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Impact of COVID-19 vaccinations on UK stock market

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Impact of COVID-19 Vaccinations on UK Stock Market

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Abstract

Using London Stock Exchange data (Jan 10, 2021, to Feb 24, 2022) and fixed-effects regression methods, this study assesses COVID-19 vaccine effects on UK stock returns. Initial protocol doses have a strong positive impact on returns, while boosters have a modest positive impact. A logarithmic unit increase in daily vaccine doses links to a 0.085p.p. stock return increase. Stringent closure policies weaken the positive vaccine influence on returns. Sector-wise, healthcare responds most positively, while basic resources and food/beverage industries show a positive but muted effect. This study sheds light on the contribution of Covid-19 vaccinations on economic recovery in the UK.

Keywords: stock returns, Covid-19, vaccinations

JEL codes: E65, G12, I18

1. Introduction

The outbreak of COVID-19, first identified in Wuhan, China in December 2019, quickly escalated into a global pandemic, infecting close to 700 million people and leading to the deaths of nearly 7 million individuals¹. As the virus spread across continents, governments worldwide were forced to enact strict measures to halt its transmission. In the United Kingdom, the first nationwide lockdown was announced on March 23, 2020, leading to the closure of all non-essential shops and public places.

To allow for a return to normality, vaccines against COVID-19 were developed and approved at an incredibly rapid pace. By the end of 2020, several pharmaceutical companies announced the successful development of a vaccine. The announcement of vaccines had a positive impact on the financial markets (Demir et al., 2021; To et al., 2021; To et al., 2023). However, there is little research on how vaccine rollout affected stock markets. This study aims to close this gap. In particular, we ask, whether an increase in daily vaccinations increased stock market returns, whether the effect was different for initial doses and booster doses, whether lockdowns mitigated or amplified the positive effect of vaccine rollout on stock returns, and whether specific industries were affected more by the COVID-19 vaccine rollout. To the best of our knowledge, this is the first study to empirically address these questions.

We study stock market returns in the United Kingdom. The UK was among the first countries to approve and distribute COVID-19 vaccines, providing the longest available period to assess the impact of vaccines on the stock market. The UK government's pandemic response offers a setting to investigate the relationship between closure policies and vaccinations. A study tailored to the UK can equip its investors with critical insights, preparing them for decision-making during similar public health events in the future. Furthermore, as a leading global financial centre, the UK's market findings can offer valuable perspectives for other major markets worldwide.

We collect the daily data on stock market returns of all 2,616 companies listed on the London Stock Exchange, from January 10, 2021 (when vaccination rollout data starts) to February 24, 2022 (when the last lockdown restrictions were lifted). Our variables of interest are different indicators of the COVID-19 vaccine rollout. We complement the data with stock-specific control variables, and other pandemic-related indicators, to analyse the relationship between the administration of the COVID-19 vaccine and stock returns in the UK. The fixed effects models are employed for analysis.

This study reports four findings. First, daily new vaccine doses have a positive effect on stock returns with a coefficient of 0.085. Second, the effect is more pronounced for

¹ Data sourced from: <https://www.worldometers.info/coronavirus/> on 14 August 2023.

the initial protocol of vaccination with a coefficient of 0.096, compared to the booster dose with a coefficient of 0.0045. Third, stringent closure policies tend to weaken the positive influence of vaccines on stock market performance. Fourth, vaccination has a positive impact across all industries but exerts a stronger effect on the healthcare industry and a weaker effect on the basic resources, and food beverage and tobacco industries.

2. Literature review

2.1 The impact of the COVID-19 vaccines on financial markets

Even before the public vaccination began, global stock markets conveyed crucial information about market expectations regarding the economic value of COVID-19 vaccine development. Chan et al. (2022) conduct panel regressions and construct dummy variables that took the value of 1 on the first day of any phase of clinical trials and 0 otherwise. They find that stock market returns worldwide respond positively when various COVID-19 vaccines begin different stages of human clinical trials, especially when phase III trials commence. Using an event study approach, Ho et al. (2022) examined the reaction of the Chinese stock market to COVID-19 vaccine approval announcements, finding that the Chinese stock market responds positively to COVID-19 vaccine approval announcements. Industries such as manufacturing, wholesale & retail, and information technology consistently benefited, while sectors like transportation and hotels & catering only responded positively to the initial vaccine approval announcements, suggesting no immediate signs of recovery for these sectors. During the clinical trial phase, announcements of progression to the next phase and vaccine approval significantly impacted the market, with the most pronounced effect occurring immediately. Thus, the event study methodology is suitable for such scenarios. However, the subsequent vaccine rollout is a more extended process. The event study can only capture short-term effects, necessitating a different approach to understanding the longer-term relationship between the vaccine and stock market performance.

The beneficial role of vaccine distribution on stock market stability has been confirmed in the literature (Demir et al., 2021; Rouatbi et al., 2021; To et al., 2023; To et al., 2021). Both To et al. (2021) and Rouatbi et al. (2021), using panel data analysis discover that the stabilizing effect of COVID-19 vaccination on market volatility is more pronounced in developed markets. Likewise, Demir et al. (2021), focusing on energy companies and employing a fixed-effects estimation method, conclude that there is a more significant stabilizing effect on market volatility in developed markets.

Vaccination also has a positive effect on stock market returns. Jeremiah et al. (2023) employ the Feasible Generalized Least Squares (FGLS) approach to analyse the effect of the Vaccine Dose Trend (VDT) on healthcare stock indices in Southeast Asia, uncovering a positive relationship. However, this positive effect might not be

universally applicable, as research suggests that the impact of vaccines on stock market returns varies across countries. Oanh (2022), using a PVAR model on data from 77 countries from March 11, 2020, to October 29, 2021, finds that COVID-19 vaccination has a positive effect on stock market returns in developing countries but a negative impact on developed countries. This contrasts with the findings of our study for the UK, a developed country, where for every unit increase in the logarithm of vaccine doses, stock returns increase by 0.085p.p..²

Motivated by these studies we focus on a single, developed economy with a large financial sector and employ panel regressions to assess the impact of COVID-19 vaccine rollout on the stock market performance. To the best of our knowledge, ours is the first study to quantify the impact of different doses on stock returns and quantify the different effects across different industries.

2.2 The impact of the COVID-19 pandemic on the financial markets

Al-Awadhi et al. (2020) and Ashraf (2020a) find that an increase in the confirmed cases leads to a decrease in stock returns in the short term. Topcu and Gulal (2020) find that emerging markets are more adversely affected than developed ones. Meanwhile, Zhang et al. (2020) and To et al. (2023) find that an increase in confirmed cases also leads to an increase in the volatility of the market. This is due to the significant risk and uncertainty that the pandemic brings to the global financial market.

The relationship between the number of deaths and stock returns is more complex. In the Chinese market, an increase in deaths decreases the stock returns (Al-Awadhi et al., 2020) and increases in volatility (Zhang et al., 2022). A similar conclusion also applies to the U.S. market (Albulescu, 2021; Baig et al., 2021), and is further corroborated by To et al. (2023) encompassing 32 countries. However, Ashraf (2020a), conducting panel regression on the data of deaths and stock returns in 64 countries, finds that the response of stock returns to death cases is not significant. This is because death cases can be roughly predicted by the confirmed cases, so the market has already responded to the death cases when it learns about the number of confirmed COVID-19 cases. Ali et al. (2022) constructs a global fear index using deaths and confirmed cases, suggesting that the Pakistan stock market is uncorrelated with COVID-19.

It is also indicated that there is a heterogeneous reaction towards different sectors within the stock market. Al-Awadhi et al. (2020) find that during the COVID-19 period, the returns in the medicine manufacturing industry were higher than the overall market, while the returns in the beverage and transportation industries were

² Within the cryptocurrency market, Havidz et al. (2023) utilize the autoregressive distributed lag panel and discover that while the Vaccine Confidence Index (VCI) increases demand in the Bitcoin market, it affects Ethereum negatively.

lower. Zhang et al. (2022) find that in the short term, the leisure service industry fluctuates the most, while the banking industry fluctuates the least. In the long term, the healthcare and pharmaceutical industries are most severely affected by the confirmed cases, while the nonferrous metals, banking, and telecommunications industries are least affected.³

Motivated by these studies, we observe that COVID-19 cases (and deaths) had heterogeneous effects across different industries. Therefore, we study and confirm that COVID-19 vaccines also exhibit heterogeneous effects across industries.

2.3 The impact of the government COVID-19 interventions on the stock market

The impact of closure policies on stock markets continues to be a subject of debate. Some studies show that the impact is negative in returns, liquidity and volatility (Baker, 2020; Baig et al., 2021; To et al., 2023). Ashraf (2020b) suggests that while closure policies have an overall negative impact on stock returns, they also indirectly produce a positive effect by reducing COVID-19 cases. Conversely, some studies suggest that lockdowns have a positive impact on returns (Narayan et al., 2021) and lead to a decrease in market liquidity (Zaremba et al., 2021).

Income support policies contribute positively to market returns in the short term, playing a crucial role in offsetting the impact of the pandemic (Ashraf, 2020b; Topcu and Gulal, 2020; Gormsen and Koijen, 2020). However, the long-term effects of the income support policies are uncertain (Zhang et al., 2020).

Motivated by these studies, we include a measure of stringency in our empirical setup and show that lockdowns had mitigating effects on the relationship between COVID-19 vaccines and the stock market returns.

3. Methodology

This study aims to investigate the influence of COVID-19 vaccine administration on companies listed on the London Stock Exchange (LSE), focusing on the overall market impact, the potential modulation of this relationship by factors such as lockdowns and vaccination rates, and the differential effects across various sectors. To address these research objectives, this section introduces the analytical strategy employed. As a benchmark, we estimate the following empirical model:

$$R_{i,t} = \alpha_0 + \beta Vac_{t-1} + \theta X_{i,t-1} + \mu_i + \varepsilon_{i,t} \quad (1)$$

$R_{i,t}$ represents the stock return of company i at day t , Vac_{t-1} is a column vector of vaccine-related variables at day $t-1$, which are the key variables. Vaccine-related data

³ In the cryptocurrency market, Sarkodie et al. (2022) employ polynomial regression, uncovering that cryptocurrencies exhibit an N-shaped relationship with the COVID-19 pandemic.

are typically reported on the following day. Therefore, it is assumed that stock prices can only respond to the vaccination situation of the previous day. $X_{i,t-1}$ is a column vector of control variables for the company i at day $t-1$, including the logarithm of daily market capitalization and price-to-book ratio. μ_i is the company-specific factor, capturing those factors that change over companies, $\varepsilon_{i,t}$ is the error term, which is uncorrelated with Vac_{t-1} and $X_{i,t-1}$.

Second, to investigate whether the impact of daily new vaccine doses on stock returns varies with other factors such as lockdowns, the total vaccination rate, and specific sectors, this study introduced interaction terms in the model. We multiply the relevant variable by the daily new vaccine doses to obtain the following regression equation:

$$R_{i,t} = \alpha_0 + \beta_1 LVAC_{t-1} + \beta_2 LVAC_{t-1} \times Int_{t-1} + \beta_3 Int_{t-1} + \theta X_{i,t-1} + \eta_{i,t} \quad (2)$$

where $LVAC_{t-1}$ is the natural logarithm of daily new vaccine doses at day $t-1$, Int_{t-1} is a relevant control variable that is being interacted, $LVAC_{t-1} \times Int_{t-1}$ is the interaction term of the natural logarithm of new vaccine doses with a control variable. At this point, the impact of daily new vaccine doses on the stock returns can be obtained by taking partial derivatives:

$$\frac{\partial R}{\partial LVAC} = \beta_1 + \beta_2 Int \quad (3)$$

When the signs of β_1 and β_2 are the same, Int enhances the effect of vaccine doses on stock returns, whereas when the signs are opposite, it has the opposite effect. Third, a panel model needs to be selected to deal with μ_i . Since the coefficients of independent variables are assumed to be constant and not vary with company changes, fixed effects and random effects models are considered. Several tests are used to determine whether to use a fixed effects model or a random effects model, including the F-test, the BP-LM test and the Hausman test.

If it is determined that the fixed effects model should be selected in the F-test and the random effects model should be selected in the BP-LM test, the Hausman Test (Hausman, 1978) can be used to choose between the fixed effects model and the random effects model. Under the assumption that the company-specific factors are uncorrelated with other independent variables, both the fixed effects model and random effects model produce unbiased and consistent parameter estimates without significant differences. The Hausman Test is based on the construction of a statistic test from the differences in parameter estimates between two models.

4. Data

4.1 Data and sources

This study uses vaccination data from the United Kingdom, including the number of daily new doses, total booster doses and people fully vaccinated. The data are sourced from Our World in Data⁴. The study spans from January 10, 2021, when the vaccination data began, to February 24, 2022, when the UK officially lifted all administrative restrictions⁵, marking a pivotal return to normalcy. We calculate daily new booster doses as the difference between the numbers of total booster on two consecutive days. We calculate daily new initial protocol doses as the difference between the daily new vaccine doses administered and daily new booster doses.

Concurrently, the study employs the Oxford COVID-19 Government Response Tracker (OxCGRT)⁶, gathered from the University of Oxford, which encapsulates information about the pandemic response measures enacted by governments. We use stringency, which reflects, as a number between 0 and 100, the degree of the government response in terms of containment and closure policies, along with the public information campaigns.

The study utilizes company-level data incorporating three variables at daily frequency: stock returns, daily market capitalization and price-to-book ratio, collected from Bloomberg. The daily market capitalization is selected as a control variable according to Al-Awadhi et al. (2020), calculated as:

$$MCAP_{i,t} = \text{Closing stock price}_{i,t} \times \text{Outstanding shares}_{i,t}, \quad (4)$$

where Closing stock price_{i,t} is the final trading price of stock i at the end of day t, Outstanding shares_{i,t} is the total number of shares that company i has issued and are in circulation in the market at day t. The price-to-book ratio is chosen following Al-Awadhi et al. (2020) and Zhang et al. (2022), calculated by:

$$PB_{i,t} = \frac{\text{Market price per share}_{i,t}}{\text{Book value per share}_{i,t}} \quad (5)$$

where Market price per share_{i,t} is the current price of a single share of stock in the company i in the open market at day t, Book value per share_{i,t} is calculated by taking the total book value of company i (total assets minus total liabilities) and dividing it by the number of outstanding shares at day t.

Stock returns are set as a dependent variable, with daily market capitalization and price-to-book ratio serving as control variables. The selection of these control variables is guided by prior research: daily market capitalization following from Al-

⁴ Our World in Data: <https://ourworldindata.org/covid-vaccinations>

⁵ GOV.UK: <https://www.gov.uk/government/speeches/pm-statement-on-living-with-covid-21-february-2022>

⁶ <https://www.bsg.ox.ac.uk/research/covid-19-government-response-tracker>

Awadhi et al. (2020), Bakry et al. (2022) and To et al. (2021), while the price-to-book ratio is shown in Al-Awadhi et al. (2020), Zhang et al. (2022), and Demir et al. (2021).

However, unlike Al-Awadhi et al. (2020), the sample in this study is not restricted to companies included in specific sectors. Instead, it comprehends all stocks traded on the London Stock Exchange up to February 24, 2022. This approach allows for the inclusion of smaller-scale companies, thereby providing a comprehensive evaluation of the influence of vaccination on the stock market. The dataset comprises a sample of 2616 stocks and 836,430 observations, covering the period from January 10, 2021, to February 24, 2022.

This study also established several dummy variables to classify companies into different industries based on the Industry Classification Benchmark (ICB) released by FTSE Russell in 2019. This classification system categorizes industries into four levels: Industry, Supersector, Sector, and Subsector. For this study, the following supersectors are selected: healthcare, financial services, travel and leisure, basic resources, food, beverage and tobacco, and real estate. Within healthcare and basic resources, the selection is further narrowed down to the following sectors: healthcare providers, medical equipment and services, pharmaceuticals and biotechnology, industrial materials, industrial metals and mining, and precious metals and mining.

4.2 Data Processing

This study applies a logarithmic transformation to the daily new vaccine doses, new initial protocol doses, new booster doses and market capitalization to normalize the magnitudes of these variables. This approach reduces the influence of absolute scale differences between variables.

Upon inspection of data, some extreme values were identified in stock returns and price-to-book value. Some were identified as data entry errors and were removed directly from the dataset, while others were influenced by corporate financing, mergers, and other activities. The approach of trimming the data at the 1st and 99th percentiles is used to remove these extreme values. After processing the data, a total of 719,237 stock returns observations, 628,760 daily market capitalization observations, and 388,552 price-to-book ratio observations not null are obtained. The software used in this study is Stata MP 17 (64-bit).

Table 1 provides a list of the variables employed in our analysis.

Table 1. Variable definitions.

Variable	Definition
<i>Dependent variable</i>	
R	The daily stock return for the company i on day t

Explanatory variables

LVAC	The natural logarithm of new vaccine doses at day t-1
LVACI	The natural logarithm of new initial protocol doses at day t-1
LVACB	The natural logarithm of new booster doses at day t-1

Company-level control variables

LMCAP	The natural logarithm of the market capitalization in USD for the company i at day t-1
PB	The price-to-book ratio for the company i at day t-1

Economy-level control variables

OxCGRT	The stringency index in the Oxford COVID-19 Government Response Tracker at day t-1
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Industry-level control variables

HEALTHCARE	The dummy variable takes 1 if the company i belongs to the Healthcare supersector and 0 otherwise
BASIC RESOURCES	The dummy variable takes 1 if the company i belongs to the Basic Resources supersector and 0 otherwise
FOOD BEVERAGE AND TOBACCO	The dummy variable that takes 1 if company i belongs to the Food, Beverage and Tobacco supersector and 0 otherwise
FINANCIAL SERVICE	The dummy variable takes 1 if the company i belongs to the Financial Service supersector and 0 otherwise
TRAVEL AND LEISURE	The dummy variable takes 1 if company i belongs to the Travel and Leisure supersector and 0 otherwise
REAL ESTATE	The dummy variable takes 1 if the company i belongs to the Real Estate supersector and 0 otherwise
HEALTHCARE PROVIDERS	The dummy variable takes 1 if the company i belongs to the Healthcare Providers sector and 0 otherwise
MEDICAL EQUIPMENT AND SERVICES	The dummy variable takes 1 if company i belongs to the Medical Equipment and Services sector and 0 otherwise
PHARMACEUTICALS AND BIOTECHNOLOGY	The dummy variable takes 1 if the company i belongs to the Pharmaceuticals and Biotechnology sector and 0 otherwise
INDUSTRIAL MATERIALS	The dummy variable takes 1 if the company i belongs to the Industrial Materials sector and 0 otherwise
INDUSTRIAL METALS AND MINING	The dummy variable takes 1 if company i belongs to the Industrial Metals and Mining sector and 0 otherwise
PRECIOUS METALS AND MINING	The dummy variable takes 1 if company i belongs to the Precious Metals and Mining sector and 0 otherwise

4.3 Comparative statistics and correlations

Figure 1 shows the cumulative average daily returns in the UK. The figure illustrates that the overall stock returns in the London Stock Exchange from the selected period exhibited an upward trend followed by a downward trend. It sees a rapid increase

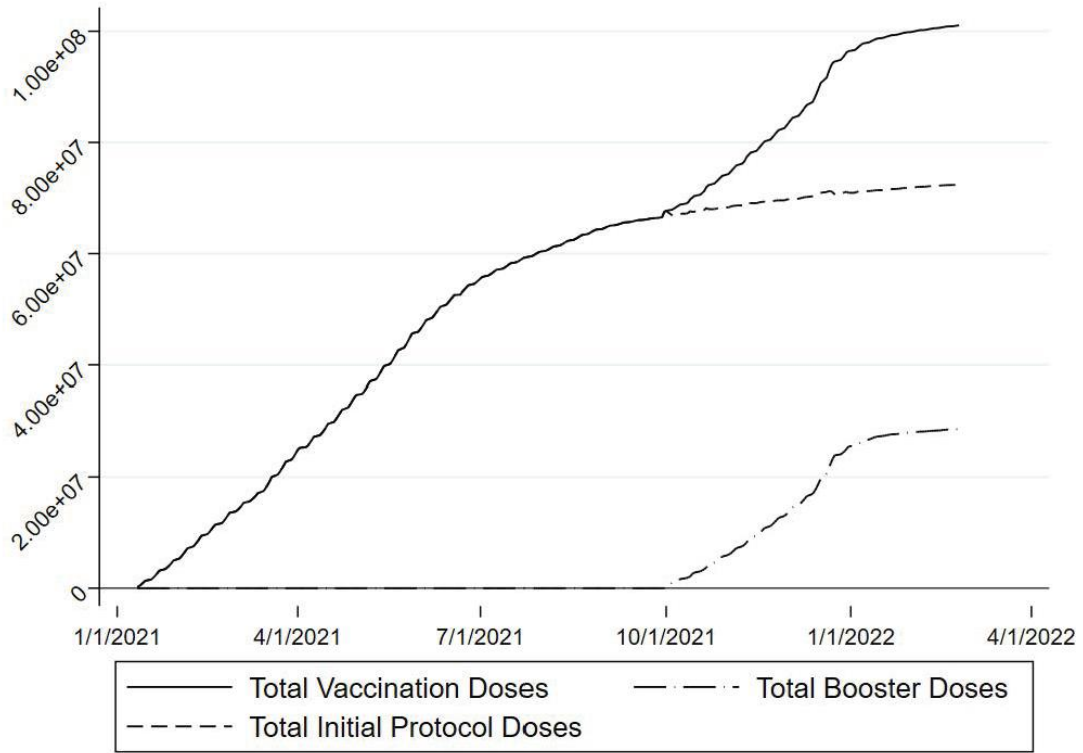
during the first half of 2021, subsequently entering a phase of volatility fluctuating around 10%. By the end of 2021, it begins a downward trend marked by fluctuations.

Fig 1. Cumulative average daily returns.



Figure 2 shows the overall vaccine doses administered in the UK, including both initial and booster shots. The figure reveals two major surges in the total vaccination count. The first surge corresponds to the initial rollout of the vaccine, while the second one is observed in January 2021. Examining the individual curves for initial and booster vaccinations, it becomes clear that the first upswing is driven by the administration of initial doses. The second surge can largely be attributed to the increased administration of booster shots, as the number of initial doses began to plateau from July 2021 onwards.

Fig 2 Total vaccine, booster and initial protocol doses



Combining the insights from Figures 1 and 2, it is observed that during the phase of rapid growth in vaccine doses, the accelerated pace of vaccinations aligns with the upward trend of cumulative stock returns, suggesting a positive relationship. However, in the second phase when the administered vaccines mainly consist of booster doses, the relationship appears to be negatively correlated. This implies that the relationship between vaccination and stock market returns is multifaceted and requires a more in-depth analysis, which this paper provides in the next section.

Table 2 presents the summary statistics of the data included. It can be seen that the average stock returns during this period are positive, with a maximum value of 9.27% and a minimum of -7.99%. Moreover, the data show leptokurtic and positively skewed distribution, a common feature observed in stock market data.

Table 2. Summary statistics.

	Mean	Median	SD	Min	Max	Skewness	Kurtosis
R	0.009	0.00	2.30	-7.99	9.27	0.39	7.74
LMCAP	4.29	4.56	2.91	-9.21	11.97	-0.68	4.29
PB	4.26	1.73	8.60	0.13	67.56	5.45	36.97
LVAC	12.54	12.73	0.70	10.74	13.88	-0.71	2.71
LVACI	11.99	12.21	1.00	9.93	13.52	-0.15	1.57
LVACB	12.10	12.40	1.01	10.15	13.79	-0.48	2.07
OxCGR	54.39	43.98	17.21	29.05	87.96	0.88	2.45

Note: R is the daily stock return, LMCAP is the natural logarithm of daily firm market capitalization, PB is the price-to-book ratio, LVAC is the natural logarithm of new vaccine doses, LVACI is the natural logarithm of new initial protocol doses, and LVACB is the natural logarithm of new booster doses.

Table 3 shows the correlations between the core variables. There is a positive, albeit small in absolute terms, correlation between stock returns and vaccination. Observing the correlation coefficients between the independent variables, it was found that the correlations are small in absolute values, so we conclude that there is no problem of multicollinearity. The complete correlation test among all variables is presented in the appendix.

Table 3 Correlation matrices results for core variables

	R	LMCAP	PB	LVAC
R	1.0000			
LMCAP	0.0085***	1.0000		
PB	-0.0014	0.019***	1.0000	
LVAC	0.0283***	0.0107***	0.0075***	1.0000

Note: R is the daily stock return, LMCAP is the natural logarithm of daily firm market capitalization, PB is the price-to-book ratio, and LVAC is the natural logarithm of new vaccine doses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Empirical Analysis

This section delves into the selection of the appropriate model for estimating the panel data and the empirical results derived from the data.

5.1 Model selection

To select the appropriate model to estimate the panel data, this study conducted the F-test, the BP-LM test and the Hausman test. The results are shown in the appendix. For each F-test, the p-value is 0.0000, rejecting the null hypothesis that the intercept terms are the same for different cross-sectional models, which considers the fixed-effects model to be more appropriate than POLS (pooled ordinary least squares); in each LM-test, the p-value of 0.0000 rejects the null that $\text{Var}(u)=0$, considering the random effects model to be more appropriate than POLS. Then, the Hausman test is used to compare fixed effects and random effects models. The p-value of 0.0000 rejects the hypothesis that the coefficients in the random effects model are unbiased and considers the fixed-effects model to be more appropriate. In summary, the fixed effects model is chosen for regressions.

5.2 Benchmark results

First, the daily new vaccine doses are used to find the effect of vaccination on stock returns. This study estimated the regression equation as:

$$R_{i,t} = \alpha_0 + \beta_1 LVAC_{t-1} + \theta_1 LMCAP_{i,t-1} + \theta_2 PB_{i,t-1} + \eta_{i,t}, \quad (6)$$

where $R_{i,t}$ represents the stock return of company i at day t , $LVAC_{t-1}$ is the logarithm of daily new vaccine doses at day $t-1$, $LMCAP_{i,t-1}$ denotes the logarithm of the daily market capitalization of the company i at day $t-1$, $PB_{i,t-1}$ stands for the price-to-book ratio of the company i at day $t-1$, $\eta_{i,t}$ is the error term.

Table 4 reports the results. The effect of the vaccine doses is always positive and stable across different specifications. A unit increase in the logarithm of vaccine doses causes an increase of between 0.058p.p and 0.085p.p. in stock returns, with all the estimators statistically significant.

Table 4. Regressions with daily new vaccine doses.

	(1)	(2)	(3)
LVAC	0.0653*** (0.0043)	0.0584*** (0.0048)	0.0850*** (0.0071)
LMCAP		-0.2605*** (0.0097)	-0.7646*** (0.0222)
PB			-0.0042*** (0.0013)
α_0	-0.8007*** (0.0534)	0.4023*** (0.0747)	2.7886*** (0.1422)
Obs	575,011	502,357	270,887

Note: LVAC is the natural logarithm of new vaccine doses, LMCAP is the natural logarithm of daily firm market capitalization, and PB is the price-to-book ratio. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.3 Initial protocol and booster doses

Next, to explore whether different stages of vaccination affect stock market returns to different extents, we split the vaccine doses into initial protocol doses and booster doses. The regression model is specified as:

$$R_{i,t} = \alpha_0 + \beta_1 LVACI_{t-1} + \beta_2 LVACB_{t-1} + \theta_1 LMCAP_{i,t-1} + \theta_2 PB_{i,t-1} + \eta_{i,t}, \quad (7)$$

where $LVACI_{t-1}$ is the logarithm of daily new initial protocol doses at day $t-1$, and $LVACB_{t-1}$ denotes the logarithm of daily new booster doses at day $t-1$.

Table 5. Regressions with new initial protocol and booster doses.

	(1)	(2)	(3)
LVACI	0.0781*** (0.0053)	0.0699*** (0.006)	0.0961*** (0.0089)
LVACB	0.0056*** (0.0009)	0.0068*** (0.001)	0.0045*** (0.0015)
LMCAP		-0.2547***	-0.7633***

		(0.0098)	(0.0222)
PB			-0.0050***
			(0.0013)
α_0	-0.9410***	0.2435***	2.6809***
	(0.0671)	(0.0884)	(0.1591)
Obs	214,376	188,610	99574

Note: LVACI is the natural logarithm of daily new initial protocol doses, and LVACB is the natural logarithm of daily new booster doses. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5 shows the results of regressions with the new initial protocol and booster doses. The coefficients for both doses are consistently positive. However, the effect of the initial protocol dose is markedly higher than the effect of the booster dose. A 1% increase in the logarithm of the initial protocol doses is associated with a 0.07-0.1p.p. increase in stock market returns, while a 1% increase in the logarithm of the booster doses is associated with an approximate 0.005-0.007p.p. increase in returns.

5.4 Lockdown stringency

Then, we study whether the effects work differently depending on the overall pandemic situation. The stringency index in OxCGRT is used to stand for the severity of closure policies. We interact this variable with the logarithm of daily new vaccines. The regression is estimated as follows:

$$R_{i,t} = \alpha_0 + \beta_1 LVAC_{t-1} + \beta_2 OxCGRT_{t-1} + \beta_3 LVAC_{t-1} \times OxCGRT_{t-1} + \theta_1 LMCAP_{i,t-1} + \theta_2 PB_{i,t-1} + \eta_{i,t}, \quad (8)$$

where $OxCGRT_{t-1}$ is the stringency index in the Oxford COVID-19 Government Response Tracker at day t-1, $LVAC_{t-1} \times OxCGRT_{t-1}$ is the interaction term of the natural logarithm of daily new vaccine doses and the stringency index.

Table 6 presents the results of regressions considering the stringency index. From Column (2), it can be observed that the coefficient of OxCGRT is 0.1194, indicating a positive impact of containment and closure policies on stock returns. However, the coefficient of the interaction term is -0.0094, indicating that the positive impact of vaccine doses on stock returns weakens with the strengthening of containment policies.

Table 6. Regressions with OxCGRT interaction term.

	(1)	(2)
LVAC	0.0805*** (0.0079)	0.4896*** (0.0286)
OxCGRT	0.0004 (0.0003)	0.1194*** (0.0080)
LVAC*OxCGRT		-0.0094*** (0.0006)

LMCAP	-0.7606*** (0.0224)	-0.7702*** (0.0224)
PB	-0.0043*** (0.0013)	-0.0044*** (0.0013)
α_0	2.8016*** (0.1426)	-2.3234*** (0.3731)
Obs	270,887	270,887

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5.5 Industry and Sector Analysis

To discuss whether the influence of vaccines is different in different industries and sectors, we first add dummy variables for the supersector (industry), and then dummy variables for selected sectors, together with their interactions with the vaccines variable. The next estimated regression accounts for the different effects of vaccinations in different supersectors:

$$R_{i,t} = \alpha_0 + \beta_1 LVAC_{t-1} + \beta_2 LVAC_{t-1} \times SS_{i,j} + \alpha_1 LMCAP_{i,t-1} + \alpha_2 PB_{i,t-1} + \eta_{i,t}, (9)$$

where $SS_{i,j}$ are the dummy variables representing firms in six different supersectors

(industries): Healthcare, Basic Resources, Food Beverage and Tobacco, Financial Services, Travel and Leisure, and Real Estate.

Table 7 displays the results of regression with supersectors dummy variables. By interpreting the sign and magnitude of the interaction coefficient we can establish, whether vaccinations have a greater or lower impact on firms in this supersector compared to the average. The interaction coefficient in the Healthcare industry is positive and statistically significant. This indicates that daily new vaccine doses have an additional 0.09p.p. positive effect on the return of stocks from the healthcare industry than of stocks from all other industries. A unit increase in the logarithm of vaccine doses is associated with a 0.17p.p. total increase in the healthcare industry's stock returns. The interaction coefficient in Basic Resources is negative and statistically significant, suggesting that the positive effect of vaccine doses on the Basic Resources industry is weaker compared to the other industries. The overall effect of vaccine doses on the basic resources industry is still positive: a unit increase in LVAC is associated with a 0.01p.p. increase in market returns of the basic resources industry. Similarly, the interaction coefficient is negative in the Food Beverage and Tobacco supersector. The interaction coefficient is negative in Real Estate and positive in Financial Services and Travel and Leisure. However, these three effects are not statistically significant, so these results should be interpreted with care.

Table 7. Regressions with supersectors dummy variable interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
LVAC	0.0770* ** (0.0074)	0.0926*** (0.0075)	0.0868*** (0.0072)	0.0840*** (0.0076)	0.0837*** (0.0073)	0.0849*** (0.0074)
LVAC* HEALTHCARE	0.0976* ** (0.0265)					
LVAC*BASIC RESOURCES		-0.0803*** (0.0239)				
LVAC*FOOD BEVERAGE AND TOBACCO			-0.0752* (0.0431)			
LVAC* FINANCIAL SERVICE				0.0060 (0.0220)		
LVAC*TRAVEL AND LEISURE					0.0220 (0.0340)	
LVAC*REAL ESTATE						-0.0026 (0.0279)
LMCAP	- 0.7660* ** (0.0222)	-0.7628*** (0.0222)	-0.7634*** (0.0222)	-0.7631*** (0.0222)	- 0.7632*** (0.0222)	-0.7632*** (0.0222)
PB	- 0.0043* ** (0.0013)	-0.0041*** (0.0013)	-0.0042*** (0.0013)	-0.0042*** (0.0013)	- 0.0042*** (0.0013)	-0.0042*** (0.0013)
α_0	2.8000* ** (0.1423)	2.7837*** (0.1423)	2.7867*** (0.1423)	2.7852*** (0.1423)	2.7857*** (0.1423)	2.7856*** (0.1424)
Obs	270,417	270,417	270,417	270,417	270,417	270,417

Note: LVAC*HEALTHCARE, LVAC*BASICRESOURCES, LVAC*FOOD BEVERAGE AND TOBACCO, LVAC*FINANCIAL SERVICE, LVAC*TRAVEL AND LEISURE, LVAC*REAL ESTATE is the interaction term of the natural logarithm of daily new vaccine doses and dummy variable of healthcare, basic resources, food beverage and tobacco, financial service, travel and leisure and real estate supersector, respectively. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

To discuss further how the Healthcare and Basic Resources industries are affected by vaccinations, we investigate the specific effects in six sectors of these two supersectors, using regression equation (9), and substituting supersectors dummy variables with dummy variables for specific sectors, three in Healthcare: Healthcare Providers, Medical Equipment and Services, Pharmaceuticals and Biotechnology, and

three in Basic Resources: Industrial Materials, Industrial Metals and Mining, Precious Metals and Mining.

The results of regressions are presented in Table 8. The interaction coefficients for the three sectors in the Healthcare industry are all positive and statistically significant, with values of 0.1804, 0.1245, and 0.0642 respectively. This indicates that all these sectors experience additional positive effects from vaccine doses than other sectors, which aligns with the direction of impacts on the Healthcare industry as a whole. Among them, the Healthcare Providers sector exhibits the highest extra positive influence, followed by the Medical Equipment and Services.

Table 8. Regressions with sectors dummy variable interaction term.

	(1)	(2)	(3)	(4)	(5)	(6)
LVAC	0.0829*** (0.0072)	0.0825*** (0.0072)	0.0814*** (0.0073)	0.0845*** (0.0072)	0.0898*** (0.0074)	0.0883*** (0.0073)
LVAC*HEALTHCARE PROVIDERS	0.1804** (0.0715)					
LVAC*MEDICAL EQUIPMENT AND SERVICES		0.1245** (0.0539)				
LVAC*PHARMACEUTICALS AND BIOTECHNOLOGY			0.0642** (0.0325)			
LVAC*INDUSTRIAL MATERIALS				0.1116 (0.1089)		
LVAC*INDUSTRIAL METALS AND MINING					-0.0760*** (0.0294)	
LVAC*PRECIOUS METALS AND MINING						-0.1035** (0.0406)
LMCAP	-0.7635*** (0.0222)	-0.7638*** (0.0222)	-0.7645*** (0.0222)	-0.7647*** (0.0222)	-0.7651*** (0.0222)	-0.7637*** (0.0222)
PB	-0.0043*** (0.0013)	-0.0043*** (0.0013)	-0.0042*** (0.0013)	-0.0042*** (0.0013)	-0.0042*** (0.0013)	-0.0041*** (0.0013)
α_0	2.7871*** (0.1423)	2.7887*** (0.1423)	2.7922*** (0.1423)	2.7891*** (0.1422)	2.7911*** (0.1422)	2.7839*** (0.1422)
Obs	270,417	270,417	270,417	270,887	270,887	270,887

Note: LVAC*HEALTHCARE PROVIDERS, LVAC*MEDICAL EQUIPMENT AND SERVICES, LVAC*PHARMACEUTICALS AND BIOTECHNOLOGY, LVAC*INDUSTRIAL MATERIALS, LVAC*INDUSTRIAL METALS AND MINING, LVAC*PRECIOUS METALS AND MINING is the interaction term of the natural logarithm of daily new vaccine doses and dummy variable of healthcare providers, medical equipment and services, pharmaceuticals and biotechnology, industrial materials, industrial metals and mining as well as precious metals and mining sector, respectively. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The excess influence of vaccinations on the returns in the Healthcare industry can be explained from the perspectives of these three sub-sectors. As the primary entities administering vaccines, healthcare providers experience a surge in patient visits, leading to increased revenues. Whilst their staff was among the first to be vaccinated, these providers can maintain consistent operations without significant disruptions from COVID-19 outbreaks, ensuring a steady flow of services and revenues. Then, the massive vaccination campaign led to a heightened demand for medical equipment, benefiting manufacturers and suppliers. Finally, pharmaceutical and biotechnology companies that have successfully developed and received approval for their COVID-19 vaccines can achieve substantial revenues from vaccine sales.

The Industrial Metals and Mining sector and Precious Metals and Mining sector, receive weaker positive influences from vaccinations, consistent with the results in Basic Resources supersector. The coefficient for the interaction term of Industrial Materials, at 0.1258, implies an additional positive impact. However, the coefficient is not statistically significant, so caution should be exercised in interpretation.

The weaker overall impact of vaccinations in the Basic Resources industry may stem from the fact, that the demand for basic resources, as well as food and beverages, is considered essential, leading to these industries experiencing a relatively milder impact during the early stages of the pandemic (Zhang et al., 2022). While other sectors witness an immediate surge in demand post-vaccination, the demand for these industries remains stable.

6. Discussion

Our benchmark regression analysis reveals a positive relationship between daily new vaccine doses and stock returns, aligning with Unal et al. (2022) but contrasting with Oanh (2022), who pointed out a negative effect in developed countries. This further confirms the hypothesis of this study: the impact of vaccines on stock market returns varies across countries.

Our further analysis differentiates between initial protocol and booster doses, indicating a stronger positive effect on stock returns during early vaccination stages. This suggests the market views the initial vaccine rollout as a stronger economic recovery indicator, which constitutes a new finding.

With the consideration of closure policies, we observe that stringent closure policies have a positive effect on stock returns, consistent with the findings of Baker (2020) and Ashraf (2020b) but weaken the positive impact of daily new vaccine doses on stock returns, which is new finding in the literature. A possible explanation is that under strict lockdown policies, the societal impact caused by the spread of the virus is limited, and thus the beneficial effects of vaccines in mitigating the pandemic are also

limited.

Industry-wise, it was found that vaccination positively impacts all industries, with the healthcare industry benefiting more significantly which is consistent with the findings of Jeremiah et al. (2023), and this trend is consistent across its sub-industries. The excess returns of the healthcare industry can be explained from the perspectives of three sub-sectors. As the primary entities administering vaccines, healthcare providers experience a surge in patient visits, leading to increased revenues. Whilst their staff was among the first to be vaccinated according to the advice from the Joint Committee on Vaccination and Immunisation (JCVI)⁷, these providers can maintain consistent operations without significant disruptions from COVID-19 outbreaks, ensuring a steady flow of services and revenues. Then, the massive vaccination campaign leads to a heightened demand for medical equipment, benefiting manufacturers and suppliers. Finally, pharmaceutical and biotechnology companies that have successfully developed and received approval for their COVID-19 vaccines can achieve substantial revenues from vaccine sales.

Conversely, basic resources, including its sub-sectors, and the food, beverage, and tobacco industries exhibit a positive effect that is less pronounced than in other sectors, attributed to the essential nature of their demand. Ours is the first study to document these facts using stock-level data, rather than index- or industry-level.

The study has certain limitations. As it focuses on the UK market, its conclusions may not be readily applicable to other regions. Additionally, stock market returns are determined by a multitude of factors. There might be other significant factors unrelated to the pandemic or events concurrent with the pandemic that have not been considered in the current study which could introduce bias or errors, although by a large set of observations and fixed-effects estimation techniques, we believe that any potential bias is minimal.

7. Conclusions

This study systematically examines the impact of COVID-19 vaccines on stock returns in the UK, employing a nuanced approach that considers vaccination stages, lockdown policies, and sector-specific dynamics. The findings show a positive relationship between daily new vaccine doses and stock returns, supporting the notion that vaccinations, by enhancing public health, stimulate economic recovery and improve expectations about future economic prospects.

⁷ GOV.UK: <https://www.gov.uk/government/publications/priority-groups-for-coronavirus-covid-19-vaccination-advice-from-the-jcvi-30-december-2020/joint-committee-on-vaccination-and-immunisation-advice-on-priority-groups-for-covid-19-vaccination-30-december-2020>

The differentiation between protocol and booster doses revealed that the market perceived the initial vaccine rollout as a stronger indicator of economic recovery and stability, with subsequent booster doses generating a relatively weaker market reaction. Incorporating the lockdown stringency measure added complexity to the analysis, demonstrating the nuanced interplay between closure policies and vaccine impact on stock returns. The exploration of industry-specific impacts unveiled the prominent positive influence in the healthcare industry, attributed to increased patient visits, consistent operations, and heightened demand for medical equipment. Conversely, basic resources and food, beverage, and tobacco industries exhibited less pronounced positive effects, reflective of their essential nature and stable demand during the pandemic.

In response to the pandemic, governments must implement timely closure policies and vaccination programs, particularly the initial protocol of vaccination, which are essential for the stabilization and revival of financial markets. As vaccines become more widely distributed, the positive impact of closure policies on financial markets gradually diminishes, making it a preferable option to gradually relax these policies at this time. Investors are recommended to allocate a portion of their portfolio to the healthcare sector during the pandemic. Healthcare stocks exhibited greater stability against the impacts of the pandemic and are likely to outperform during the recovery phase.

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8. Appendix

Table 9. Correlation matrices results for all variables.

	R	LMCAP	PB	LVAC	LVACI	LVACB	OGRT
R	1.0000						
LMCAP	0.0085***	1.0000					
PB	-0.0014	0.019***	1.0000				
LVAC	0.0283***	0.0107***	0.0075***	1.0000			
LVACI	0.0284***	0.0142***	-0.0021***	0.6042***	1.0000		
LVACB	0.0397***	0.0137***	0.0155***	0.9300***	0.2818***	1.0000	
OGRT	0.0277***	0.0131***	-0.0006	0.4701***	0.6353***	0.7881***	1.0000

Note: *** p<0.01, ** p<0.05, * p<0.1.

Table 10. Results of F-test, BP-LM test and Hausman test.

	F test	LM test	Hausman test
(7)	3.41 (0.0000)	1129.59 (0.0000)	1263.26 (0.0000)
(8)	2.74 (0.0000)	384.72 (0.0000)	953.32 (0.0000)
(9)	3.41 (0.0000)	1132.19 (0.0000)	1252.16 (0.0000)
(10)	3.42 (0.0000)	1130.33 (0.0000)	1260.88 (0.0000)

Note: This table shows the statistics of the F-test, BP-LM test and Hausman test for the first four formulas. The numbers in the first column correspond to formulas (7), (8), (9) and (10). P-value in parentheses.

Table 11. Results of F-test, BP-LM test and Hausman test for regression with supersector.

	F test	LM test	Hausman test
(1)	3.41 (0.0000)	1116.65 (0.0000)	1271.87 (0.0000)
(2)	3.40 (0.0000)	1103.67 (0.0000)	1261.77 (0.0000)
(3)	3.41 (0.0000)	1130.47 (0.0000)	1259.90 (0.0000)
(4)	3.41 (0.0000)	1132.56 (0.0000)	1256.79 (0.0000)
(5)	3.41 (0.0000)	1131.69 (0.0000)	1257.10 (0.0000)
(6)	3.41 (0.0000)	1126.56 (0.0000)	1257.09 (0.0000)

Note: P-value in parentheses. The numbers in the first column correspond to the six regressions in formula (12).

Table 12. Results of F-test, BP-LM test and Hausman test for regression with sector.

	F test	LM test	Hausman test
(1)	3.42 (0.0000)	1132.25 (0.0000)	1263.89 (0.0000)
(2)	3.41 (0.0000)	1124.66 (0.0000)	1263.13 (0.0000)
(3)	3.41 (0.0000)	1123.82 (0.0000)	1261.14 (0.0000)
(4)	3.41 (0.0000)	1129.31 (0.0000)	1264.32 (0.0000)
(5)	3.41 (0.0000)	1116.80 (0.0000)	1265.49 (0.0000)
(6)	3.40 (0.0000)	1110.70 (0.0000)	1268.27 (0.0000)

Note: P-value in parentheses. The numbers in the first column correspond to the six regressions in formula (13).