooldridge, 2010). Panel diagnostic test has been undertaken to choose a more consistent model among ordinary least squares (OLS), fixed effect (FE), and random effect (RE) models. The result of the Hausman test (see Appendix) concludes that the fixed effect model is more consistent for the data.

By using the panel data analysis, we specify 3 separate empirical fixed effect regression models for Confirmed cases, Deaths, and WPUI as follows:

$$Y_{ct} = \alpha + \beta_1 \text{Confirmed Cases}_{ct} + \beta_2 \text{ Control Variables}_{ct} + \gamma_t + \varepsilon_{ct-} \quad (1)$$

$$Y_{ct} = \alpha + \beta_1 \text{Deaths}_{ct} + \beta_2 \text{ Control Variables}_{ct} + \gamma_t + \varepsilon_{ct-} \quad (2)$$

$$Y_{ct} = \alpha + \beta_1 \text{WPUI}_{ct} + \beta_2 \text{ Control Variables}_{ct} + \gamma_t + \varepsilon_{ct-} \quad (3)$$

where,

c = Cross-sectional unit, i. e., country;

t = Time dimension, i. e., each day;

Confirmed Cases= Number of persons tested positive for Covid-19;

Deaths= number of persons who died of Covid-19;

WPUI= Uncertainty created in a country due to Covid-19.

Control variables include USA Daily Confirmed Cases, USA Daily Deaths, USA WPUI, and the Globalization index of each country.

γ_t = Daily fixed effects;

ε_{ct} = Error term.

The 3 models specified above are used for measuring the impact of Covid-19 on the exchange rate behaviour for the whole sample, which has been reported in Table 4. Further, the same models were also used for sub-sample analysis to measure the impact of Covid-19 on exchange rate behavior over time and economies, reported in Table 5 and Table 6, respectively.

We have taken daily confirmed cases and daily deaths as a proxy for Covid-19, as the prevalence and spread of the pandemic is visible through the number of people tested positive for Covid-19 and the number of people who died of Covid-19 (Ashraf, 2020). WPUI is also another proxy of Covid-19, as the Covid-19 pandemic is a health-related uncertainty, and it has led to the economic and political uncertainties measured through

WPUI (Ho & Gan, 2021). USA Daily Confirmed Cases, USA Daily Deaths, and USA WPUI are taken as control variables to count for the Covid-19 situation prevailing in the USA. To capture the impact of all economic developments on the exchange rate, we considered the KOF index of globalization as the control variable. This is because globalization is a multidimensional concept encompassing economic, social, and political aspects that go beyond indicators such as trade openness and capital movements (Gygli et al., 2019; Potrafke, 2015). Further, the KOF Index of Globalisation is superior to other measures of Globalization (Potrafke, 2015), and it is the most widely used index in international economic literature (Eppinger & Potrafke, 2016; Osterloh, 2012; Quinn et al., 2011; Villaverde & Maza, 2011).

4. Empirical Results

This section provides the empirical results consisting of summery statistics, correlation matrix and regression evidence.

Summary Statistics

TABLE 2. **Summary Statistics**

Variables	Mean	Minimum	Maximum	Std. Dev.
Exchange Rate/USD	174.730	0.081	4153.900	630.260
Daily Confirmed Cases	3967.600	0.000	386450.000	14467.000
Daily Deaths	91.341	0.000	4195.000	265.410
WPUI	24.574	1.851	90.768	20.463
USA Daily Confirmed Cases	66390.000	0.000	299560.000	59681.000
USA Daily Deaths	1117.000	0.000	6409.000	918.500
USA WPUI	11.227	7.272	43.573	10.955
Globalization Index	74.627	55.950	91.190	9.520

Source: Authors' calculation.

Table 2 reports the summary statistics of the variables taken in this study. The exchange rate results indicate a considerable variation in the exchange rate of different countries against the USD and signal asymmetry in countries' economic growth and economic fundamentals across the globe. The result of daily confirmed cases, daily deaths, and WPUI document that there is higher variation in daily confirmed cases than daily deaths and WPUI across the countries, which shows an asymmetric spread of Covid-19 daily infection across the globe.

Correlation Matrix

TABLE 3. **Correlation Matrix**

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Exchange Rate/ USD	1							
(2) Daily Confirmed Cases	0.095	1						
(3) Daily Deaths	0.086	0.736	1					
(4) WPUI	-0.134	-0.017	-0.078	1				
(5) USA Daily Confirmed Cases	-0.014	0.093	0.100	-0.131	1			
(6) USA Daily Deaths	0.001	0.049	0.101	-0.083	0.630	1		
(7) USA WPUI	0.016	-0.094	-0.114	0.180	-0.373	-0.392	1	
(8) Globalization Index	-0.129	-0.152	-0.157	-0.073	-0.022	-0.023	0.051	1

Source: Authors' calculation.

Table 3 reports the Pearson's correlation matrix among variables under study. The correlation coefficient ranges from 0.001 to 0.736, which signifies the absence of collinearity among the variables (Gujarati, 2004). Further, we check multicollinearity by using variance inflation factor (VIF). The highest VIF is 2.717, which states that multicollinearity is not present among the variables (Chatterjee & Hadi, 1977; O'Brien, 2007).

Impact of Covid-19 on Exchange Rate

Table 4 reports the results of the regression measuring the effect of Covid-19 daily confirmed cases, daily deaths, and WPUI on exchange rate behaviour. The exchange rate is taken as the dependent variable and is measured as each country's exchange rate against the USD. Daily confirmed cases, daily deaths, and WPUI are taken as the measure for Covid-19. The USA daily confirmed cases, USA deaths, and USA WPUI count for the Covid-19 situation in the USA. KOF Index of Globalization counts for the cross-country difference in the extent of economic integration with the rest of the world. T statistics are reported in parentheses. *, ** and *** indicate statistical levels of significance at 10%, 5%, and 1% respectively.

The results presented in Table 4 show a positive effect of daily confirmed cases and daily deaths on the exchange rate, which indicates that the currency of other countries against the USD has weakened due to economic disruption caused by the Covid-19 pandemic. This results confirm the rational expectation hypothesis of the exchange rate. However, the WPUI has an insignificant impact on the exchange rate, indicating

TABLE 4. **Impact of Covid-19 on Exchange Rate Behaviour**

Variables	Daily Exchange Rate against USD		
Daily Confirmed Cases	0.001***		
	(4.298)		
Daily Deaths		0.001***	
		(2.977)	
WPUI			-0.001
			(-0.127)
USA Daily Confirmed Cases	-0.001		
	(-0.944)		
USA Daily Deaths		-0.001	
		(-0.929)	
USA WPUI			0.001
			(0.928)
Globalization Index	0.009***	0.009***	0.009***
	(11.11)	(10.52)	(11.62)
Daily fixed-effects	Yes	Yes	Yes
Intercept	1.549***	1.567***	1.479**
	(20.77)	(20.59)	(23.14)
Observations	10002	10002	10002
Adjusted R^2	0.154	0.153	0.153

Source: Authors' calculation.

that with the increase in uncertainty of the respective countries, their currencies did not see any significant change in the value against the USD. It means that the exchange rate market is responsive to the incidence of Covid-19 confirmed cases and deaths but not to the incidence of uncertainty created due to the pandemic. This result goes in line with the findings of Duro et al. (2020) and contradicts the result of Camba and Camba (2020). This result also supplements the studies by Sharma et al. (2021) and Chang et al. (2021) measuring the effect of Covid-19 on exchange rate fluctuation. Looking at the macroeconomic measurement, i. e., globalization index, we can infer that currencies of more globalized countries have depreciated more as the incidence of Covid-19 spread across the globe due to the interlinking of the economies.

Impact of Covid-19 on Exchange Rate Behaviour over Time

To get insight into the impact of Covid-19 on the exchange rate over time, the entire data set was classified into 3 different phases. We considered the first 100th case of each country as the first phase because at the initial stage of the Covid-19 spread, there were no stringent restrictions by the governments on the movement of people and economic activities. Hence, such period is considered as a unique phase. This classification goes in line with Phan and Narayan (2020). After the 100th case, an alarming situation was

created in every country; as a result, the governments resorted to several measures such as shutdown, lockdown, social distance, suspension of movement of people, etc., to contain the spread of the virus, and such measures were continued for one month in most of the countries in the globe (Oxford Covid-19 Government Response Tracker, BBC Research 2020)[5]. Hence, we classified one month following the first 100th case as the second phase. Further, after the 30 days following the first 100th case, the countries witnessed an exponential growth in the spread of the Covid-19 virus. Hence, we classified the remaining period after 30 days of the 100th case, i. e., till 30th April 2021, as the third phase.

TABLE 5. **Impact of Covid-19 on Exchange Rate Behaviour over Time**

Variables	Daily Exchange Rate against USD								
	First Phase			Second Phase			Third Phase		
Daily Confirmed Cases	0.044***			0.003***			0.001**		
	(3.21)			(5.21)			(2.28)		
Daily Deaths		0.001			-0.001**			0.001	
		(0.24)			(-2.04)			(0.27)	
WPUI			-0.011***			-0.001			0.001
			(-3.093)			(-1.02)			(0.60)
USA Daily Confirmed Cases	-0.001			-0.001			-0.001***		
	(-0.20)			(-0.24)			(-2.95)		
USA Daily Deaths		0.001			-0.001			-0.001***	
		(0.20)			(-0.19)			(-2.84)	
USA WPUI			0.149*			-0.031			0.223**
			(1.778)			(-0.97)			(2.10)
Globalization Index							.006***	0.006***	0.006***
							(8.81)	(8.70)	(9.02)
Daily fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	1.874 ***	1.856***		2.290***	2.612	1.759	1.755*	1.747***	0.115
	(12.45)	(53.84)	(0.309)	(24.18)	(1.44)	(0.661)	(31.10)	(30.18)	(0.15)
Observations	605	605	605	696	696	696	8690	8690	8690
Adjusted R^2	0.354	0.340	0.304	0.204	0.172	0.168	0.191	0.190	0.190

Source: Authors' calculation.

[5] https://www.bbc.com/news/world-52103747

Table 5 demonstrates the results of the regression measuring the impact of Covid-19 daily confirmed cases, daily deaths, and WPUI on the exchange rate over time. The exchange rate is taken as the dependent variable and is measured as each country's exchange rate against the USD. Daily confirmed cases, daily death, and WPUI are taken as the measure for Covid-19. The USA daily confirmed cases, USA deaths, and USA WPUI count for the Covid-19 situation in the USA. KOF Index of Globalization counts for the cross-country difference in the extent of economic integration with the rest of the world. In our data classification, there is variation in the length of each phase, and the first two phases belong to the same year, while the third phase belongs to two different years. Hence, being an annual data, the globalization index remains the same for the first and second phase and remains different for the third phase. As a result, the effect of the globalization index was omitted in the first and second phases because of fixed-effects use within estimator for demeaning the data. However, the effect of globalization was reported for the third phase. Statistics are reported in parentheses. *, ** and *** indicate statistical significance levels at 10%, 5%, and 1% respectively.

The regression evidence presented in Table 5 shows that daily confirmed cases remain positive and significant in all the phases, which corroborates with the findings of Duro et al., (2020) and contradict the results of Camba and Camba (2020). It is also observed that the impact of daily confirmed cases is more pronounced in the first phase than in the second and third phases. Death remains insignificant in the first and third phases while negatively affecting the exchange rate only in the second phase. The effect of WPUI remains negative in the first phases implying an appreciation in the currency of sample countries due to uncertainties. However, the impact of WPUI becomes insignificant in the later phases. The results show that all the Covid-19 proxies influence the exchange rate asymmetrically both in degree and direction. More specifically, though the increase in daily confirmed cases leads to depreciation in the value of the currencies in all the phases, such depreciation is more pronounced in the first phase and fades out gradually over later phases. Similarly, death cases also have a time-varying impact on the exchange rate, which appreciated in the second phase. In contrast, the exchange rate did not see significant changes in the first and third phases due to daily deaths. Further, WPUI exhibits an appreciation in the exchange rate during the first phase, while such an effect is absent in the later phases. So, the above ambivalent results evidence that Covid-19 exerted an asymmetric impact on exchange rate behaviour over time. This phenomenon agrees with Dornbusch's exchange rate overshooting hypothesis that the exchange rate reacts more in the initial stage of an event, and gradually the reaction fades out. It also corroborates the Farhi and Gabaix (2016) revelation that the country's exposure to the disaster risk is different and time-varying.

Impact of Covid-19 on Exchange Rate Behaviour of Economies

Though Covid-19 pandemic was first detected in one of the emerging nations, at the initial period, its spread was rampant in developed nations, and later on, it spread

TABLE 6. **Impact of Covid-19 on Exchange Rate Behaviour of Economies**

Variables	Daily Exchange Rate against USD					
	Emerging Economies			Advanced Economies		
Daily Confirmed Cases	0.001***			0.001***		
	(3.80)			(2.79)		
Daily Deaths		0.001***			0.001*	
		(2.28)			(1.67)	
WPUI			0.002***			-0.001***
			(9.37)			(-9.32)
USA Daily Confirmed Cases	-0.001**			-0.001***		
	(-2.52)			(-2.73)		
USA Daily Deaths		-0.001**			-0.001**	
		(-2.56)			(-2.33)	
USA WPUI			0.002			0.001
			(0.00)			(0.00)
Globalization Index	0.009***	0.009***	0.010 ***	0.014 ***	0.014***	0.009***
	(12.51)	(11.80)	(13.75)	(3.75)	(3.63)	(2.63)
Daily fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	1.883***	1.902***	1.792	0.550 *	15.388***	0.906
	(34.91)	(33.95)	(0.00)	(1.74)	(6.975)	(0.00)
Observations	6177	6117	6117	3761	3761	3761
Adjusted R^2	0.210	0.296	0.219	0.123	0.121	0.141

Source: Authors' calculation.

over emerging nations. This difference in the spread of the pandemic was accentuated through differences in the economic fundamentals of the countries. Such differences can be witnessed in the form of population density, economic growth, industrialization, ease of doing business, technological advancement, the standard of living, infrastructure, the balance of payment, growth of GDP, fiscal discipline, consumer market, financial system (Awan & Khan, 2015), unemployment rate, public debt (IMF, 2010), demographic dividend (Hagemann & Nicoletti, 1988), health care system and life expectancy (Minois, 1989), etc. So there is a logical stand to believe that there is an asymmetric effect of the pandemic on both emerging and advanced economies. The hypoth-

esized asymmetric effect is reflected in Table 5, showing the impact of Covid-19 daily confirmed cases, daily deaths, and WPUI on the exchange rate. The exchange rate is taken as the dependent variable and is measured as each country's exchange rate against the USD. Daily confirmed cases, daily death, and WPUI are taken as the measure for Covid-19. The USA daily confirmed cases, USA deaths, and USA WPUI count for the Covid-19 situation in the USA. KOF Index of Globalization counts for the cross-country difference in the extent of economic integration with the rest of the world. T statistics are reported in parentheses. *, ** and *** indicate statistical levels of significance at 10%, 5%, and 1% respectively.

The regression evidence presented in Table 6 shows that daily confirmed cases and daily deaths positively affect the exchange rate of both emerging and advanced economies. It means the economic dislocations triggered by the pandemic in terms of confirmed cases and deaths have led to depreciation in the currency value irrespective of economies. However, the impact of WPUI is positive in the emerging economy, but negative in the case of advanced economies. It implies that with the growth of intensity of the pandemic uncertainty, the currency value of advanced economies has gained. In contrast, the currency value of emerging economies has weakened, which exhibits a difference in the effect of WPUI on exchange rate behaviour. Looking at the severity of the impact of WPUI, our finding aligns with the work of Devpura (2021) that the effect of Covid-19 is less on developed economies than emerging economies. So we can conclude that pandemic has an asymmetric impact on the currency value of emerging and advanced economies in terms of pandemic induced uncertainty.

5. Conclusion

In our attempt to examine the effect of Covid-19 on exchange rate, the study reveals that daily confirmed cases and daily deaths positively affect the exchange rate. It means that the currency of other countries has weakened against USD in response to daily confirmed cases and daily deaths due to the Covid-19 pandemic. However, the uncertainty created due to Covid-19 pandemic does not significantly affect the exchange rate. Further, the study demonstrates an asymmetric effect of Covid-19 in terms of daily confirmed cases, daily deaths, and WPUI on exchange rate owing to the time, where the impact of daily confirmed cases is more pronounced in the first phase than the later phases. The daily deaths have a negative effect on the exchange rate only in the second phase, but the effect is absent in the first and third phases. The WPUI has a negative impact in the first phase but does not have a significant impact in the second and third phase, which means that in the initial stage of the Covid-19 spread, the currency of other countries against the USD had appreciated, but afterward, the exchange rate became irresponsive to the WPUI. As far as the asymmetric effect of Covid-19 on the exchange rate of advanced and emerging economies is concerned, the study reveals that the currency of both emerging and advanced economies has witnessed significant deprecia-

tion against the USD due to Covid-19 daily confirmed cases and daily deaths. Further, due to uncertainty created out of Covid-19, emerging economies' currency has depreciated, while the currency of advanced economies has appreciated. Finally, the study concludes that the economic consequences of the Covid-19 pandemic are uneven in terms of daily confirmed cases, daily deaths, and WPUI. Further, such consequences are also uneven owing to the timeframe and level of economic development of the countries. The outcome of this study will help the policymakers of different economies in devising suitable economic policy interventions by which the negative consequence of Covid-19 on the economy, more specifically on the exchange rate, can be mitigated.

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Appendix

TABLE A1. **Hausman Test Results for Selection of Models**

Model		Hausman test statistic	Selection of Model (FE /RE)
Impact of Covid-19 on Exchange Rate Behaviour			
	Impact of Daily Confirmed Cases on Exchange Rate	H = 2.76885 with p-value = prob. (chi-square (3) > 2.76885) = 0.428653	FE Model
Overall Analysis	Impact of Daily Deaths on Exchange Rate	H = 1.37162 with p-value = prob. (chi-square (3) > 1.37162) = 0.7122	FE Model
	Impact of WPUI on Exchange Rate	H = 2.18319 with p-value = prob. (chi-square (3) > 2.18319) = 0.535268	FE Model
Impact of Covid-19 on Exchange Rate Behaviour over Time			
First Phase	Impact of Daily Confirmed Cases on Exchange Rate	H = 9.96236 with p-value = prob. (chi-square (2) > 9.96236) = 0.00686596	FE Model
	Impact of Daily Deaths on Exchange Rate	H = 6.01013 with p-value = prob. (chi-square (2) > 6.01013) = 0.0495356	FE Model
	Impact of WPUI on Exchange Rate	H = 5.02012 with p-value = prob. (chi-square (2) > 5.02012) = 0.0395346	FE Model
Second Phase	Impact of Daily Confirmed Cases on Exchange rate	H = 7.24323 with p-value = prob. (chi-square (2) > 7.24323) = 0.0267395	FE Model
	Impact of Daily Deaths on Exchange rate	H = 0.331746 with p-value = prob. (chi-square (2) > 0.331746) = 0.847154	FE Model
	Impact of WPUI on Exchange rate	H = 3.12454 with p-value = prob. (chi-square (2) > 3.12454) = 0.20966	FE Model

Model		Hausman test statistic	Selection of Model (FE /RE)
Third Phase	Impact of Daily Confirmed Cases on Exchange Rate	H = 7.34963 with p-value = prob. (chi-square (3) > 7.34963) = 0.0615507	FE Model
	Impact of Daily Deaths on Exchange Rate	H = 1.43081 with p-value = prob. (chi-square (3) > 1.43081) = 0.698329	FE Model
	Impact of WPUI on Exchange Rate	H = 1.9418 with p-value = prob. (chi-square (3) > 1.9418) = 0.584574	FE Model
Impact of Covid-19 on Exchange Rate Behaviour of Economies			
Emerging Economies	Impact of Daily Confirmed Cases on Exchange Rate	H = 1.53492 with p-value = prob. (chi-square (3) > 1.53492) = 0.674234	FE Model
	Impact of Daily Deaths on Exchange Rate	H = 2.34138 with p-value = prob. (chi-square (3) > 2.34138) = 0.50464	FE Model
	Impact of WPUI on Exchange Rate	H = 0.492556 with p-value = prob. (chi-square (3) > 0.492556) = 0.920524	FE Model
Advanced Economies	Impact of Daily Confirmed Cases on Exchange Rate	H = 1.56398 with p-value = prob. (chi-square (3) > 1.56398) = 0.667583	FE Model
	Impact of Daily Deaths on Exchange Rate	H = 2.04598 with p-value = prob. (chi-square (3) > 2.04598) = 0.562918	FE Model
	Impact of WPUI on Exchange Rate	H = 3.55574 with p-value = prob. (chi-square (3) > 3.55574) = 0.313604	FE Model

Source: Author's own calculation.

Note. A low p-value counts against the null hypothesis that the random effects model is consistent, in favour of the fixed effects model.