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Recent trends in economic research

Japanese currency and stock market—What happened during the COVID-19 pandemic? ☆

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ABSTRACT

This paper examines the relationship between the Japanese Yen and the country's stock returns. Using several variants of econometric models and empirical specifications, we unravel that the depreciation of the Yen vis-à-vis the US dollar led to gains in Japanese stock returns. A one standard deviation depreciation of the Yen during the COVID-19 period (equivalent to 0.588%) improved stock market returns by 71% of average returns. We see that this relationship was stronger over the COVID-19 period (January 2020 to August 2020) compared to the pre-crisis period.

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1. Introduction

The stock returns–exchange rate nexus has been a subject of both academic and policy research for several decades. Given the large volume of studies on this subject, the hypothesis that exchange rates influence stock returns is perceived to be a traditional hypothesis in financial economics. Naturally when a shock, as devastating as the current COVID-19, hits the financial and economic systems in the manner we are experiencing now, this calls into question the relevance of existing theories and hypotheses. It is in this spirit that we re-visit the stock returns–exchange rate hypothesis to test how the relationship evolved over time and evaluate the current status of the relationship as it has unfolded over the COVID-19 period (January 2020 to August 2020) in comparison to the pre-COVID-19 period. The objective is to see how, if at all, COVID-19 has shaped or influenced the manner in which exchange rates have been traditionally believed to effect stock returns.

The theoretical foundation on which to examine the stock price–exchange rate relation is well established and can be traced to the work of [Dornbusch and Fischer \(1980\)](#), in particular to their “flow-oriented” exchange rate model. The main tenet of these models is the idea that exchange rates influence international competitiveness. The flow on effect is on current accounts, which is reflected in the effects they have on real output and incomes. Stock prices react to exchange

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rates too because they represent present values of firms' future cash flows. As stock prices change, they influence not only future income but current investment and consumption. There are also the stock-oriented models of exchange rates, as represented in the work of Branson (1983) and Frankel (1983). These models see exchange rates as equating to supply and demand for assets. Given that asset valuation and pricing are contingent on present values of future cash flows, exchange rates are directly related to asset prices.

Empirical studies have concluded with mixed findings on whether or not exchange rates influence stock prices. The literature is extensive, so we do not review it here. Several papers do undertake detailed literature review and interested readers are referred to these papers including Sui and Sun (2016).

Our hypothesis is that exchange rates influence stock returns more strongly as a result of the COVID-19 pandemic. The motivation for this hypothesis is based on the recent literature that shows that COVID-19 has affected both the financial and economic systems as well as firm performances; see Sha and Sharma (2020) and Section 2. One limitation of this literature is that none has examined how the pandemic influenced the exchange rates–stock returns relation. We focus on the Japanese exchange rate because in this COVID-19 pandemic Japan, amongst developed countries, has been an outlier, both in terms of government reactions to the crisis and the outcomes. First, Japan was the first country amongst the G7 to impose a travel ban (see Narayan et al., 2020). Second, unlike other G7 countries, Japan has not locked down country and borders. Comparatively, the approach to people movement within the country has been unrestricted. Third, Japan has experienced the least deaths from COVID-19 and has managed to contain the spread of the virus much better. This has, in part, been attributed to Japanese culture and history which, for instance, sees people accustomed to wearing face masks, inspired by their experience during the 1919 flu.¹ Lastly, Narayan (2020a) shows that Japanese Yen has become more resistant to shocks in the COVID-19 period compared to the pre-COVID-19 period.

We use daily time-series data and a generalized autoregressive conditional heteroskedasticity in mean (GARCH-M) model to test our hypothesis. We find that a one standard deviation (equivalent to 0.588%) depreciation of the Yen–US exchange rate over the COVID-19 period improves average stock returns by 71%. When we compare this with the effect during the pre-COVID-19 sub-samples, we discover that a similar depreciation of the Yen only improves Japanese stock returns by between 24% and 49%. We conclude that the effect of exchange rate on stock returns has become stronger during the pandemic. Our contribution to the literature is precisely this.

There are several ways we test the robustness of our findings. First, while we start with a GARCH-M (1,1) model, we also utilize higher order GARCH-M models. Our conclusion remains unchanged. Like GARCH, the exponential GARCH (EGARCH) model is also popular and the literature uses it. We test whether using a different model from the GARCH family influences our findings. We find that the EGARCH model produces insensitive outcomes leaving our main conclusions intact. Comparing a crisis sample (regardless of the type of crisis) with a pre-crisis sample is somewhat problematic because this comparison is characterized by a longer sample of data in the pre-crisis period compared to the crisis period, particularly when the crisis is new. We have the same issue on hand. Our crisis period sample has 165 observations while the pre-crisis period has over 2000 observations. When a comparison is done using these two sets of observations as sub-samples, it naturally introduces a large sample bias. This bias can be a source of misleading conclusions. We obviate this concern by choosing an equivalent sub-sample from the pre-crisis period that matches the number of observations in the crisis sample. This exercise tells that our main conclusions are insensitive. Finally, we use a completely different model to GARCH. The idea is to assess whether the choice of estimation technique renders results insensitive. In this regard, while we use a vector autoregressive (VAR) model, we wish to point out that a VAR model, given the data characteristics (see Section 3), is not ideal. However, we find consistent results in that exchange rates statistically significantly influence stock returns. Overall, an extensive robustness test leads us to conclude that our results survive different modelling techniques as well.

Our main contribution therefore is clear. Ours is the first paper to study the relationship between the exchange rate and the stock market in the context of the COVID-19 pandemic. Our main point of entry is to evaluate and document the strength of the exchange rate–stock returns relation as a result of the pandemic. We show that compared to normal times, exchange rate has had a much stronger impact on the stock market following the pandemic. Except Iyke (2020), who examines how COVID-19 predicts exchange rates – a completely different hypothesis to ours – there is nothing known about the role of exchange rates in shaping the behaviour of the financial market from the stock return point of view.

The paper's coverage proceeds with an overview of selected literature on COVID-19. This literature review is important because (a) COVID-19 research is at a nascent stage and less is understood of its role and (b) it helps us identify our paper's contribution and strength. Section 3 is where we propose an empirical framework to test our hypothesis. The results are presented in Section 4 and robustness tests occupy Section 5. The final section concludes with a summary.

2. COVID-19 literature: what have we learned so far?

There is now a growing body of empirical literature on COVID-19 (see Phan and Narayan, 2020; Akhtaruzzaman et al., 2020). They cover both the effects of COVID-19 on the financial as well as the economic system with studies on the financial system gaining more prominence particularly given greater availability of data.²

¹ This information is obtained from this news article. <https://www.bbc.com/news/world-asia-53188847>.

² Since this is an evolving literature, it is impossible to cover all.

This literature can be categorized into three streams. The first group of studies (see [Qin et al., 2020](#); [Apergis and Apergis, 2020](#)) takes issue with how COVID-19 has impacted the energy market. Within this energy literature, three aspects have been studied: (a) effects of COVID-19 on oil prices or oil price volatility (see [Gil-Alana and Monge, 2020](#); [Narayan, 2020b](#); [Devpura and Narayan, 2020](#); [Salisu and Adediran, 2020](#); [Huang and Zheng, 2020](#); [Ertugrul et al., 2020](#)); (b) the effect of the pandemic on stock returns of energy firms ([lyke, 2020](#); [Liu et al., 2020a,b](#); [Prabheesh et al., 2020](#)); (c) the effect of COVID-19 on energy firm performance ([Fu and Shen, 2020](#)); and (d) bubble activity in exchange rates ([Narayan, 2020c](#)). The overall, conclusive, message from these studies is that COVID-19 has influenced energy stock prices, its volatility, and firm performance. In other words, there is a clear role identified for COVID-19 in (a) shaping performance, and volatility of energy markets; and (b) influencing the relationship between energy and other financial and macroeconomic indicators like stock returns.

The second group of studies ([Gu et al., 2020](#); [Shen et al., 2020](#); [Xiong et al., 2020](#)) has focused on firm reactions to COVID-19. [Gu et al. \(2020\)](#), for instance, use an extensive dataset covering 34,000 firms and show that COVID-19 resulted in a 57% decline in electricity consumption in the first week of the crisis. In their study, with time, energy usage increased, with some firms consuming more than in the pre-COVID-19 period. [Shen et al. \(2020\)](#) demonstrate that while COVID-19 negatively impacted Chinese firm performance, the crisis impacted certain industries, like tourism, catering and transportation, most as measured by the decline in their corporate performance.

The third group of studies examines the role of COVID-19 on other aspects of the financial system.³ [Haroon and Rizvi \(2020a,b\)](#), for instance, focus on stock market liquidity. [He et al. \(2020b\)](#) examine how COVID-19 impacted different sectors of the stock market. Their finding is interesting because they show that while some sectors have been adversely affected by the pandemic, others (such as manufacturing, information technology, education, and health care) have survived the crisis. In a multi-country study, [lyke \(2020\)](#) shows that COVID-19 predicted exchange rate volatility more successfully than exchange rate returns. [Chen et al. \(2020\)](#) examine the role of COVID-19 on Bitcoin returns. In their study, the authors construct what they refer to as the fear sentiment index (an outcome of the pandemic). This index, they show, explains the negative returns on the Bitcoin. A different type of index, to which [He et al. \(2020a\)](#) refer to as the synthetic index, based on big data portrait analysis, is used to show that most Chinese industries were negatively impacted by the COVID-19 pandemic. [Wang et al. \(2020\)](#) study the insurance market and show that the Chinese insurance industry was negatively impacted by COVID-19. In their study, property and personal insurance were most impacted. Household level data was used by [Yue et al. \(2020\)](#) to show that due to the COVID-19 pandemic households are likely to change their investment portfolios. [Liu et al. \(2020a,b\)](#), on the other hand, show that while the pandemic reduced consumption in urban households, COVID-19 had limited effects on consumption of rural households. The work of [Vidya and Prabheesh \(2020\)](#) analyse the relation between COVID-19 and international trade, showing a significant reduction in trade for most countries. [Ming et al. \(2020\)](#) explore the relationship between COVID-19 and air quality in China. Using extensive city-level data, they show that air quality in China improved due to the COVID-19 pandemic. Bitcoin reactions and contagion as a result of COVID-19 have been shown by [Conlon and McGee \(2020\)](#) and [Corbet et al. \(2020\)](#), respectively. The effects of COVID-19 on stock market volatility have been shown by [Zaremba et al. \(2020\)](#). Several studies have also focused on stock market returns; see [Baig et al. \(2020\)](#); [Ali et al. \(2020\)](#), [Al-Awadhi et al. \(2020\)](#), and [Zhang et al. \(2020\)](#), amongst others. [Salisu and Sikiru \(2020\)](#) evaluates hedging effectiveness of Islamic stocks and finds that it has declined in the COVID-19 period. Finally, [Liu et al. \(2020a,b\)](#) study China's financial and business cycles and show that those cycles were already in contractionary phase prior to COVID-19; they argue that China, as a result, maybe able to better deal with the repercussions of COVID-19.

The main message emerging from the literature alluded to above is that COVID-19 has reshaped almost all facets of financial and economic systems studied to-date. The one aspect of work not previously considered is the relationship between the currency and the stock market and how this traditional relation has been disturbed by COVID-19. Our contribution to the literature is precisely through addressing this issue.

3. Model and results

We test the exchange rate effects on stock prices using a GARCH-M (1,1) model. The mean equation can be written as:

$$SR_t = \alpha + \beta ER_t + \delta V_t + \varepsilon_t$$

where SR_t is the Japanese stock market returns proxied using the Nikkei stock price index (log percentage returns are computed), ER_t is the Yen–US dollar exchange rate (log percentage returns) such that an increase denotes a depreciation of the Japanese Yen, V_t is the conditional variance and the model's innovations, ε_t , follows a Student t -distribution, and $\varepsilon_t = V_t u_t$. Following [Bollerslev \(1986\)](#), the conditional volatility is obtained as $V_t = \rho_0 + \rho_1 \varepsilon_{t-1}^2 + \rho_2 V_{t-1}$, where ρ_s ($s = 0,1,2$) are parameters to be estimated and the sum of non-intercept terms are less than one. To obtain robust estimates of the standard errors, we estimate the model using the quasi maximum likelihood function of [Bollerslev and Wooldridge \(1992\)](#).

We augment the mean equation with several controls that act as robustness test. In particular, we include a Japanese stock market volatility index (the Nikkei stock average volatility index, SV), the West Texas Intermediate oil spot price

³ [Salisu and Vo \(2020\)](#) and [Salisu et al. \(2020a,b\)](#) focus on predictability aspects of stock and commodity returns.

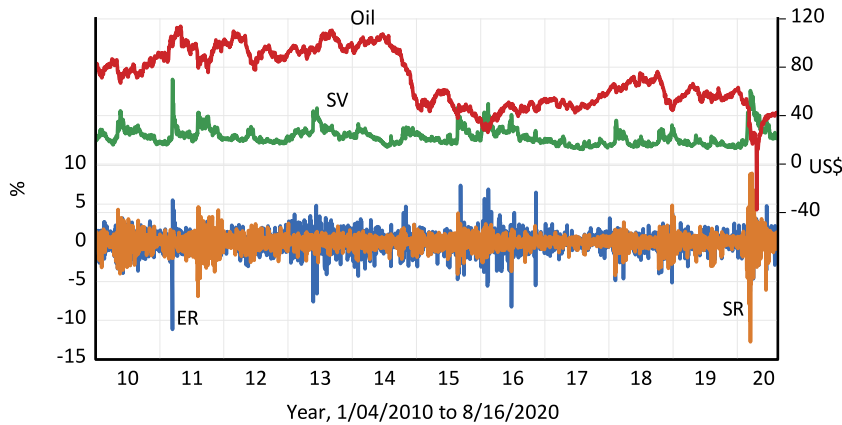


Fig. 1. Plots of key variables. The figure illustrates the line charts for key variables of interest to the paper's hypothesis that exchange rate returns determine stock price returns of Japan. The variables are SR, which is the log percentage return of the Nikkei price index; ER, which is the log percentage returns of the Yen–US dollar exchange rate specified such that an increase in Yen–US dollar indicates a depreciation of the Yen; SV, which is the Nikkei stock average volatility index; and OIL, which is the WTI spot price of oil. The data sample is 04/1/2010 to 16/8/2020.

returns (*OP*), and day-of-the-week (*DOW*) (Monday, Tuesday, Thursday and Friday) dummy variables. All data are obtained from Datastream while dummy variables are constructed by the authors.

Several studies show that there can be unidirectional relationship between stock prices and exchange rates. [Smyth and Nanda \(2010\)](#), for instance, show that for the majority of the countries in their sample, there is a unidirectional causality running from exchange rates to stock prices suggesting that exchange rates are exogenous. This observation is consistent with our mean specification. In additional results, however, using the [Westerlund and Narayan \(2015\)](#) approach, we control for possible endogeneity of the exchange rate. This approach obviates any concerns with the endogeneity of the exchange rate returns.

The first obvious point emanating from the data is how the Japanese Yen has depreciated due to the COVID-19. Over the 04/01/2010 to 30/12/2019 period (pre-COVID-19), 101.23 Yen bought 1 US dollar while over the COVID-19 sample (12/31/2019 to 8/17/2020) 107.89 Yen bought 1 US dollar. The Yen–US dollar exchange rate returns have also been negative in the COVID-19 sample compared to the historical pre-COVID-sample. Exchange rate skewness is negative, suggesting higher chances of making a loss from exchange rate trading. The distribution of the variables is non-normal, heteroskedasticity is present, and return variables are stationary as per the [Narayan and Popp \(2010, 2013\)](#) test. These statistics all motivate the choice of a GARCH model (see [Fig. 1](#) and [Table 1](#)).

[Table 2](#) has results for both models without control variables and with control variables. The estimated results are based on quasi maximum likelihood function (QMLF) (Panel A) and QMLF but with control for endogeneity of exchange rate (Panel B). The first point of note is that exchange rates positively influence Japanese stock returns, and this result is insensitive to the choice of estimator and control variables. We, therefore, focus only on the model that includes all control variables and controls also for endogeneity (Panel B). We observe that over the COVID-19 sample, a one standard deviation increase in the Yen–USD exchange rate return (which is equivalent to 0.588%) increases mean sample stock returns (which is -0.0145%) by 71%. To understand this further from an economic significance point of view consider this. The annualized mean stock returns over the COVID-19 sample is 5.22% (negative). A one standard deviation depreciation of the Yen will improve stock returns by 71%. Consider now the pre-COVID-19 sub-sample, when the exchange rate slope coefficient was 1.32 (04/01/2010 to 30/12/2019, sub-sample A) and 1.38 (31/12/2018 to 16/8/2019, sub-sample B). Over these two sub-samples, the Yen–US dollar exchange rate standard deviation was 0.5592% and 0.4269%, respectively. The corresponding sample mean stock returns were 0.031% and 0.012%. On an annualized basis, over the pre-COVID-19, a one standard deviation depreciation of the Yen would improve stock returns by 23.81% (of sample mean returns of 11.16%) and 49.09% (of sample mean returns of 4.356%) over sub-samples A and B, respectively. The improvement in stock returns experienced during the COVID-19 sample of 71% is much higher than in the past, suggesting that the role of the exchange rate in influencing stock returns has become stronger in the COVID-19 period.

4. Robustness tests

This section embarks on a range of robustness tests. We do four things to check the sensitivity of our main conclusion. First, some studies show that the GARCH orders matter. Although the Akaike Information Criterion supports a (1,1) model, we still check the role of higher orders. We employ higher order GARCH-M models like GARCH-M (1,2), GARCH-M (2,1) and GARCH-M (2,2). Results are presented in [Table 3](#), columns 2 to 4. We observe only marginal differences in the slope coefficients. For instance, a GARCH-M (2,2) model produces an exchange rate return slope coefficient of 1.534 whereas a GARCH (2,1) model has the corresponding slope coefficient of 1.6731. Our conclusion remains unchanged.

Table 1

Selected descriptive statistics. This table reports descriptive statistics (namely, mean, standard deviation (SD), maximum (Max.), minimum (Min.), Narayan and Popp (NP, 2010) structural break unit root test, skewness, the autoregressive conditional heteroskedasticity Lagrange multiplier (ARCH-LM) test for heteroskedasticity, and the Jarque–Bera (JB) test which examines the null hypothesis of normality (*p*-values are reported). The variables are the Japanese Yen to US dollar (EXR) exchange rate, the log percentage returns of EXR (ER), the Nikkei stock average price index (SP), the log percentage returns of SP (SR), the crude spot price of oil (OIL) which we proxy using the West Texas Intermediate price, and the Nikkei stock average volatility index (SV). Three sub-samples of data are considered. Panel A results are based on a data covering the COVID-19 sample (31/12/2019 to 17/08/2020); statistics in Panel B cover the pre-COVID-19 sample (04/01/2010 to 30/12/2019); and statistics obtained in Panel C cover a corresponding pre-COVID-19 sample (31/12/2018 to 16/08/2019) that matches the number of observations in the COVID-19 sample (panel A). The NP test critical values are −4.67 (10%), −4.08 (5%), and −3.77 (5%). The trimming region of 10% is considered and the model uses a maximum of eight lags to control for serial correlation with the optimum lag length chosen using the Schwarz information criterion. The ARCH-LM test is based on running a 12th order autoregressive regression, estimated using ordinary least squares, and subjecting the residuals to the LM test with 12 lags. The resulting *F*-statistics, testing the null hypothesis of no ARCH effects, are reported.

Panel A: COVID-19 sample, 31/12/2019 to 17/8/2020								
Variables	Mean	SD	Max.	Min.	NP test	Skewness	ARCH-LM (12)	JB
EXR	107.89	1.59	111.73	102.22	−0.00 (−0.59)	−0.13	13.01***	0.24
ER	−0.01	0.59	2.07	−3.43	−0.05* (−3.96)	−0.86	3.39***	0.00
SP	21586	1938	24083	16552	−0.02 (−2.71)	−0.76	>100***	0.00
SR	−0.01	1.87	7.73	−6.27	−0.09*** (−4.94)	0.26	6.31***	0.00
OIL	37.97	14.25	63.29	−37.63	−0.02 (−1.90)	−0.93	1.22	0.00
SV	29.15	11.58	60.67	13.20	−0.16 (−1.41)	0.77	42.17	0.00
Panel B: Pre-COVID-19 Sample A, 04/01/2010 to 30/12/2019								
Variables	Mean	SD	Max.	Min.	NP test	Skewness	ARCH-LM (12)	JB
EXR	101.23	14.06	125.22	75.84	−0.29 (−2.94)	−0.39	>100***	0.00
ER	0.01	0.56	3.84	−2.74	−0.98** (−4.40)	0.24	6.20***	0.00
SP	15790	4926	24270	8160	0.10 (1.17)	−0.10	>100***	0.00
SR	0.03	1.27	7.43	−11.15	−0.84** (−4.11)	−0.59	18.58***	0.00
OIL	72.45	21.95	113.93	26.21	−0.35 (−3.71)	0.03	>100***	0.00
SV	22.24	6.07	69.88	12.19	−0.09*** (−6.55)	1.42	>100***	0.00
Panel C: Pre-COVID-19 Sample B, 31/12/2018 to 16/08/2019								
Variables	Mean	SD	Max.	Min.	NP test	Skewness	ARCH-LM (12)	JB
EXR	109.56	1.64	112.01	105.19	−0.37 (−3.10)	−0.32	16.78***	0.05
ER	−0.023	0.43	1.18	−2.33	−0.91** (−4.09)	−1.59	0.81	0.00
SP	21230	578	22307	19561	−0.38 (−2.24)	−0.23	20.60***	0.31
SR	0.01	0.90	2.58	−3.05	−0.87 (−3.60)	−0.10	0.62	0.01
OIL	57.05	4.41	66.43	45.21	−0.13 (−1.18)	−0.08	25.64***	0.68
SV	18.13	3.19	29.32	13.12	−0.36* (−3.68)	1.40	19.13***	0.00

*Denotes statistical significance at the 10% level.

**Denotes statistical significance at the 5% level.

***Denotes statistical significance at the 1% level.

Table 2

The effect of exchange rate on Japanese stock returns. This table reports predictability test results based on the following time-series regression model:

$$SR_t = \alpha + \beta ER_t + \delta V_t + \varepsilon_t$$

Where SR_t is the Japanese stock market returns proxied using the Nikkei stock price index (log percentage returns are computed), ER_t is the Yen–US dollar exchange rate such that an increase denotes a depreciation of the Japanese Yen, V_t is the conditional variance and the model's innovations, ε_t , follow a Student *t* distribution, and $\varepsilon_t = V_t u_t$. Following Bollerslev (1986), the conditional volatility is obtained as $V_t = \rho_0 + \rho_1 \varepsilon_{t-1}^2 + \rho_2 V_{t-1}$, where ρ_s ($s = 0, 1, 2$) are parameters to be estimated and the sum of non-intercept terms are less than one. To obtain robust estimates of the standard errors we estimate the model using the quasi maximum likelihood function (QMLF) of Bollerslev and Wooldridge (1992). We only report the main slope coefficient relating to $\beta = 0$ for three sample periods: COVID-19 sample (31/12/2019 to 17/8/2020); pre-COVID-19 Sample A (04/1/2010 to 30/12/2019); and pre-COVID-19 Sample B (31/12/2018 to 16/8/2019). Here, *DOW* is day-of-the-week and *GOIL* is oil price growth. Standard errors are reported in parenthesis.

Sample periods	Panel A: QMLF			Panel B: QMLF with control for endogeneity		
	No controls	<i>DOW</i> controls	<i>DOW+GOIL</i> controls	No controls	<i>DOW</i> controls	<i>DOW+GOIL</i> controls
COVID-19 sample	1.5510*** (0.1309)	1.5216*** (0.1615) <i>R</i> ² = 7.80%	1.4624*** (0.1631)	1.6836*** (0.2295)	1.7052*** (0.2358)	1.7408*** (0.2514) <i>R</i> ² = 7.94%
Pre-COVID-19 Sample A	1.1621*** (0.0283)	1.1655*** (0.0284) <i>R</i> ² = 30.67%	1.1740*** (0.0285)	1.2766*** (0.030)	1.2819*** (0.0425)	1.3216*** (0.0438) <i>R</i> ² = 31.06%
Pre-COVID-19 Sample B	1.0887*** (0.1219)	1.1175*** (0.1218) <i>R</i> ² = 36.16%	1.1703*** (0.1264)	1.2611*** (0.1853)	1.3310*** (0.1773)	1.3796*** (0.1982) <i>R</i> ² = 36.12%

***Denotes statistical significance at the 1% level.

Table 3

Results from alternative GARCH models. This table reports the effect of ER on SR . The following time-series regression model (GARCH-M) is employed: $SR_t = \alpha + \beta ER_t + \delta V_t + \varepsilon_t$. In this regression, SR_t is the Japanese stock market returns proxied using the Nikkei stock price index (log percentage returns are computed), ER_t is the Yen–US dollar exchange rate such that an increase denotes a depreciation of the Japanese Yen, V_t is the conditional variance and the model's innovations, ε_t , follow a Student t distribution, and $\varepsilon_t = V_t u_t$. Following [Bollerslev \(1986\)](#), the conditional volatility is obtained as $V_t = \rho_0 + \rho_1 \varepsilon_{t-p}^2 + \rho_2 V_{t-q}$, where ρ_s ($s = 0, 1, 2$) are parameters to be estimated, the sum of non-intercept terms are less than one, and the GARCH-M orders, p and q , are set to (1,2), (2,1), and (2,2). Results from these models are in columns 2 to 4. An exponential GARCH (EGARCH) in mean version of the model is also estimated and results are reported in column 5. To obtain robust estimates of the standard errors we estimate the model using the quasi maximum likelihood function (QMLF) of [Bollerslev and Wooldridge \(1992\)](#). We only report the main slope coefficient relating to $\beta = 0$ for three sample periods: COVID-19 sample (31/12/2019 to 17/8/2020); pre-COVID-19 Sample A (04/1/2010 to 30/12/2019); and pre-COVID-19 Sample B (31/12/2018 to 16/8/2019). And, we only consider the full-scale model—that is, the model that includes all controls. Standard errors are reported in parenthesis.

Sub-samples	GARCH (2,1)	GARCH (1,2)	GARCH (2,2)	EGARCH (1,1)
COVID-19	1.6731*** (0.2494) $R^2 = 7.02\%$	1.6779*** (0.2383) $R^2 = 4.63\%$	1.5344*** (0.1950) $R^2 = 4.25\%$	1.4911*** (0.2372) $R^2 = 9.34\%$
Pre-COVID-19 Sample A	1.3218*** (0.0439) $R^2 = 31.09\%$	1.3223*** (0.0439) $R^2 = 31.08\%$	1.3216*** (0.0438) $R^2 = 35.05\%$	1.2691*** (0.0417) $R^2 = 31.07\%$
Pre-COVID-19 Sample B	1.5269*** (0.1832) $R^2 = 35.17\%$	1.5093*** (0.1885) $R^2 = 35.64\%$	1.5049*** (0.2014) $R^2 = 35.46\%$	1.3607*** (0.1742) $R^2 = 38.86\%$

***Denotes statistical significance at the 1% level.

Table 4

Results from a VAR model. This table reports results from a VAR model in which stock price returns and exchange rate returns are endogenous while all control variables are exogenous including the contemporaneous exchange rate returns, β . Two lags are used in the VAR model based on the schwarz information criterion. We only report the null hypothesis that $\beta = 0$ —both the slope coefficient and the t -statistic are reported for the three sample periods, namely the COVID-19 sample (31/12/2019 to 17/8/2020); the pre-COVID-19 Sample A (04/1/2010 to 30/12/2019); and the pre-COVID-19 Sample B (31/12/2018 to 16/8/2019). A total of three models are estimated: (a) model with no controls, (b) model with day-of-the-week (*DOW*) controls only, and (c) model with both the *DOW* and oil price growth (*GOIL*) controls.

Panel A: Post-COVID-19 period			
	No controls	<i>DOW</i> controls	<i>DOW</i> + <i>GOIL</i> controls
$\beta = 0$	1.1092*** (4.7385)	1.0356*** (4.6026)	1.1068*** (4.8141)
R^2	16.5%	24.6%	20.4%
Panel B: Pre-COVID-19 Sample A			
	No controls	<i>DOW</i> controls	<i>DOW</i> + <i>GOIL</i> controls
$\beta = 0$	1.2532*** (33.8591)	1.2297*** (33.2836)	1.2538 (33.8447)
R^2	31.28%	32.44%	31.32%
Panel A: Pre-COVID-19 Sample B			
	No controls	<i>DOW</i> controls	<i>DOW</i> + <i>GOIL</i> controls
$\beta = 0$	1.2492*** (9.1889)	1.2031*** (8.6716)	1.2414*** (9.1407)
R^2	34.52%	36.98%	35.89%

***Denotes statistical significance at the 1% level.

Second, we turn attention to employing a different version of the GARCH model. Like GARCH, the EGARCH model is also popular and the literature uses it. We connect with this literature to check if our results are sensitive to a different version of a GARCH model. We find that the EGARCH model produces insensitive outcomes leaving our main conclusions intact. [Table 3](#) (column 5), for instance, suggests that the EGARCH model gives a slope coefficient of 1.491 which while slightly smaller than the estimates from the GARCH model is equally statistically significant.

Third, we take issue with the bias resulting from comparing results from two different sub-samples. In comparing a crisis sample (regardless of the type of crisis) with a pre-crisis sample is somewhat problematic because this comparison is characterized by a longer sample of data in the pre-crisis period compared to the crisis period. We have the same issue on hand. Our crisis period sample has 165 observations while the pre-crisis period has over 2,000 observations. When a comparison is done by using these two sets of observations as sub-samples, it naturally introduces a large sample bias. This bias can be a source of misleading conclusions. We obviate this concern by choosing an equivalent sub-sample from the pre-crisis period that matches the number of observations in the crisis sample. This exercise tells that our main conclusions are insensitive.

Lastly, our empirical framework is based exclusively on a GARCH type model. A natural question is: do non-GARCH models produce similar patterns in the results obtained from GARCH models? To answer this question, we employ a VAR model. The results are summarized in Table 4. We obtain slightly smaller magnitude of effects, but the slope coefficients are still very close to those obtained from the GARCH models. We experimented with different lags in the VAR model. Considering up to 6 lags, we observed only trivial changes to the slope coefficients compared to those reported in Table 4. From this exercise, we conclude that our results survive different modelling techniques test as well. With these results, we remain alert to the fact that in our argument, guided by the statistical preliminary results in Section 3, a VAR model is not the ideal model because it ignores heteroskedasticity. We, therefore, refrain from making further conclusions from the VAR model and take a preference for results from the GARCH models.

5. Concluding remarks

In this paper, we evaluate the effectiveness of the exchange rate (Yen–US dollar) in explaining Japanese stock market returns. Our hypothesis, motivated by a growing literature on COVID-19 and its effects on the financial and economic systems, is that COVID-19 has influenced the relation between exchange rate and stock returns for Japan. Using daily time-series data for Japan fitted to a GARCH model, we show that consistent with the literature, exchange rate is a statistically significant determinant of stock market returns. Our main contribution though is the discovery that a one standard deviation depreciation of the Yen during the COVID-19 period (equivalent to 0.588%) improves stock market returns by 71% of average returns. The corresponding improvement in stock returns during the pre-COVID-19 period was only between 24% and 49%. We conclude that during the COVID-19 pandemic, the role of the exchange rate has become stronger.

We subject our hypothesis test to multiple sensitivity tests. We select a second comparative pre-COVID-19 sub-sample that matches the size (data-wise) of the COVID-19 sample; we use different versions of the GARCH model including higher GARCH orders; we use a non-GARCH model, namely a VAR model; and we correct for endogeneity of the exchange rate. All these attempts (except the VAR model) confirm our finding that the impact of exchange rate on Japanese stock returns was stronger over the COVID-19 period compared to pre-COVID-19 period.

The implications from our research can potentially instigate further research. In our economic analysis, for instance, we only identify and document how exchange rate changes influence stock returns. This is an important starting point. The next step, and possible extension, is to utilize these findings to devise trading strategies. We do not take this route because our objective is different. We leave this issue for future research.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

- Akhtaruzzaman, M., Boubaker, S., Sensoy, A., 2020. Financial contagion during COVID-19 crisis. *Finance Res. Lett.* <http://dx.doi.org/10.1016/j.frl.2020.101604>.
- Al-Awadhi, A.M., Al-Saifi, K., Al-Awadhi, A., Alhamadi, S., 2020. Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns. *J. Behav. Exp. Finance* 100326.
- Ali, M., Alam, N., Rizvi, S.A.R., 2020. Coronavirus (COVID-19) – An epidemic or pandemic for financial markets. *J. Behav. Exp. Finance* 100341.
- Apergis, E., Apergis, N., 2020. Can the COVID-19 pandemic and oil prices drive the US partisan conflict index? *Energy Res. Lett.* 1 (1), 13144. <http://dx.doi.org/10.46557/001c.13144>.
- Baig, A.S., Butt, H.A., Haroon, O., Rizvi, S.A.R., 2020. Deaths, panic, lockdowns and US equity markets: The case of COVID-19 pandemic. *Finance Res. Lett.* <http://dx.doi.org/10.1016/j.frl.2020.101701>.
- Bollerslev, T., 1986. Generalized autoregressive conditional heteroskedasticity. *J. Econometrics* 31, 307–327.
- Bollerslev, T., Wooldridge, J., 1992. Quasi-maximum likelihood estimation and inference in dynamic models with time-varying covariances. *Econom. Rev.* 11, 143–172.
- Branson, W.H., 1983. Macroeconomic determinants of real exchange risk. In: Herring, R.J. (Ed.), *Managing Foreign Exchange Risk*. Cambridge University Press, Cambridge, pp. 33–74.
- Chen, C., Liu, L., Zhao, N., 2020. Fear sentiment, uncertainty, and bitcoin price dynamics: The case of COVID-19. *Emerg. Mark. Finance Trade* 56 (10), 2298–2309. <http://dx.doi.org/10.1080/1540496X.2020.1787150>.
- Conlon, T., McGee, R., 2020. Safe haven or risky hazard? Bitcoin during the COVID-19 bear market. *Financ. Res. Lett.* 101607. <http://dx.doi.org/10.1016/j.frl.2020.101607>.
- Corbet, S., Larkin, C., Lucey, B., 2020. The contagion effects of the COVID-19 pandemic: Evidence from gold and cryptocurrencies. *Finance Res. Lett.* 101554. <http://dx.doi.org/10.1016/j.frl.2020.101554>.
- Devpura, N., Narayan, P.K., 2020. Hourly oil price volatility: The role of COVID-19. *Energy Res. Lett.* 1 (2), 13683. <http://dx.doi.org/10.46557/001c.13683>.
- Dornbusch, R., Fischer, S., 1980. Exchange rates and the current account. *Amer. Econ. Rev.* 70, 960–971.

- Ertugrul, H.M., Gungor, B.O., Soytaş, U., 2020. Effect of COVID-19 outbreak on Turkish diesel consumption volatility dynamics. *Energy Res. Lett.* (in press).
- Frankel, J.A., 1983. Monetary and portfolio-balance models of exchange rate determination. In: Bhandari, J.S., Putnam, B.H. (Eds.), *Economic Interdependence and Flexible Exchange Rates*. MIT, Cambridge.
- Fu, M., Shen, H., 2020. COVID-19 and corporate performance in the energy industry. *Energy Res. Lett.* 1 (1), 12967. <http://dx.doi.org/10.46557/001c.12967>.
- Gil-Alana, L.A., Monge, M., 2020. Crude oil prices and COVID-19: Persistence of the shock. *Energy Res. Lett.* 1 (1), 13200. <http://dx.doi.org/10.46557/001c.13200>.
- Gu, X., Ying, S., Zhang, W., Tao, Y., 2020. How do firms respond to COVID-19? First evidence from Suzhou, China. *Emerg. Mark. Finance Trade* 56 (10), 2181–2197. <http://dx.doi.org/10.1080/1540496X.2020.1789455>.
- Haroon, O., Rizvi, S.A.R., 2020a. COVID-19: Media coverage and financial markets behavior—A sectoral inquiry. *J. Behav. Exp. Finance* 100343.
- Haroon, O., Rizvi, S.A.R., 2020b. Flatten the curve and stock market liquidity—An inquiry into emerging economies. *Emerg. Mark. Finance Trade* 56 (10), 2151–2161. <http://dx.doi.org/10.1080/1540496X.2020.1784716>.
- He, P., Niu, H., Sun, Z., Li, T., 2020a. Accounting index of COVID-19 impact on Chinese industries: A case study using big data portrait analysis. *Emerg. Mark. Finance Trade* 56 (10), 2332–2349. <http://dx.doi.org/10.1080/1540496X.2020.1785866>.
- He, P., Sun, Y., Zhang, Y., Li, T., 2020b. COVID-19's impact on stock prices across different sectors—An event study based on the Chinese stock market. *Emerg. Mark. Finance Trade* 56 (10), 2198–2212. <http://dx.doi.org/10.1080/1540496X.2020.1785865>.
- Huang, W., Zheng, Y., 2020. COVID-19: Structural changes in the relationship between investor sentiment and crude oil futures price. *Energy Res. Lett.* 1 (2), 13685. <http://dx.doi.org/10.46557/001c.13685>.
- Ilyke, B., 2020. COVID-19: The reaction of US oil and gas producers to the pandemic. *Energy Res. Lett.* 1 (2), 13912. <http://dx.doi.org/10.46557/001c.13912>.
- Liu, D., Sun, W., Zhang, X., 2020a. Is the Chinese economy well positioned to fight the COVID-19 pandemic? The financial cycle perspective. *Emerg. Mark. Finance Trade* 56 (10), 2259–2276. <http://dx.doi.org/10.1080/1540496X.2020.1787152>.
- Liu, L., Wang, E.Z., Lee, C.C., 2020b. Impact of the COVID-19 pandemic on the crude oil and stock markets in the US: A time-varying analysis. *Energy Res. Lett.* 1 (1), 13154. <http://dx.doi.org/10.46557/001c.13154>.
- Ming, W., Zhou, Z., Ai, H., Bi, H., Zhong, Y., 2020. COVID-19 and air quality: Evidence from China. *Emerg. Mark. Finance Trade* 56 (10), 2422–2442. <http://dx.doi.org/10.1080/1540496X.2020.1790353>.
- Narayan, P.K., 2020a. Has COVID-19 changed exchange rate resistance to shocks? *Asian Econ. Lett.* (in press).
- Narayan, P.K., 2020b. Oil price news and COVID-19—Is there any connection? *Energy Res. Lett.* 1 (1), 13176. <http://dx.doi.org/10.46557/001c.13176>.
- Narayan, P.K., 2020c. Did bubble activity intensify during COVID-19? *Asian Econ. Lett.* (in press).
- Narayan, P.K., Phan, D.H.B., Liu, G., 2020. COVID-19 lockdowns, stimulus packages, travel bans, and stock returns. *Finance Res. Lett.* <http://dx.doi.org/10.1016/j.frl.2020.101732>.
- Narayan, P.K., Popp, S., 2010. A new unit root test with two structural breaks in level and slope at unknown time. *J. Appl. Stat.* 37, 1425–1438.
- Narayan, P.K., Popp, S., 2013. Size and power properties of structural break unit root tests. *Appl. Econ.* 45, 721–728.
- Phan, D.H.B., Narayan, P.K., 2020. Country responses and the reaction of the stock market to COVID-19—a preliminary exposition. *Emerg. Mark. Finance Trade* 56 (10), 2138–2150. <http://dx.doi.org/10.1080/1540496X.2020.1784719>.
- Prabheesh, K.P., Padhan, R., Garg, B., 2020. COVID-19 and the oil price—stock market nexus: Evidence from net oil-importing countries. *Energy Res. Lett.* 1 (2), 13745. <http://dx.doi.org/10.46557/001c.13745>.
- Qin, M., Zhang, Y.C., Su, C.W., 2020. The essential role of pandemics: A fresh insight into the oil market. *Energy Res. Lett.* 1 (1), 13166. <http://dx.doi.org/10.46557/001c.13166>.
- Salisu, A., Adediran, I., 2020. Uncertainty due to infectious diseases and energy market volatility. *Energy Res. Lett.* 1 (2), 14185. <http://dx.doi.org/10.46557/001c.14185>.
- Salisu, A.A., Akanni, L., Raheem, I., 2020a. The COVID-19 global fear index and the predictability of commodity price returns. *J. Behav. Exp. Finance* 27 (2020), 100383.
- Salisu, A.A., Ebu, G., Usman, N., 2020b. Revisiting oil-stock nexus during COVID-19 pandemic: Some preliminary results. *Int. Rev. Econ. Finance* 69, 280–294.
- Salisu, A.A., Sikiru, A.A., 2020. Pandemics and the Asia-Pacific Islamic stocks. *Asian Econ. Lett.* (in press).
- Salisu, A.A., Vo, X.V., 2020. Predicting stock returns in the presence of COVID-19 pandemic: The role of health news. *Int. Rev. Financ. Anal.* 71, 101546. <http://dx.doi.org/10.1016/j.irfa.2020.101546>.
- Sha, Y., Sharma, S.S., 2020. Research on pandemics special issue of the journal emerging markets finance and trade. *Emerg. Mark. Finance Trade* 56, 2133–2137. <http://dx.doi.org/10.1080/1540496X.2020.1795467>.
- Shen, H., Fu, M., Pan, H., Yu, Z., Chen, Y., 2020. The impact of the COVID-19 pandemic on firm performance. *Emerg. Mark. Finance Trade* <http://dx.doi.org/10.1080/1540496X.2020.1785863>.
- Smyth, R., Nanda, M., 2010. Bivariate causality between exchange rates and stock prices in South Asia. *Appl. Econ. Lett.* 10, 699–704.
- Sui, L., Sun, L., 2016. Spillover effects between exchange rates and stock prices: Evidence from BRICS around the recent global financial crisis. *Res. Int. Bus. Finance* 36, 459–471.
- Vidya, C.T., Prabheesh, K.P., 2020. Implications of COVID-19 pandemic on the global trade networks. *Emerg. Mark. Finance Trade* 56 (10), 2408–2421.
- Wang, Y., Zhang, D., Wang, X., Fu, Q., 2020. How does COVID-19 affect China's insurance market? *Emerg. Mark. Finance Trade* <http://dx.doi.org/10.1080/1540496X.2020.1791074>.
- Westerlund, J., Narayan, P.K., 2015. Testing for predictability in conditionally heteroskedastic stock returns. *J. Financ. Econ.* 13, 342–375.
- Xiong, H., Wu, Z., Hou, F., Zhang, J., 2020. Which firm-specific characteristics affect the market reaction of Chinese listed companies to the COVID-19 pandemic? *Emerg. Mark. Finance Trade* 56 (10), 2231–2242. <http://dx.doi.org/10.1080/1540496X.2020.1787151>.
- Yue, P., Korkmaz, A.G., Zhou, H., 2020. Household financial decision making amidst the COVID-19 pandemic. *Emerg. Mark. Finance Trade* 56 (10), 2363–2377. <http://dx.doi.org/10.1080/1540496X.2020.1787149>.
- Zaremba, A., Kizys, R., Aharon, D.Y., Demir, E., 2020. Infected markets: Novel coronavirus, government interventions, and stock return volatility around the globe. *Financ. Res. Lett.* 101597. <http://dx.doi.org/10.1016/j.frl.2020.101597>.
- Zhang, D., Hu, M., Ji, Q., 2020. Financial markets under the global pandemic of COVID-19. *Finance Res. Lett.* 101528.