RIETI Discussion Paper Series 22-E-001

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Research Institute of Economy, Trade & Industry, IAA

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https://www.rieti.go.jp/en/

RIETI Discussion Paper Series 22-E-001
January 2022

Tracking Exchange Rate Determinants amid the Pandemic*

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Abstract

This paper investigates how exchange rate determinants and channels changed during the COVID-19 crisis. Compared to the Global Financial Crisis and non-crisis periods, the smaller interest rate differentials among major economies and large shocks to the real economy shed light on the importance of trade channels, while the impacts on the movements of the exchange rate through the portfolio investment channel appear to be smaller. Daily activity indexes developed from high frequency datasets including web-search data and electricity demand are used to track the movements of the exchange rate. After controlling interest rates and risk factors, the business activity of the home country and overseas are significantly associated with the exchange rate movement for the majority of the economies during the pandemic, though the directions of impacts are different between advanced and emerging economies. Higher safe haven demand tends to appreciate the yen during a crisis, but the effects via trade channels partially offset safe-haven effects, which is associated with the relatively stable yen amid the pandemic. The effects via trade channels could support a faster recovery of Japan's exports after the pandemic ends.

Keywords: Covid-19, Safe-haven Currency, Trade, High-Frequency Data
JEL classification: E44; F31; G15

* This study is conducted as a part of the Project "Exchange Rates and International Currency" undertaken at Research Institute of Economy, Trade and Industry (RIETI). The views expressed here are solely the responsibility of the author and do not necessarily reflect the views of the Bloomberg L.P. and the Bloomberg Economics.

1. Introduction

This paper tries to investigate how driving factors of foreign exchange (FX) rates have been changing overtime, particularly during the pandemic compared to the past financial crisis. A big question is why the yen's move was relatively stable under uncertainty during the Covid -19 Crisis, which tends to appreciate during the risk-off episodes due to the safe-haven currency demand that rewinds carry trade.

Financial indicators –interest rates and financial volatility indexes– tend to move first, capturing news, risks, and uncertainty, based on the market risk appetite, increasing the importance of the portfolio investment channel (Table 1). The foreign exchange rates are also incorporated with economic indicators such as industrial production, trade, employment, and business sentiment data, but the exchange rate changes only when the data is surprising (i.e., the outcome is out of the consensus of the market participants) because the exchange rate has already reflected the market expectation of the data.

A key difference between the financial data and the economic data was frequency and timeliness. The financial data is available in real-time as long as the market is open, so investors immediately capture financial market activities. However, the announcement of economic data is usually unavailable in real-time. It's often lagged for a week, or even much longer. During the financial crisis, exchange market participants rush to acquire info and move as fast as possible in the same direction. As a result, the FX moves tends to be more sensitive to the high frequent financial data to reallocate their portfolio. That makes financial market activities the exchange rate determinants of short-term fluctuations, while economic activities are usually determinants of medium to long-term equilibrium exchange rates, rather than short-term fluctuations.

This norm could change during the Covid-19 pandemic. The pandemic hit the real

economy severely, while financial institutions were relatively sound because the Covid-19 crisis is not driven by financial markets or financial intermediaries. Moreover, prompt responses from the governments and central banks of major advanced economies eased concerns in financial markets, developing optimism for the outlook. Interest rate differentials among advanced economies became minimal, having smaller impacts on the FX rates as major central banks moved to the same direction— extremely accommodative monetary policy. Business activities in the real economy didn't go in that way. The waves of the new Covid-19 infections almost immediately shaved daily business activities, restricted by the government virus containment measures.

The pace of daily deterioration in economic activity during the pandemic was even faster a monthly change during the normal period. For example, when the Covid-19 outbreak started in China, China's economic activity fell about 15% on January 23, 2020 from the previous day, according to Bloomberg Economics' business activity index (Figure 1). During the global financial crisis, China's industrial production only slowed to a 5.4% rise year on year in November 2008 from a 11.4% increase in September 2008. So, the daily activity moves are big enough to change the exchange rates with a surprise. A sudden contraction in business activities reduced imports and probably increased the significance of trade channel[1,2].

A challenge is how to track the day-to-day change in real business activity. It wasn't trackable in real-time in the past. If no one tracks the data in public, it's hard to change the FX rate right away. But this time the virus infections spread over in the world

[1] Trade related the FX transaction is much smaller than total FX turnovers, which are mostly related to capital flows of investments. Trading in FX markets reached $6.6 trillion per day in April 2019, almost five times from $1.2 trillion yen in 2001 according to the Bank for International Settlement (2019). Global trade (exports) increased to $18.8 trillion yen in 2019, about tripled from $6.1 trillion yen.

[2] This paper's concept of the trade channel includes the indirect impacts from the real economic activities on the exchange rate movement, not limited to the direct impacts though international trade activities.

and new virus cases are reported very quickly – daily or even more frequently. That boosts financial market participants' attention on high frequency data of virus infections and various business activities from web search data to congestion of trains, daily drugstore sales, enhancing the real-time link between the daily business activity and the FX moves.

Based on the high-frequency data, Orlik and van Roye (2020) developed novel data set—daily activity index of 16 countries covering both advanced economies and emerging markets from January 8 until September 30. The new indexes make it available to test how the determinates of exchange rates shifted during the pandemic. This paper developed the empirical model that tracks daily exchange rate percentage change, using four factors: interest rate differentials between home and overseas (U.S.), safe-haven currency effects, a change in home and oversea activities that measure trade effects, and Covid-19 related factors.

The results pointed to the importance of trade effects and some virus-related effects. A change in the daily activities of home and overseas are significantly associated with the exchange rate movement for many of economies. Adding safe-haven currency effects, measured by the equity market volatility indexes, didn't change its significance of daily activities on the FX rates. In contrast, the equity volatility indexes as the proxy of the market uncertainty have smaller impacts on the exchange rate movements during the first stage of pandemic (a period from January 2020 to September 2020) than the Global Financial Crisis of 2008-09, particularly for the emerging markets. The impacts of interest rate differentials between home and overseas weakened during the pandemic, which had bigger impacts on the FX moves aftermath of the Global Financial Crisis, driven by unconventional monetary policies including quantitative easing and the yield curve control. Virus-related factors such as the number of the new virus infection cases

and lockdown conditions (the level of government containment measures) are also associated with the FX moves in some cases, but not as significant as the daily economic activity indexes as people's response to virus infections and law enforcement of virus-related measures vary among countries and areas.

This paper contributes to strands of literature that explain the link between the pandemic and the FX moves, which are extremely limited so far. Its main contributions are: (1) tracking a shift of the FX determinants during the Covid-19 pandemic via portfolio investment channel, compared to the Global Financial Crisis; (2) showing the significance of trade channel for the exchange rate movements, using daily business activities in home and overseas; (3) proving safe-haven effects of the yen remained significant even during the early stage of the pandemic, while its relevance to the emerging markets became much weaker.

Policy implication from the results point to how to incorporate trade channel and portfolio investment channel with exchange rate management and trade policies, based on the stages of the virus-infections and its recovery as the impacts of business activities on the FX moves may shift in transition to post-lockdown period. At the stage of lockdown and early post-lockdown period, the economic recovery is associated with the currency depreciation due to trade channel. In the Japanese yen's case, higher safe haven demand tends to appreciate the yen during a crisis, but the effects via trade channel partially offset safe-haven effects, resulting into with relatively stable yen amid the pandemic. That could support a faster recovery of Japan's exports after the waves of virus infections end.

2. Literature Review

A limited number of papers explain a relationship between the Covid-19 crisis and the exchange rate movement. Liao and Zhang (2020) show the hedging channel of portfolio investments. Investors' desire to hedge exchange rate risk in their net foreign asset positions explains the movements in exchange rates and swap line usage. This hedging channel of exchange rate determination connects exchange rate behavior to countries' external imbalances through the behavior of financial intermediaries, but it's not trade balance in out paper. Daehler, Aizenman, and Jinjarak (2020) focus on relationship between the Covid-19 new cases and Credit Default Swap (CDS). that Covid-19 new mortality and new mortality growth rates are positively associated with Covid-19 CDS residuals in all specifications. While the mortality and mortality growth rates together only explain a small share of the variation in residuals (R-squared of 1.24%), adding the other Covid-19-related variables (mobility index and growth of policy stringency index) increases the explanatory power to 5.3% and further to 19.2% with the inclusion of policy responses and economic fundamentals. Following Daehler et al. (2020), this paper uses daily activity indexes that includes mobility index and also add policy stringency index as explanatory variables in the model.

One way to explain trade channel approach is some similarity to the Fundamental Equilibrium Exchange Rate (FEER), which is called as the Macroeconomic Balance Framework by IMF, though it's medium to long term equilibrium rather than short-term fluctuation of the trade channel in this paper. In this approach, the real exchange rate that is consistent with macroeconomic balance, which is identified as the rate that brings the current account into equality with the underlying or sustainable capital account, where the determinants of both the current and capital account have been set at their full

employment values. Because this approach aims at calculating exchange rates for a particular set of economic conditions, it abstracts from short-run cyclical conditions and temporary factors and focuses on "economic fundamentals," which are identified as those conditions or variables that are likely to persist over the medium term (Clark and MacDonald, 1998). Moreover, Federal Reserve Bank San Francisco (1999) describes how trade imbalance influences on exchange rates. through its effect on the supply and demand for foreign exchange.

Strands of literature focus on interest rates, carry trade, and dollar are significant factors as exchange rate determinants. Since the global financial crisis of 2008-09, however, the investor's risk aversion appetite under uncertainty, gauged by VIX -- Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index options[3], has tended to drive the exchange rate movement. The Japanese yen and the Swiss franc are often cited as a safe-haven currency that tend to appreciate during the risk-off episodes as the uncertainty of economic policy and outlook increase, while the U.S. dollar tended to appreciate with a surge in geopolitical risks in the globe, regarded as the most reliable international currency.

This paper focuses on a shift in effects of interest rate differentials on the exchange rate movement. When the foreign interest rate is higher than the U.S. interest rate, risk-neutral and rational U.S. investors should expect the foreign currency to depreciate against the dollar by the difference between the two interest rates. Therefore, borrowing at home and lending abroad, or vice versa, produces a zero return in excess of the U.S. short-term interest rate. This is known as the uncovered interest rate parity (UIP) condition, and it is violated in the data, except in the case of very high inflation currencies

[3] The VIX, which often referred to as the fear index or the fear gauge, is calculated by the Chicago Board Options Exchange (CBOE), representing the market's expectation of stock market volatility over the next 30-day period.

(Lustig and Verdelhan 2007). In the past data, higher foreign interest rates tend to predict higher excess returns for a U.S. investor in foreign currency markets. However, the development of higher frequency trade instrument may mean rebalancing the currency portfolio is more often. Thus, the day-to-day change in interest rate differentials of currencies rather than the level of their interest rate differentials could be a more important factor to determine the daily returns of exchange rates. In the same context, rather than the level of the uncertainty, a daily change in an uncertainty gauge could play a more vital role to move the exchange rates.

The risk-based interpretation of the carry factor is well known. Verdelhan (2018) added the dollar factor in the risk-based factor model. Masujima (2019b) added another risk factor – uncertainty. The economic source of those global shocks and safe-haven tendency of currencies associated with uncertainty is an open question. The status of safe-haven currencies is traditionally linked to a country that has large current account surplus, low sovereign risks, and/or its high share in trade settlements. This economic fundamentals-based tendency may be shifting to market -driven behavior in the aftermath of the 2008–2009 financial crisis (Masujima 2019a). That could reflect cross-asset correlations broadly rose in the financial crisis, driven by global central bank interdependence and investor risk sentiment.

The safe-haven status may signal in advance shifts in risk appetite in the foreign exchange market. The VIX is often used as the proxy of global financial risk outlook and the gauge of the uncertainty. There are a number of possible explanations for the close relationship between the VIX and the safe-haven behavior of currencies, and in turn the vulnerable behavior of the emerging market currencies. High uncertainty may change exchange rate movements to shocks via two channels – safe-haven effects and interest

rate differential between local and foreign currency. Ismailov and Rossi (2017) suggest that uncovered interest rate parity (UIP) is more likely to hold in low uncertainty environments, relative to high uncertainty ones, based on the assessment of a new exchange rate uncertainty index. Decomposing the uncertainty of a typical forecaster into common and idiosyncratic uncertainty, Ozturk and Sheng (2017) point to persistent effects on economic activity from common uncertainty and short-lived effects from idiosyncratic uncertainty. Despite development of new uncertainty index, the VIX is still reliable and high frequency uncertainty measurement.

The correlation between equity volatility index and the implied volatility of the currency has strengthen since the global financial crisis of 2008-09. Higher volatility in U.S. stocks could affect expectations about the future monetary policy stances of major central banks, resulting in shifts of capital out of dollars and into yen. The safe-haven behavior as well as vulnerable behavior of currencies are common factors responding to a change in global uncertainty, but this tendency doesn't necessarily suit amid the pandemic as lower interest rate differentials reduces the chance of carry trade.

The bottom line is that investors always need a safe-haven to flee from risks. Thus, the safe-haven effects and the Covid-19 conditions likely drives the exchange rate movement. Adding uncertainty, trade, and virus-related measurements in the traditional models may more properly track exchange movement with time-variant betas of FX determinants, captured by interaction terms with crisis dummies. Risk factor models without trade channel may miss a key independent factor in the pandemic crisis context.

3. Data and the Model

3.1. Development of Activity Index and Data

The activity indexes are estimated using a dynamic factor model. This methodology extracts an unobservable latent common factor of the underlying high-frequency data in the spirit of Stock and Watson (2011). The model is estimated with daily figures from Jan. 1, 2020 to September 30, 2020. The high-frequency data has some obvious advantages -- providing a more timely read than traditional data series. It also comes with some caveats. The high weight of travel and mobility indicators may lead to overweighting this type of activity in the index. The index is not fully comparable across countries as we partly use different indicators for different countries. More details of indexes and a complete set of sources is shown in the Appendix.

3.2. The Model

The model consists of three channel of exchange rate determinants: portfolio investment channel, trade channel, and risks factors including safe haven effects and the Covid-19 related factors. The model starts from Verdelhan (2018) that offers a simple portfolio investment model of the contemporaneous regressions of bilateral exchange rates on the interest rate differentials, carry trade and dollar factors. Masujima (2019b) added an uncertainty measurement to the model as the new risk factor associated with the exchange rate movement. I aim to track the exchange rate determinants amid the pandemic. So, business activities in home and overseas as the proxy of demand for exports and imports and the virus-related factors are added in the model. This is new and contributions to the literature above.

Based on the background above, I start from the first empirical model that consists

of three factors related to investment, risks, and trade:

$$\Delta \boldsymbol{s_t} = \boldsymbol{\alpha} + \boldsymbol{\beta}_1 \Delta(\boldsymbol{r_t} - \boldsymbol{r_t^*}) + \boldsymbol{\gamma_1} \Delta(\boldsymbol{VIX_t}) + \boldsymbol{\delta} \Delta(\boldsymbol{Business\ Activity(Home)_t}) + \boldsymbol{\tau} \Delta(\boldsymbol{Business\ Activity(Overseas)_t}) + \boldsymbol{\varepsilon} \quad -(1)$$

where s_t denotes the bilateral exchange rate in home currency per U.S. dollar (Bloomberg Dollar Index in case of the United States), $r_t - r^*$ is the two-year interest rate differential between the home country and the United States (Germany in case of the U.S. is home country) , VIX_t reflects Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index, *Business Activity(Home)t*.is daily activity index of a home country, *Business Activity(Overseas)t* is daily activity index of the world. All the data source is Bloomberg.

The activity index shows the level of activities with scale between 0 and 100 during the pandemic. If the business activity is the same level of the pre-Covid-19 crisis, the index is 100. So, this index is 100 in and before 2019. Stronger business activity in a home country is usually associated with bigger imports, which leads to the trade deficit and thus currency depreciation if the trade channel works. In this case, the expected sign of coefficient ($\boldsymbol{\delta}$) is negative. If the investment channel dominates, weaker home economy provides more investment opportunity – currency depreciation with smaller capital inflows and expected lower yields. Thus, the expected sign of coefficient ($\boldsymbol{\tau}$) is negative. Higher business activity overseas also has the same signs of the coefficient through exports as above.

The VIX is a good measure of global investors' risk sentiment. Increases in the VIX are associated with higher volatility in Japanese and Germany stock prices, as measured by the Nikkei Volatility Index (VI) and VDAX—volatility index of Deutsche Börse DAX, as well as in the yen's exchange rate to dollar. The VIX correlates to the Nikkei VI at 0.83, to the VDAX at 0.87 and to implied volatility on 1-month at-the-money

yen-dollar options at 0.71. Movement of equity volatility indexes has been more closely associated with exchange rate index since September 2008. The sample period is January of 2005 to September 2020, which varies by currency. The coefficient of the *VIX* is defined as the Safe-Haven Index (*SH*) and assessed the safe-haven status as follows:

- $SH > 0$: Period and country specific "safe-haven" type tendency.
- $SH < 0$: Period and country specific “vulnerable currency" type tendency.
- $SH = 0$ or insignificant: exchange rate movement doesn’t follow specific tendency.

So, the expected signs of the coefficient (γ) is positive if a home currency is the safe-haven currency such as the Japanese yen, and the U.S. dollar and it’s negative if a home currency is vulnerable to a common shock related to market uncertainty – typically emerging market currencies including the Chinese renminbi. The status of the safe-haven currency has been changing over two decades (Table 2).

Interest rate differentials between home and U.S. are excess returns of investment in a home country borrowing the U.S. dollar. So, the expected sign of coefficient (β) is positive. The safe-haven status of a currency is developed under the assumption that capital flows driven by excess returns from the currency carry trade, rather than uncovered interest rate parity (UIP). This paper’s view is close to Brunnermeier, Nagel, and Pedersen (2013)’s carry trade hypothesis that defines the currency carry trade, which consists of selling low interest-rate currencies “funding currencies” and investing in high interest-rate currencies “investment currencies.” They find that carry trades losses money on average in times of rising VIX. While the UIP hypothesizes that the carry gains due to the interest-rate differential is offset by a commensurate depreciation of the investment currency, empirically the reverse holds[4]. The investment currency appreciates a little on

[4] During a crisis period, the UIP doesn’t appear to hold. Ismailov and Rossi (2017) points out since arbitrage opportunity gains become more uncertain in a highly unpredictable environment, thus blurring the relationship

average despite with a low predictive R^2 (Fama 1984). This violation of the UIP – often referred to as the "forward premium puzzle" – is precisely what makes the carry trade profitable on average. The sample period is January of 2005 to September 2020, which varies by currency.

To track a shift of the FX determinants, the interaction term with dummy variables of the Global Financial Crisis and the Covid-19 crisis are added. To check the direct impacts of the number of the Covid-19 confirmed cases in a home country is also added. This is the basic model.

$$\Delta \boldsymbol{s_t} = \boldsymbol{\alpha} + \boldsymbol{\beta}_0 \Delta(\boldsymbol{r_t} - \boldsymbol{r_t^*}) + \sum_{c=1}^{2} \boldsymbol{\beta}_c \Delta(\boldsymbol{r_t} - \boldsymbol{r_t^*}) \cdot \boldsymbol{Crisis\ Dummy}_c + \boldsymbol{\gamma}_0 \Delta(\boldsymbol{VIX_t}) + \sum_{c=1}^{2} \boldsymbol{\gamma}_c \Delta(\boldsymbol{VIX_t}) \cdot \boldsymbol{Crisis\ Dummy}_c + \boldsymbol{\delta} \Delta(\boldsymbol{Business\ Activity(Home)_t}) + \boldsymbol{\tau} \Delta(\boldsymbol{Business\ Activity(Overseas)_t}) + \boldsymbol{\nu} \Delta \boldsymbol{ln(Covid-19\ Cases(Home)_{t-1})} + \boldsymbol{\varepsilon} \quad -(2)$$

where *Crisis Dummy* is the dummy variable of a crisis period, which is 1 during the crisis and otherwise zero and *Covid-19 cases* is the number of the Covid-19 confirmed cases.

The expected signs ($\boldsymbol{\nu}$) of C*ovid-19cases* $_{t-1}$ is positive, assuming people or the government limit business activity after noticing an increase in virus infections in the previous day.

4. Results

4.1. Basic Model Results

The basic model results for eight advanced economies are shown in Table 3. Wider interest rate differentials (higher for home or lower for foreign) have positive impacts on a home currency, following the expectation for all the advanced economies.

between exchange rates and interest rate differentials. Fukuda (2016) finds EU bank credit risk and global market risk had asymmetric effect on the deviations from the covered interest parity, differentiating features between the Sterling pound and the Danish kroner during a crisis.

Its magnitude is probably linked to the carry trade opportunities as well as the relationship to the U.S. and the global economy. One percentage point increase in the differentials is associated with a 5.5% appreciation in the Japanese yen (JPY) as the highest to a 1.2% rise in Norwegian krone (NOK) as the lowest. The UIP doesn't hold day-to-day changes of the FX moves.

During the Covid-19 crisis, its magnitude shrank for the euro (EUR), and the U.S. dollar (USD) and reversed for NOK, while there is no significant change in other economies and its magnitude of all the countries but NOK shrank. These are similar results to Masujima (2017) and Masujima (2019a). This doesn't mean market participants lost a focus on interest rate differentials during the Global Financial Crisis. Expansion of unconventional monetary policies aftermath of the financial crisis probably increased sensitivity to the interest rate differentials. For example, the magnitude of the Japan-U.S. two-year yield differentials on the FX moves hit the first peek when the U.S. Quantitative Easing started in late 2012 and hit the second peak in late 2017 after the U.S. President Donald Trump emphasized the large fiscal stimulus. In order to capture the effects of unconventional policies that could soften risk premiums in a crisis, long-term yield spread added in the extended model for Japan, U.S., and the Euro Area in the next section.

Higher market uncertainty has the positive impacts on JPY and USD. That means both currencies have safe-haven status. In contrast, higher uncertainty depreciated the Australian dollar (AUD), the Canadian dollar (CAD), the British pound (GBP), the Swedish Krona (SEK), NOK, and EUR. All the currencies significantly move with the VIX. Its negative magnitude is probably related to whether the currency is a commodity currency or not, which is highly correlated with commodity prices. Ten percentage increase in the VIX is associated with a 0.7% appreciation in the JPY as the highest to a

1.2% drop in AUD.

During the Covid-19 crisis, its magnitude shrank for all the currencies but JPY. The EUR's status actually turned into the safe-haven currency from a fragile currency (Table 2). During the Global Financial Crisis, its magnitude increased for all the countries but GBP. A difference comes from the type of crisis. The Global Financial Crisis is driven by price discrepancy of the synthetic securities products. It's closely connected with the market uncertainty. The Covid-19 crisis hit the real economy first, while the financial sector is relatively sound. In addition, immediate implementation of mega fiscal stimulus and additional liquidity support from the central banks significantly improved the financial market sentiment. That could distort the relationship between the market uncertainty and the FX moves.

A change in business activity, compared to the pre-virus crisis level via trade channel factors appears to work for some currencies during the pandemic. Ten percentage point increase in a business activity at home is associated with a 1.0% depreciation in AUD as the largest to a 0.6% drop in EUR as the narrowest. The FX moves of five currencies are associated with foreign business activities. Ten percentage point increase in a business activity overseas is associated with a 2.3% appreciation in AUD as the largest to a 0.7% rise in JPY. A rise in the new Covid-19 cases, which could weigh on a home activity next day, boosted a home currency (AUD, JPY, and NOK) in the next day.

The basic model for eight advanced economies was extended in Table 4. The world business activities are divided into three groups: advanced economies, China, and emerging economies except China. That captured more detailed effects from trade partners. Business activities from advanced economies have more tighter link to five currencies (AUD, EUR, GBP, JPY, and NOK), while there is no significant relationship

to emerging economies except China. Japan's home business activity is significantly associated with the FX moves in this model. Other results are consistent with Table 3.

The basic model results for eight emerging economies and off-shore renminbi (CNH) are shown in Table 5. Wider interest rate differentials (higher for home country or lower for foreign one) have positive impacts on on-shore renminbi (CNY) and CNH, following the expectation, but the signs of the coefficient do not follow the expectation, different from advanced economies. A main reason is, the central banks in emerging economies needs to respond to the Federal Reserve's action (FRB) to stabilize the exchange rate changes. In this case, the UIP conditions work as a reason why policy rate hikes are often related to the expected depreciation of the currency. One percentage point increase in the differentials is associated with a 2.9% depreciation in the South African rand (ZAR) as the highest to a 0.4% rise in Indian rupee (INR). In contrast, CNY and CNH appreciated 0.2% in this case.

During the Covid-19 crisis, its magnitude shrank for the Brazilian liar (BRL), Turkish Lira (TRY), while it expanded for the Indonesia rupiah (IDR), the South Korean won (KRW), and CNH. There is no significant change in the Mexican peso (MXN) and CNY.

Higher market uncertainty has a negative impact on all the eight emerging currencies and CNH. on JPY and USD. That means both currencies are safe-haven status. All the currencies significantly move with the VIX. Ten percentage increase in the VIX is associated with a 2.2% depreciation in the ZAR as the highest to a 0.04% drop in CNY as the smallest. During the Covid-19 crisis, its magnitude shrank for all the currencies but CNY and IDR., while its magnitude was expanded for KRW, TRY, and ZAR.

A change in business activity at home, compared to the pre-virus crisis level via

trade channel factors appears not to work for emerging currencies during the pandemic. The signs of the coefficient are positive. This means portfolio investment channel dominates trade effects. Ten percentage point increase in a business activity at home is associated with a 1.5% appreciation in IDR as the highest to a 0.5% drop in INR as the smallest. In contrast, a change in overseas business activity, compared to the pre-virus crisis level via trade channel factors appears to work for BRL and CNY, KRW, MXN, and CNH. That said, the pull factor (an idiosyncratic factor) doesn't work well but the FX moves are significantly associated with the push factor (a common factor). A rise in the new Covid-19 cases, which could slow a home business activity next day, boosted a home currency CNY, CNH) in the next day.

The basic model for eight emerging economies was extended in Table 6. The world business activities are divided into three groups: emerging economies, China, and emerging economies except China. The updated results are shown in Table 6. That captured more detailed effects from trade partners. Business activities from emerging economies except China have tighter link to three currencies (CNY, CNH, IDR), while business activity in advanced economies has significantly positive impacts on BRL and MXN.

4.2. Extended Model Results

In order to capture the effects of unconventional policies that could soften risk premiums in a crisis, long-term yield spread added in the extended model for Japan (Table 7), U.S. (Table 8), and the Euro Area (Table 9). Moreover, other variables such as the business activity gap between home and overseas and the Covid-19 cases in overseas were used for the robustness tests. Overall results followed the basic model, but there are some differences of the Covid-19 related impacts on the FX moves among three

economies.

The FX moves are more significantly associated with the number of the virus confirmed cases on the previous day in case of Japan, while the U.S. and Euro Area's case are significantly linked to lockdown index as the proxy of the government measures. The difference probably came from the law enforcement of the government's virus containment measures. In the U.S. and European cases, the virus measures have law enforcement. In contrast, Japan's state of emergency doesn't have the law enforcement to stop private business activities. That probably reduced the significance of lockdown indexes on the FX moves in Japan. Instead, Japanese people are more sensitive to social mood. The greater number of the virus cases naturally limit business activity without law enforcement.

5. Conclusion

This paper tries to investigate how driving factors of exchange rates have been changing overtime. The results show a change in the daily business activities in a home country and overseas are significantly associated with the exchange rate movement for many of economies. Adding safe-haven currency effects, measured by the equity market volatility indexes, didn't change its significance of daily business activity.

This paper aims to show how the Covid-19 crisis could affect the exchange rate moves as soon as possible, in order to respond to the pandemic that still continues. So, some of methodologies are not applicable due to the size of samples. Even so, literature for the link between the pandemic and the FX moves are still extremely limited. So, this paper still has contributions to the strands of literature.

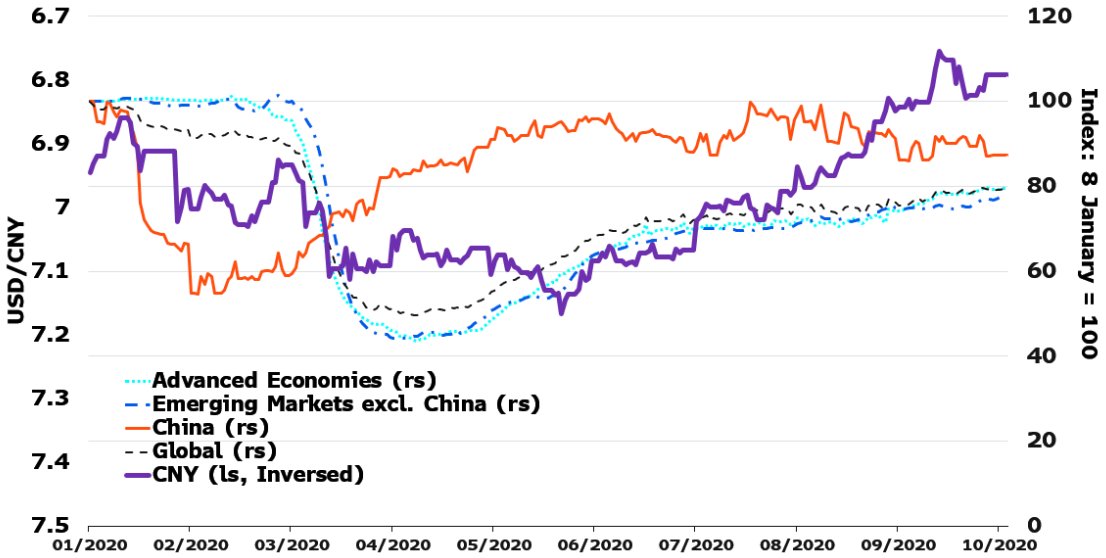
Policy implication from the results point to how to incorporate trade channel and

portfolio investment channel with exchange rate management and trade policies, based on the stages of the virus-infections and its recovery as the impacts of business activities on the FX moves may diminish in transition to post-covid period. At the stage of lockdown and early post-lockdown period, the economic recovery is associated with the currency depreciation due to trade channel in most advanced economies, but this may not work smoothly in some emerging market because portfolio investment channel dominates trade channel even during the pandemic. Moreover, due to slow progress in vaccination, the economic recovery of the emerging economies should delay, compared to the U.S. The central banks of the emerging economies could have to respond to the Fed's tightening before the recovery. Effects from trade effects should boost their currencies, increasing the exchange rate volatilities. That said, the global support for vaccination in the emerging market could also support the exchange rate stability.

As the virus-containment measures soften and business activities approach the pre-virus crisis level, effects via the trade channel could diminish. At the same time impacts via the portfolio channel should increases and the economic recovery is also associated with the currency appreciation with higher interest rates and inward foreign investment.

The exchange rate moves are determined by the balance between the trade channel and portfolio investment channel. In post-covid period, exchange rate determinants could be dominated by the investment channel. Therefore, the government and monetary authorities need to make careful adjustments of fiscal policy and monetary policy, based on the stage of the pandemic to stabilize exchange rates as well as the real economy.

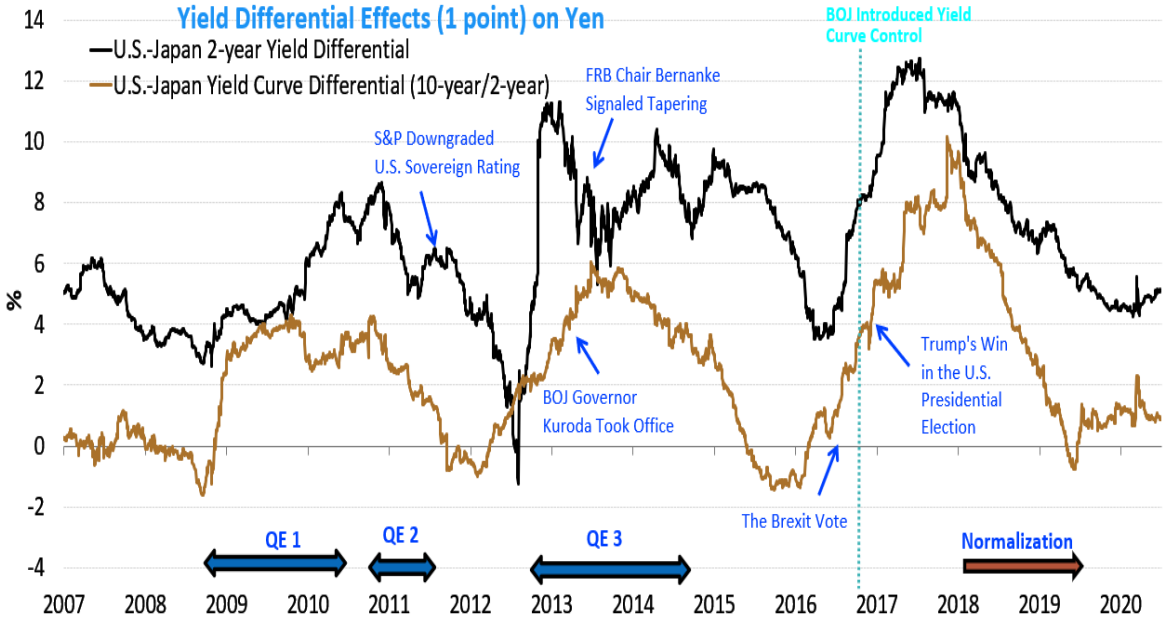
Figure 1. On-Shore Renminbi, Economic Activity amid the Pandemic



Notes: Aggregates are weighted using 2019 GDP weights. Advanced economies comprise, United States, Canada, Japan Germany, France, Italy, Spain and Australia. Emerging market economies comprise Brazil, Mexico, Argentina, Colombia, Chile, Turkey, India, South Africa, Russia, Indonesia, Saudi Arabia, Taiwan and Hong Kong.

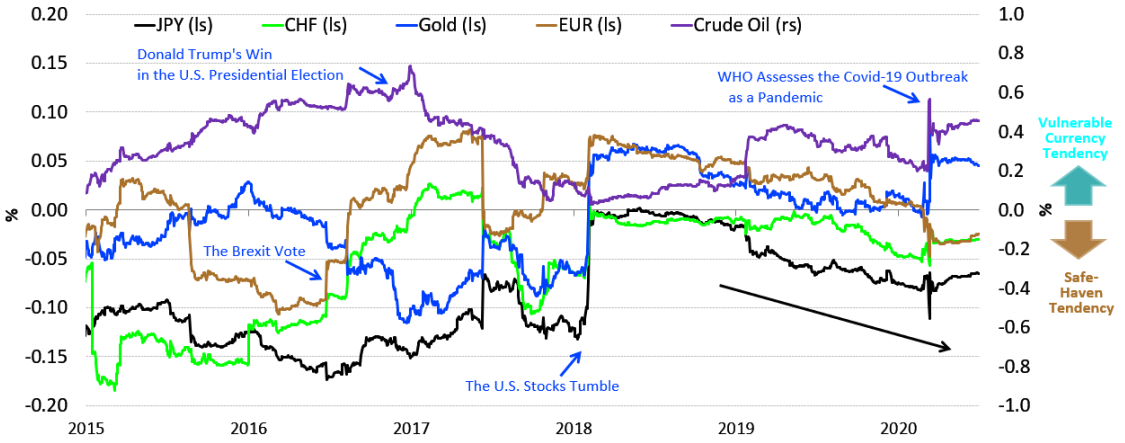
Source: Bloomberg Economics,

Figure 2. Interest Rate Differentials Have Smaller Effect on FX moves amid the Pandemic



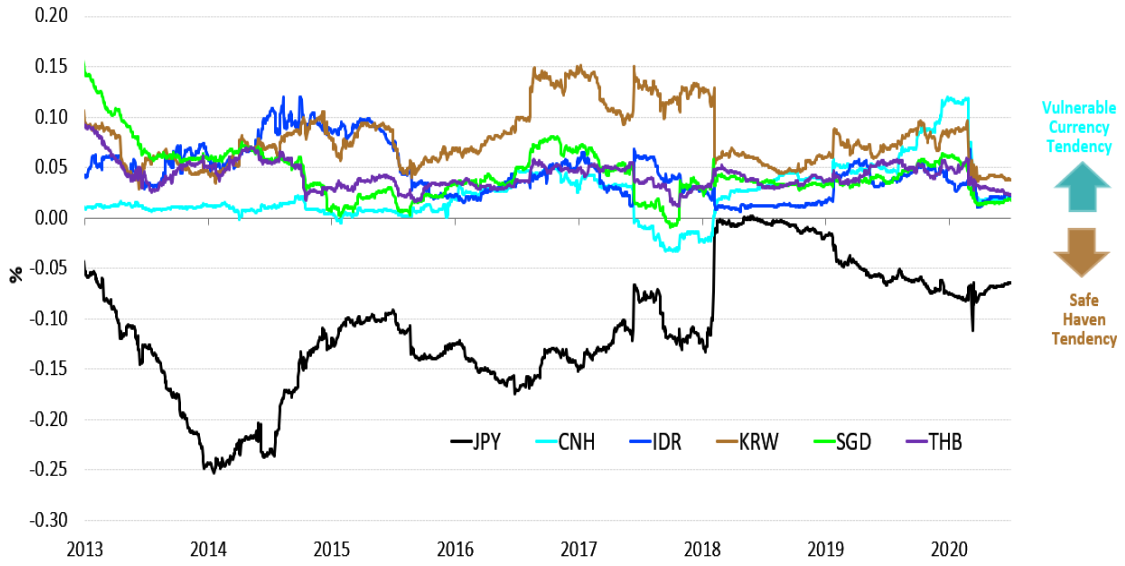
Source: Bloomberg Economics

Figure 3. Yen's Safe Currency Status Relatively Stable amid the Pandemic



Note: The charts above show the coefficients and p-values estimated from the rolling regression with a 250-business-day window
Source: Bloomberg Economics

Figure 4. VIX Sensitivity of Emerging Currencies Weakens amid the Pandemic



Note: The charts above show the coefficients from the rolling regression with a 250-business-day window
Source: Bloomberg Economics

Table 1. Trade Channel Versus Portfolio Investment Channel

	Trade Channel	Portfolio Investment Channel
Economic Activity ↑ (Home)	Domestic Consumption ↑ Imports ↑ Trade Deficit ↑ Currency Depreciation	Domestic Demand ↑ Domestic Price, Interest Rate ↑ Capital Inflows ↑ Currency Appreciation
Economic Activity ↑ (Overseas)	External Demand↑ Exports ↑ Trade Surplus ↑ Currency Appreciation	External Demand ↑ Foreign Price, Interest Rate ↑ Capital Outflows ↑ Currency Depreciation

Source: Bloomberg Economics

Table 2. Safe-haven Ranking with Alternative Assets

Ranking	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	1H 2020
1	CHF	CHF	CHF	THB	CHF	CHF	JPY	JPY	JPY	USD	USD	JPY	JPY	JPY	JPY	JPY	JPY	JPY	JPY
2	EUR	GOLD	Oil	HKD	THB	JPY	CHF	HKD	USD	JPY	JPY	Bitcoin	CHF	CHF	CHF	GOLD	CHF	CHF	CHF
3	SGD	EUR	HKD	Oil	GBP	THB	THB	USD	THB	GOLD	GOLD	HKD	Bitcoin	HKD	Bitcoin	CHF	CNY	Bitcoin	EUR
4	GOLD	THB	EUR	MYR	USD	USD	USD	CNY	CNY	Bitcoin	CNH	USD	CNY	GOLD	EUR	CNY	USD	USD	HKD
5	GBP	SGD	GOLD	USD	IDR	HKD	HKD	CHF	Bitcoin	CHF	CNY	IDR	USD	EUR	GOLD	USD	CNH	CNY	USD
6	JPY	GBP	GBP	GBP	EUR	Oil	Oil	THB	IDR	CNH	IDR	CNY	GOLD	CNY	USD	CNH	GOLD	HKD	CNY
7	THB	Oil	THB	CHF	Oil	CNY	CNY	MYR	HKD	CNY	Bitcoin	CNH	EUR	USD	CNY	Bitcoin	Oil	GOLD	GBP
8	USD	JPY	USD	EUR	HKD	EUR	GOLD	GOLD	CNH	THB	HKD	GBP	HKD	GBP	MYR	EUR	IDR	GBP	GOLD
9	HKD	USD	CAD	IDR	AUD	GBP	EUR	IDR	CHF	HKD	CHF	MYR	CNH	CNH	IDR	SGD	HKD	EUR	IDR
10	AUD	IDR	KRW	AUD	SGD	SGD	KRW	KRW	GOLD	IDR	THB	KRW	IDR	SGD	HKD	MYR	GBP	IDR	Bitcoin
11	Oil	HKD	SGD	SGD	CAD	CAD	SGD	GBP	MYR	MYR	MYR	THB	GBP	Bitcoin	SGD	GBP	EUR	Oil	KRW
12	KRW	KRW	IDR	GOLD	CNY	GOLD	GBP	EUR	KRW	Oil	Oil	CHF	Oil	THB	CNH	IDR	Bitcoin	KRW	SGD
13	CAD	AUD	JPY	JPY	JPY	IDR	MYR	Oil	EUR	GBP	KRW	GOLD	CAD	AUD	GBP	THB	MYR	CNH	CNH
14		CAD	AUD	CAD	KRW	KRW	IDR	SGD	GBP	EUR	GBP	Oil	THB	IDR	THB	HKD	SGD	SGD	Oil
15				KRW	MYR	MYR	CAD	CAD	Oil	KRW	EUR	EUR	MYR	KRW	KRW	Oil	KRW	THB	THB
16				CNY	GOLD	AUD	AUD	AUD	SGD	CAD	CAD	SGD	KRW	Oil	Oil	AUD	AUD	AUD	AUD
17									CAD	SGD	SGD	CAD	SGD	MYR	AUD	KRW	THB	CAD	CAD
18									AUD	AUD	AUD	AUD	AUD	CAD	CAD	CAD	CAD	MYR	MYR

Source: Masujima (2020)

Table 3. Exchange Rate Determinant Model for Advanced Economies

This table reports country-level results from the regression

$$\Delta s_t = \alpha + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(r_t - r_t^*) \cdot \textit{Covid-19 Dummy} + \beta_3 \Delta(r_t - r_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \gamma_1 \Delta(VIX_t) + \gamma_2 \Delta(VIX_t) \cdot \textit{Covid-19 Dummy} + \gamma_3 \Delta(VIX_t) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \delta \Delta(\textit{Business Activity}(\textit{Home})_t) + \tau \Delta(\textit{Business Activity}(\textit{Overseas})_t)$$
$$+ \upsilon \Delta ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1}) + \varepsilon$$

where s_t denotes the bilateral exchange rate in home currency per U.S. dollar (Bloomberg Dollar Index in case of the United States), $r_t - r^*$ is the two-year interest rate differential between the home country and the United States (Germany in case of the U.S. is home country) , VIX_t reflects Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index, *Business Activity(Home)t*.is daily activity index of a home country, *Business Activity(Overseas)t* is daily activity index of the world, *Covid-19 cases* is the number of the Covid-19 confirmed cases. The table reports the constant α, the slope coefficients β, γ, δ, τ, and υ, as well as the R^2 of this regression (in 0.01 percentage point). *** corresponds to a rejection of the null hypothesis at the 1% confidence level; ** and * correspond to the 5% and 10% confidence levels. Data are daily, from Bloomberg. The sample period is January of 2005 to September 2020, which varies by currency.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependant Variable		*dln(bilateral exchange rate against the U.S. dollar) [t]*							*dln(Bloomberg Dollar Index)*
Currency		**AUD**	**CAD**	**EUR**	**GBP**	**JPY**	**NOK**	**SEK**	**USD**
Starting Date		Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005
End Date		Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020
Constant [t]	α	-0.003	-0.001	-0.001	-0.005	0.001	-0.008	-0.005	0.001
d(Two-year government bond yield differential[t])	β1	2.675***	4.582***	4.166***	3.562***	5.463***	1.207***	2.910***	2.865***
- Covid-19 Dummy	β2	1.039	-1.170	-2.705**	1.462	0.535	-3.017**	0.478	-1.597*
- Global Financial Crisis Dummy	β3	-0.908**	-2.412***	-2.204***	-1.270***	-1.790***	-1.616***	-1.673***	-1.043***
d(VIX[t])	γ1	-0.200***	-0.144***	-0.063***	-0.081***	0.072***	-0.129***	-0.119***	0.056***
- Covid-19 Dummy	γ2	0.125***	0.091***	0.085***	0.071***	-0.016	0.032*	0.080***	-0.054***
- Global Financial Crisis Dummy	γ3	-0.123***	-0.036***	-0.030***	-0.012	0.048***	-0.032**	-0.050***	0.029***
d(Business Activity -Home[t])	δ	-0.099*	0.033	-0.062*	-0.055	-0.064	-0.018	0.060	-0.093***
d(Business Activity -World[t])	τ	0.229***	0.094	0.139**	0.197***	0.071*	0.192***	0.075	0.010
dln(Covid-19 confirmed cases - Home[t-1])	υ	0.462*	0.118	-0.015	-0.089	0.616*	0.976***	0.289	-0.165
R-squared		0.287	0.273	0.120	0.119	0.272	0.116	0.123	0.145
Durbin-Watson		2.145	2.077	2.008	1.949	2.065	2.006	2.075	1.997
Observations		4025	4024	3987	4026	4027	4025	4023	1669

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 4. Exchange Rate Determinant Model for Advanced Economies by Trade Partners

This table reports country-level results from the regression

$$\Delta s_t = \alpha + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(r_t - r_t^*) \cdot \textit{Covid-19 Dummy} + \beta_3 \Delta(r_t - r_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \gamma_1 \Delta(VIX_t) + \gamma_2 \Delta(VIX_t) \cdot \textit{Covid-19 Dummy} + \gamma_3 \Delta(VIX_t) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \delta \Delta(\textit{Business Activity}(\textit{Home})_t) + \tau_j \Delta(\textit{Business Activity}(\textit{Overseas})_t)$$
$$+ \upsilon \Delta ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1}) + \varepsilon$$

where s_t denotes the bilateral exchange rate in home currency per U.S. dollar (Bloomberg Dollar Index in case of the United States), $r_t - r^*$ is the two-year interest rate differential between the home country and the United States (Germany in case of the U.S. is home country), VIX_t reflects Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index, *Business Activity(Home)t*.is daily activity index of a home country, *Business Activity(Overseas)t* is daily activity index of the advanced economies, China, and the emerging economies except China, *Covid-19 cases* is the number of the Covid-19 confirmed cases. The table reports the constant α, the slope coefficients β, γ , δ, τ, and υ, as well as the R^2 of this regression (in 0.01 percentage point). *** corresponds to a rejection of the null hypothesis at the 1% confidence level; ** and * correspond to the 5% and 10% confidence levels. Data are daily, from Bloomberg. The sample period is January of 2005 to September 2020, which varies by currency.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependant Variable		*dln(bilateral exchange rate per U.S. dollar) [t]*							*dln(Bloomberg Dollar Index)*
Currency		**AUD**	**CAD**	**EUR**	**GBP**	**JPY**	**NOK**	**SEK**	**USD**
Starting Date		Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005
End Date		Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020
Constant [t]	α	-0.004	-0.001	-0.001	-0.006	0.000	-0.008	-0.005	0.001
d(Two-year government bond yield differential[t])	β1	2.675***	4.582***	4.166***	3.562***	5.463***	1.207***	2.910***	2.865***
- Covid-19 Dummy	β2	0.801	-1.266	-2.613**	1.378	0.740	-3.336***	0.528	-1.523*
- Global Financial Crisis Dummy	β3	-0.908**	-2.412***	-2.204***	-1.270***	-1.790***	-1.617***	-1.673***	-1.043***
d(VIX[t])	γ1	-0.200***	-0.144***	-0.063***	-0.081***	0.072***	-0.129***	-0.119***	0.056***
- Covid-19 Dummy	γ2	0.128***	0.089***	0.086***	0.077***	-0.011	0.035**	0.077***	-0.052***
- Global Financial Crisis Dummy	γ3	-0.123***	-0.036***	-0.030***	-0.012	0.048***	-0.032**	-0.050***	0.029***
d(Business Activity - Home[t])	δ	-0.160**	0.008	-0.094**	-0.183**	-0.098**	-0.060	0.069	-0.103**
d(Business Activity - China[t])	τ1	-0.065	-0.037	-0.024	-0.111*	0.004	0.015	-0.041	0.031
d(Business Activity - Emerging Markets ex China[t])	τ2	0.155	0.089	0.043	0.222*	-0.093	-0.072	0.102	-0.043
d(Business Activity - Advanced Economies[t])	τ3	0.177***	0.061	0.152**	0.198***	0.163***	0.272***	-0.007	0.042
dln(Covid-19 confirmed cases - Home[t-1])	υ	0.472**	0.155	-0.041	-0.090	0.708**	1.072***	0.260	-0.170
R-squared		0.287	0.272	0.120	0.121	0.274	0.118	0.123	0.145
Durbin-Watson		2.145	2.075	2.008	1.958	2.066	2.009	2.073	1.995
Observations		4025	4024	3987	4026	4027	4025	4023	1669

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 5. Exchange Rate Determinant Model for Emerging Economies

This table reports country-level results from the regression

$$\Delta s_t = \alpha + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(r_t - r_t^*) \cdot \textit{Covid-19 Dummy} + \beta_3 \Delta(r_t - r_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \gamma_1 \Delta(VIX_t) + \gamma_2 \Delta(VIX_t) \cdot \textit{Covid-19 Dummy} + \gamma_3 \Delta(VIX_t) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \delta \Delta(\textit{Business Activity}(\textit{Home})_t) + \tau \Delta(\textit{Business Activity}(\textit{Overseas})_t)$$
$$+ \upsilon \Delta \ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1}) + \varepsilon$$

where s_t denotes the bilateral exchange rate in home currency per U.S. dollar, $r_t - r^*$ is the two-year interest rate differential between the home country and the United States, VIX_t reflects Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index, *Business Activity(Home)t*.is daily activity index of a home country, *Business Activity(Overseas)t* is daily activity index of the world, *Covid-19 cases* is the number of the Covid-19 confirmed cases. The table reports the constant α, the slope coefficients β, γ, δ, τ, and υ, as well as the R^2 of this regression (in 0.01 percentage point). *** corresponds to a rejection of the null hypothesis at the 1% confidence level; ** and * correspond to the 5% and 10% confidence levels. Data are daily, from Bloomberg. The sample period is January of 2005 to September 2020, which varies by currency.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependant Variable		*dlog(bilateral exchange rate per U.S. dollar) [t]*								
Currency		**BRL**	**CNY**	**IDR**	**INR**	**KRW**	**MXN**	**TRY**	**ZAR**	**CNH**
Starting Date		Mar. 2007	June 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Apr. 2005	Jan. 2005	Aug. 2010
End Date		Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020
Constant [t]	α	-0.029*	0.009***	-0.014	-0.015*	0.006	-0.018	-0.045***	-0.022	0.001
d(Two-year government bond yield differential[t])	β1	-2.858***	0.219***	-0.475***	-0.415***	-0.539**	-1.295***	-1.275***	-2.939***	0.208*
- Covid-19 Dummy	β2	1.332***	0.287	-2.627***	-0.523	-2.240*	0.808	0.640***	-2.075**	0.672*
- Global Financial Crisis Dummy	β3	0.148	-0.091	0.211*	0.297	-1.921***	0.725	-0.405*	-0.113	
d(VIX[t])	γ1	-0.181***	-0.004*	-0.048***	-0.041***	-0.088***	-0.208***	-0.134***	-0.216***	-0.026***
- Covid-19 Dummy	γ2	0.143***	0.000	-0.003	0.040***	0.047***	0.082***	0.097***	0.121***	0.013**
- Global Financial Crisis Dummy	γ3	-0.032	0.004	-0.007	-0.003	-0.059***	-0.026	-0.061***	-0.059***	
d(Business Activity - Home[t])	δ	-0.027	0.007	0.146***	0.049**	-0.040	0.021	0.025	0.114**	0.001
d(Business Activity - World[t])	τ	0.276***	0.057***	0.061	0.022	0.164***	0.269***	0.021	0.017	0.053***
dln(Covid-19 confirmed cases - Home[t-1])	υ	-0.314	0.862***	-0.048	0.211	0.093	-1.763***	0.494	0.002	0.479***
R-squared		0.276	0.021	0.087	0.033	0.081	0.276	0.216	0.267	0.039
Durbin-Watson		2.127	2.054	2.270	1.983	2.098	2.004	1.971	2.061	2.121
Observations		4025	4024	3987	4026	4027	4025	4023	1669	2740

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 6. Exchange Rate Determinant Model for Emerging Economies by Trade Partners

This table reports country-level results from the regression

$$\Delta s_t = \alpha + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(r_t - r_t^*) \cdot \textit{Covid-19 Dummy} + \beta_3 \Delta(r_t - r_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \gamma_1 \Delta(VIX_t) + \gamma_2 \Delta(VIX_t) \cdot \textit{Covid-19 Dummy} + \gamma_3 \Delta(VIX_t) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \delta \Delta(\textit{Business Activity}(\textit{Home})_t) + \tau_j \Delta(\textit{Business Activity}(\textit{Overseas})_t)$$
$$+ \upsilon \Delta \ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1}) + \varepsilon$$

where s_t denotes the bilateral exchange rate in home currency per U.S. dollar, $r_t - r^*$ is the two-year interest rate differential between the home country and the United States, VIX_t reflects Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index, *Business Activity(Home)t*.is daily activity index of a home country, *Business Activity(Overseas)t* is daily activity index of the advanced economies, China, and the emerging economies except China, *Covid-19 cases* is the number of the Covid-19 confirmed cases. The table reports the constant α, the slope coefficients β, γ , δ, τ, and υ, as well as the R^2 of this regression (in 0.01 percentage point). *** corresponds to a rejection of the null hypothesis at the 1% confidence level; ** and * correspond to the 5% and 10% confidence levels. Data are daily, from Bloomberg. The sample period is January of 2005 to September 2020, which varies by currency.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependant Variable		*dlog(bilateral exchange rate per U.S. dollar) [t]*								
Currency		**BRL**	**CNY**	**IDR**	**INR**	**KRW**	**MXN**	**TRY**	**ZAR**	**CNH**
Starting Date		Mar. 2007	June 2005	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005	Apr. 2005	Jan. 2005	Aug. 2010
End Date		Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020
Constant [t]	α	-0.029*	0.009***	-0.015	-0.015*	0.005	-0.018	-0.045***	-0.022	0.000
d(Two-year government bond yield differential[t])	β1	-2.858***	0.219***	-0.310***	-0.415***	0.353	-1.295***	-1.275***	-2.939***	0.217*
- Covid-19 Dummy	β2	1.306***	0.197	-2.244***	-0.445	0.305	0.684	0.643***	-1.985**	0.680*
- Global Financial Crisis Dummy	β3	0.148	-0.091	0.055	0.297	-2.879***	0.725	-0.405*	-0.113	
d(VIX[t])	γ1	-0.181***	-0.004*	-0.045***	-0.041***	-0.089***	-0.208***	-0.134***	-0.216***	-0.027***
- Covid-19 Dummy	γ2	0.140***	-0.001	0.012	0.040***	0.049***	0.079***	0.097***	0.119***	0.009
- Global Financial Crisis Dummy	γ3	-0.032	0.004	-0.008	-0.003	-0.031**	-0.026	-0.061***	-0.059***	
d(Business Activity - Home[t])	δ	-0.062	-0.042**	-0.054	0.073	-0.019	-0.109	0.018	0.089	-0.067***
d(Business Activity - China[t])	τ1	-0.055		-0.174**	0.036	0.006	-0.126**	-0.012	-0.061	
d(Business Activity - Emerging Markets ex China[t])	τ2	0.153	0.131***	0.423***	-0.078	0.099	0.193*	-0.001	0.116	0.174***
d(Business Activity - Advanced Economies[t])	τ3	0.196**	-0.011	0.017	0.042	0.083	0.342***	0.042	-0.028	-0.036
dln(Covid-19 confirmed cases - Home[t-1])	υ	-0.272	0.821***	-0.168	0.198	0.046	-1.481***	0.539	-0.010	0.357
R-squared		0.276	0.024	0.077	0.033	0.077	0.281	0.216	0.267	0.042
Durbin-Watson		2.745	2.062	2.267	1.983	2.099	2.008	1.971	2.061	2.122
Observations		4025	4024	3987	4026	4027	4025	4023	1669	2740

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 7. Extended Exchange Rate Determinant Model for Japan

This table reports country-level results from the regression

$$\Delta s_t = \alpha + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(r_t - r_t^*) \cdot \textit{Covid-19 Dummy} + \beta_3 \Delta(r_t - r_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \beta_4 \Delta(y_t - y_t^*) + \beta_5 \Delta(y_t - y_t^*) \cdot \textit{Covid-19 Dummy} + \beta_6 \Delta(y_t - y_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \gamma_1 \Delta(VIX_t) + \gamma_2 \Delta(VIX_t) \cdot \textit{Covid-19 Dummy} + \gamma_3 \Delta(VIX_t) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \delta \Delta(\textit{Business Activity}(\textit{Home})_t) + \tau_j \Delta(\textit{Business Activity}(\textit{Overseas})_t)$$
$$+ \nu_1 \Delta ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1}) + \nu_2 \Delta ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1})$$
$$+ \nu_3 \Delta(\textit{Lockdown}(\textit{Home})_t) \quad + \varepsilon$$

where s_t denotes the bilateral exchange rate in home currency per U.S. dollar, $r_t - r^*$ is the two-year interest rate differential between the home country and the United States (Germany in case of the U.S. is home country), $y_t - y^*$ is the two-year/ten-year yield spreads between the home country and the United States, VIX_t reflects Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index, *Business Activity(Home)t*.is daily activity index of a home country, *Business Activity(Overseas)t* is daily activity index of the world, *Lockdown* is a stringency index of home government's measures in response to the Covid-19 infections, *Covid-19 cases* is the number of the Covid-19 confirmed cases. The table reports the constant α, the slope coefficients β, γ, δ, τ, and ν, as well as the R^2 of this regression (in 0.01 percentage point). *** corresponds to a rejection of the null hypothesis at the 1% confidence level; ** and * correspond to the 5% and 10% confidence levels. Data are daily, from Bloomberg. The sample period is January of 2005 to September 2020, which varies by currency.

	(1)	(2)	(3)	(4)
Dependant Variable	***dln(bilateral exchange rate per U.S. dollar) [t]***			
Country	Japan			
Starting Date	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005
End Date	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020
Constant[t]	0.001	0.001	0.001	0.001
d(Two-year government bond yield differential[t])	5.462***	5.716***	5.716***	5.716***
- Covid-19 Dummy		0.141	-0.032	-0.056
- Global Financial Crisis Dummy		-1.266***	-1.267***	-1.267***
d(Long-term yield curve spread differential[t])	2.126***	1.815***	1.815***	1.815***
- Covid-19 Dummy		-1.130	-1.054	-1.373
- Global Financial Crisis Dummy		2.021***	2.022***	2.022***
d(VIX[t])	0.071***	0.063***	0.063***	0.063***
- Covid-19 Dummy		-0.008	-0.008	-0.005
- Global Financial Crisis Dummy		0.052***	0.052***	0.052***
d(Business Activity -Home[t])	-0.075*	-0.072*	-0.078*	
d(Business Activity -World[t])	0.083**	0.074**	0.077**	
d(Business Activity Gap: Japan - USA[t])				-0.089***
d(Lockdown Index[t])			-0.018	-0.018
dln(Covid-19 confirmed cases - Home[t-1])		0.640*	1.047***	1.063***
dln(Covid-19 confirmed cases - World[t-1])			-0.176*	-0.167*
	OLS	OLS	OLS	OLS
Adj. R-squared	0.285	0.292	0.293	0.295
Durbin-Watson	2.083	2.081	2.083	2.084
Observations	3808	3808	3808	3808

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 8. Extended Exchange Rate Determinant Model for United States

$$\Delta s_t = \alpha + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(r_t - r_t^*) \cdot \textit{Covid-19 Dummy} + \beta_3 \Delta(r_t - r_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \beta_4 \Delta(y_t - y_t^*) + \beta_5 \Delta(y_t - y_t^*) \cdot \textit{Covid-19 Dummy} + \beta_6 \Delta(y_t - y_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \gamma_1 \Delta(VIX_t) + \gamma_2 \Delta(VIX_t) \cdot \textit{Covid-19 Dummy} + \gamma_3 \Delta(VIX_t) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \delta \Delta(\textit{Business Activity}(\textit{Home})_t) + \tau_j \Delta(\textit{Business Activity}(\textit{Overseas})_t)$$
$$+ \nu_1 \Delta ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1}) + \nu_2 \Delta ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1})$$
$$+ \nu_3 \Delta(\textit{Lockdown}(\textit{Home})_t) + \varepsilon$$

where s_t denotes the Bloomberg Dollar Index (nominal effective exchange rate), $r_t - r^*$ is the two-year interest rate differential between the United States and Germany, $y_t - y^*$ is the two-year/ten-year yield spreads between the United States and Germany, VIX_t reflects Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index, *Business Activity(Home)t*.is daily activity index of a home country, *Business Activity(Overseas)t* is daily activity index of the world, *Lockdown* is a stringency index of home government's measures in response to the Covid-19 infections, *Covid-19 cases* is the number of the Covid-19 confirmed cases. The table reports the constant α, the slope coefficients β, γ , δ, τ, and ν, as well as the R^2 of this regression (in 0.01 percentage point). *** corresponds to a rejection of the null hypothesis at the 1% confidence level; ** and * correspond to the 5% and 10% confidence levels. Data are daily, from Bloomberg. The sample period is January of 2005 to September 2020, which varies by currency.

	(1)	(2)	(3)	(4)
Dependant Variable	***dln(Bloomberg Dollar Index) [t]***			
Country	United States			
Starting Date	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005
End Date	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020
Constant[t]	0.001	0.001	0.001	0.001
d(Two-year government bond yield differential[t])	2.796***	3.088***	3.089***	3.090***
- Covid-19 Dummy		-1.700**	-0.581	-1.750**
- Global Financial Crisis Dummy		-1.023***	-1.023***	-1.024***
d(Long-term yield curve spread differential[t])	0.619***	0.602***	0.604***	0.608***
- Covid-19 Dummy		-0.322	-0.328	-0.186
- Global Financial Crisis Dummy		0.029	0.028	0.026
d(VIX[t])	0.055***	0.058***	0.058***	0.058***
- Covid-19 Dummy		-0.057***	-0.087***	-0.059***
- Global Financial Crisis Dummy		0.029***	0.029***	0.029***
d(Business Activity -Home[t])	-0.086***	-0.098***	-0.091***	
d(Business Activity -World[t])	0.026	0.012	0.018	
d(Business Activity Gap: USA - World[t])				-0.096***
d(Lockdown Index[t])			0.014	0.035**
dln(Covid-19 confirmed cases - Home[t-1])	-0.173	-0.378	-0.320	-0.348
dln(Covid-19 confirmed cases - World[t-1])			-1.933	-1.849
	OLS	OLS	OLS	OLS
Adj. R-squared	0.129	0.148	0.150	0.146
Durbin-Watson	2.015	2.008	2.010	2.008
Observations	3806	3806	3806	3806

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 9. Extended Exchange Rate Determinant Model for Euro Area

$$\Delta s_t = \alpha + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(r_t - r_t^*) \cdot \textit{Covid-19 Dummy} + \beta_3 \Delta(r_t - r_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \beta_4 \Delta(y_t - y_t^*) + \beta_5 \Delta(y_t - y_t^*) \cdot \textit{Covid-19 Dummy} + \beta_6 \Delta(y_t - y_t^*) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \gamma_1 \Delta(VIX_t) + \gamma_2 \Delta(VIX_t) \cdot \textit{Covid-19 Dummy} + \gamma_3 \Delta(VIX_t) \cdot \textit{Global Financial Crisis Dummy}$$
$$+ \delta \Delta(\textit{Business Activity}(\textit{Home})_t) + \tau_j \Delta(\textit{Business Activity}(\textit{Overseas})_t)$$
$$+ \nu_1 \Delta ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1}) + \nu_2 \Delta ln(\textit{Covid} - 19\ \textit{Cases}(\textit{Home})_{t-1})$$
$$+ \nu_3 \Delta(\textit{Lockdown}(\textit{Home})_t) + \varepsilon$$

where s_t denotes the bilateral exchange rate in the euro currency per U.S. dollar, $r_t - r^*$ is the two-year interest rate differential between Germany and the United States (Germany in case of the U.S. is home country), $y_t - y^*$ is the two-year/ten-year yield spreads between the home country and the United States, VIX_t reflects Chicago Board Options Exchange (CBOE) volatility index of S&P 500 index, *Business Activity(Home)t*.is daily activity index of GDP weighted average of Germany, France, Spain, and Italy, *Business Activity(Overseas)t* is daily activity index of the world, *Lockdown* is a stringency index of home government's measures in response to the Covid-19 infections, *Covid-19 cases* is the number of the Covid-19 confirmed cases. The table reports the constant α, the slope coefficients β, γ, δ, τ, and ν, as well as the R^2 of this regression (in 0.01 percentage point). *** corresponds to a rejection of the null hypothesis at the 1% confidence level; ** and * correspond to the 5% and 10% confidence levels. Data are daily, from Bloomberg. The sample period is January of 2005 to September 2020, which varies by currency.

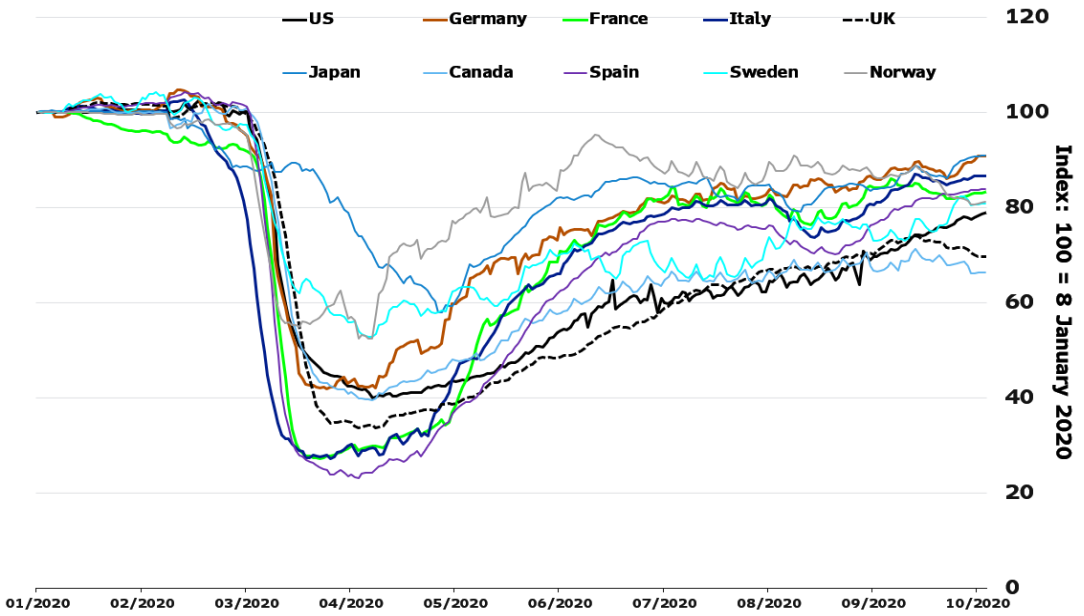
	(1)	(2)	(3)	(4)
Dependant Variable	***dln(bilateral exchange rate per U.S. dollar) [t]***			
Country/Area	**Euro Area**			
Starting Date	Jan. 2005	Jan. 2005	Jan. 2005	Jan. 2005
End Date	Sept. 2020	Sept. 2020	Sept. 2020	Sept. 2020
Constant[t]	0.000	-0.001	0.000	-0.001
d(Two-year government bond yield differential[t])	3.833***	4.297***	4.297***	4.297***
- Covid-19 Dummy		-2.778**	-2.824**	-3.027***
- Global Financial Crisis Dummy		-1.845***	-1.845***	-1.845***
d(Long-term yield curve spread differential[t])	0.652***	0.361	0.361	0.361
- Covid-19 Dummy		0.761	0.608	0.615
- Global Financial Crisis Dummy		0.999*	0.998*	0.999*
d(VIX[t])	-0.057***	-0.064***	-0.064***	-0.064***
- Covid-19 Dummy		0.082***	0.084***	0.085***
- Global Financial Crisis Dummy		-0.032***	-0.032***	-0.032***
d(Business Activity - Euro Area [t])	-0.084***	-0.054	-0.069*	
d(Business Activity -World[t])	0.132**	0.125**	0.118*	
d(Business Activity Gap: Euro Area - USA[t])				-0.063**
d(Lockdown Index[t])			-0.027	-0.035*
dln(Covid-19 confirmed cases - Home[t-1])		-0.004	-0.093	-0.160
dln(Covid-19 confirmed cases - World[t-1])			0.136	0.232
	OLS	OLS	OLS	OLS
Adj. R-squared	0.101	0.121	0.121	0.122
Durbin-Watson	0.000	2.011	2.010	2.010
Observations	3820	3820	3820	3820

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Appendix: Daily Activity Index

The activity indexes are estimated using a dynamic factor model by Orlik and Roye (2020). This methodology extracts an unobservable latent common factor of the underlying high-frequency data in the spirit of Stock and Watson (2010).

Appendix Chart I. Daily Activity Indexes for Advanced Economies



Source: Orlik and Roye (2020), Bloomberg Economics

Appendix Table I. Definition - Daily Activity Index for Advanced Economies

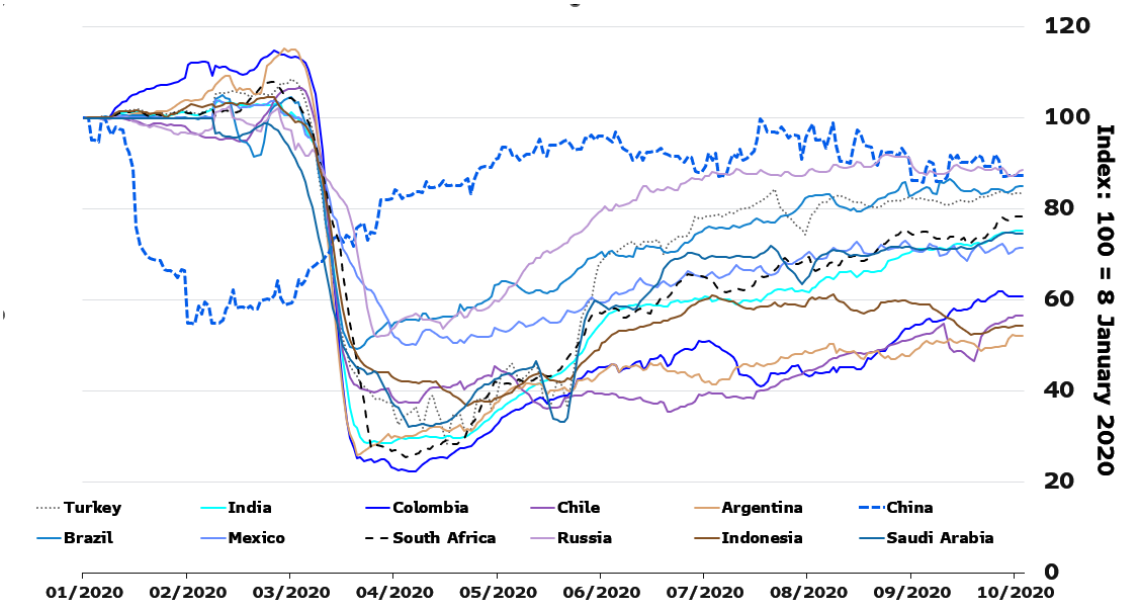
Source	Mobility data +Google.com				Moovitapp.com	Statistical Office	Electricity BNEF.com	Financial market Bloomberg	Retail ShopperTrak
Description	Grocery and pharmacy	Transit stations	Retail and recreation	Work places	Public transit demand	Toll Mileage	Electricity demand	Stock market index	Retail footfall
United States	x	x	x	x	x		x	x	
Germany	x	x	x	x	x	x	x	x	x
France	x	x	x	x	x		x	x	x
Italy	x	x	x	x	x		x	x	x
Spain	x	x	x	x	x		x	x	x
Japan	x	x	x	x			x	x	
United Kingdom	x	x	x	x	x		x	x	x
Canada	x	x	x	x	x		x	x	

Source: Orlik and Roye (2020), Bloomberg Economics

Description of the Activity Index

- Sample period: daily data from Jan. 1, 2020 to September 30, 2020
- Country/area coverage: 23 economies (11 advanced, 12 emerging economies).
- The high weight of travel and mobility indicators may lead to overweighting activities in the index.
- The index is not fully comparable across countries as different indicators are partly used by country.
- In a dynamic factor model, component weights adjust as new data becomes available. Future updates of the index will likely result in small backward revisions to historical readings.

Appendix Chart II. Daily Activity Indexes for Emerging Markets



Source: Orlik and Roye (2020), Bloomberg Economics

Appendix Table II. Definition: Daily Activity Indexes for Emerging Markets

	Mobility data					Electricity	+ Financial market		Retail
Source	Google.com				Moovitapp.com	BNEF.com	Bloomberg	https://evds2.tcmb.gov.t	https://yandex.ru/
Description	Grocery and pharmacy	Transit stations	Retail and recreation	Work places	Public transit demand	Electricity demand	Stock market index	Credit card payments	Retail footfall
Brazil	x	x	x	x	x		x		
Russia	x	x	x	x			x		x
India	x	x	x	x	x		x		
Indonesia	x	x	x	x	x		x		
South Africa	x	x	x	x	x		x		
Turkey	x	x	x	x	x		x	x	
Saudi Arabia	x	x	x	x			x		
Mexico	x	x	x	x	x		x		
Argentina	x	x	x	x	x		x		
Chile	x	x	x	x	x		x		
Colombia	x	x	x	x	x		x		
	FX turnover	Steel bar inventories	Refinary run rate						
China	x	x	x			x	x		

Source: Orlik and Roye (2020), Bloomberg Economics

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