Research of the Impact of COVID-19 on the Retail and Stock Market based on Large Scale Retail and Sales Data Analysis

Yiming Wei
wyiming2022@163.com

Xi'an Kang Qiao School

Abstract- The COVID-19 global outbreak has been proven to be one of the most devastating events in human history. This article exams its impact on the UK, particularly the retail sales and stock markets. The classical theory of Efficient Market Hypothesis is overviewed and its validity and reliability of explaining the market behaviour is investigated. A novel methodology based on behavioural finance utilising Google Trends service is advocated as a superior mechanism to explicate the UK stock market during the COVID-19 pandemic instead of the traditional financial theory. The innovative approach is assessed by the Granger causality and is found to be statistically efficient. The practical way of constructing and validating the behavioural index is discussed in detail.

Keywords- behavioural finance; retail sales index; FTSE 100; autocorrelation; Ljung-Box test; Google Trends; coronavirus search volumn index; efficient market hypothesis; Granger causality

1 INTRODUCTION

The unfolding global pandemic of coronavirus disease 2019 (COVID-19) was precipitated by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) which was first detected in December 2019. Within a couple of months, it rapidly spread around the world and has resulted in colossal loss of lives and relentless global social and economic turmoil. COVID-19 symptoms could be life-threatening, although severe illness is regularly associated with older adults and people with underlying medical conditions. As of 16 August 2021, more than 4 million deaths have been confirmed, which makes it one of the deadliest pandemics in history.

The impact of the coronavirus pandemic on the global economy is immense, causing omnipresent supply shortages and the greatest global recession since the Great Depression in the 1930s. This article attempts to study such impact by inspecting the reactions of the retail and stock markets, which are the most sensitive, to the pandemic, and explain them by the approach of behavioural finance instead of traditional financial theories. To do so, we focus on the situation in the United Kingdom, not only because the UK has been one of the worst hit countries by the pandemic in terms of death toll and GDP decline, but also the UK possess some of the most advanced retail and financial markets in the world.

In this article, we first outline the COVID-19 outbreak in the UK and its impact on the retail and stock markets.

ICEMME 2022, November 18-20, Nanjing, People's Republic of China

DOI 10.4108/eai.18-11-2022.2326864

Thereafter, the traditional financial theory, in particular the Efficient Market Hypothesis, is briefly introduced and its applicability during the pandemic is inspected. Finally, the approach from behavioural finance is employed to create a fear index based on internet searching activities and its usage of understanding the UK stock market is explored.

2 COVID-19 IMPACT ON THE UNITED KINGDOM ECONOMICS AND STOCK MARKET

2.1 COVID-19 outbreak in the United Kingdom

The first coronavirus case in the UK was reported on 31 January 2020, and the virus rapidly spread throughout the country and became one of the most predominant diseases in the UK in March. The UK government imposed nationwide lockdown in March and banned all non-essential travel and human contact. Almost all schools and businesses were shut down, and anyone with the symptoms was told to self-isolate. The lockdown was lifted in summer and most schools were re-opened in September. However, cases and deaths rose significantly in the winter and parts of the country went into lockdown again in November. A third lockdown was enforced in January 2021 for the whole UK and a nationwide campaign for vaccination started. So far, the UK has one of the highest vaccination rates in the world and the successful mass vaccination program enabled the government to lift all mandatory restrictions in late July 2021.

In addition to the major strain on the UK's healthcare service, the pandemic has had calamitous and far-reaching impacts on the UK’s economy and society, causing enormous disruptions to education, putting severe strain on the UK’s health care service, and resulting in more than 6.5 million confirmed cases and 130 thousand deaths so far.

2.2 Impact on the UK economics - retail sales

As an important part of the UK economy, the retail industry consists of more than 5% of the UK GDP and has been massively affected by the pandemic, due to the lockdown restrictions and the social distancing. Many non-essential retail stores were forced to close on 23 March 2020 and only allowed to reopen in June with restrictions in place. The second lockdown later in 2020 worsened the situation even further. The impact can be distinctly perceived from the official retail sales figures, which reveal a 1.9% drop of total volume of retail sales in 2020 compared with that in 2019, the largest plummet since records began.

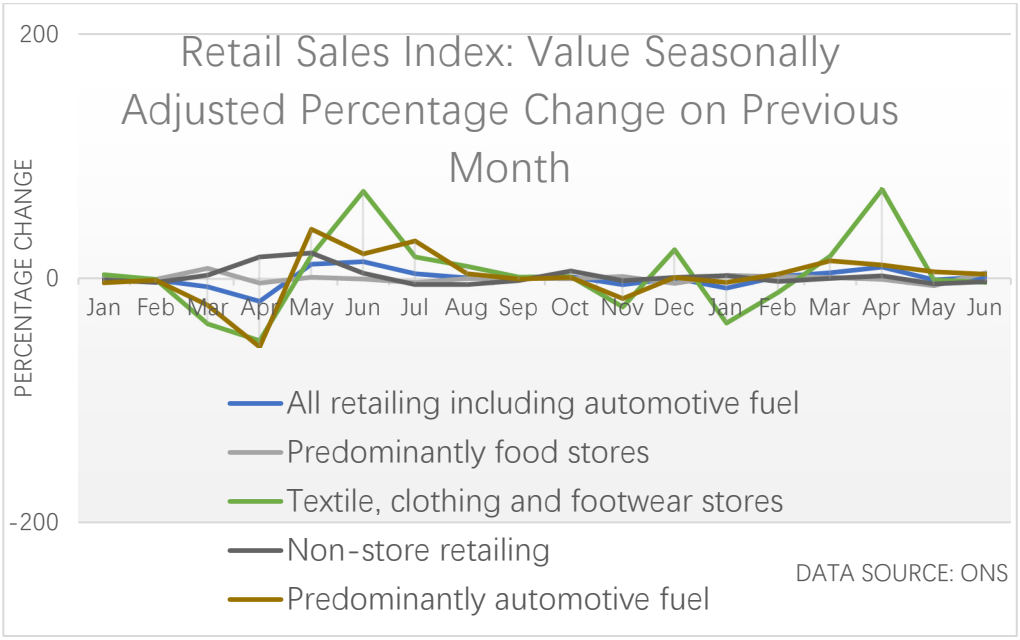

Figure 1. Retail Sales Index: Value Seasonally Adjusted Percentage Change on Previous Month (January 2020-June 2021)

We gather the retail sales data from ONS[1] to study the behaviour of different retail sectors. Fig. 1 shows the monthly percentage change of the retail sales value after seasonal adjustment, from the start of COVID-19 in January 2020 until June 2021 (Figure 1). It can be demonstrated that, while the essential food sales remained largely unaffected, non-essential retail sales, such as 'Textile, clothing and footwear stores', had fluctuated dramatically during the period of interest. The automotive fuel and clothing sales suffered massively in March-April, at the beginning of pandemic, which was caused by the nationwide lockdown imposed in March. Unsurprisingly, the Non-store retailing sales increased significantly in the same period as most people conducted purchases online. Interestingly, the clothing sales bounced back remarkably not only after the first lockdown, but also in April 2021. This indicates that, due to the fiscal policy and financial support of the UK government, the household finance and purchasing power in the UK had been in good shape throughout the pandemic.

In order to understand the distinguishable change of the retail sales market during the pandemic, we compute relevant statistics to further investigate the pattern. Specifically, we apply the analysis of correlation for historical sales between different retail sectors before the pandemic and compared with the correlation obtained during the pandemic. We apply the Pearson correlation formula for calculating the sample correlation, i.e., given two sets of sample data with N data each, $\{x_1, x_2, \dots, x_N\}$ and $\{y_1, y_2, \dots, y_N\}$, the sample correlation $\rho_{x,y}$ between these two sets of data is computed as follows:

[1] Office for National Statistics: the executive office of the UK Statistics Authority reporting directly to the UK Parliament

$$\rho_{x,y} = \frac{\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{N}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{N}(y_i - \bar{y})^2}} \quad (1)$$

where $\bar{x} = \frac{1}{\mathrm{N}}\sum_{i=1}^{N} x_i$ and $\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$ are the averages of the two sets of sample data.

The calculated results are displayed in the two tables below. It can be illustrated that, the sales of the three non-essential retail sectors, 'Household goods', 'Predominantly automotive fuel' and 'Textile, clothing and footwear stores' are statistically independent to each other before the pandemic, since their inter-correlation are less than 30% which is generally regarded as no or very weak relationship. However, during the pandemic period, the table demonstrates that the inter-correlation of those three sectors became strongly and positively correlated. This reinforces the observation that the pandemic has been affecting the non-essential retails market in a unique way which provoked similar reactions from those sectors.

TABLE 1: CORRELATION OF SALES (PRE COVID-19)

Correlation of sales value monthly change across different retail sectors (pre COVID-19, January 1996 – December 2019)	Predominantly food stores	Household goods stores	Predominantly automotive fuel	Textile, clothing and footwear stores	Non-store retailing
Predominantly food stores	1	-5%	17%	28%	-16%
Household goods stores	-5%	1	-2%	3%	14%
Predominantly automotive fuel1	17%	-2%	1	16%	-5%
Textile, clothing and footwear stores	28%	3%	16%	1	1%
Non-store retailing	-16%	14%	-5%	1%	1

TABLE 2: CORRELATION OF SALES (COVID-19)

Correlation of sales value monthly change across different retail sectors (COVID-19, January 2020 – June 2021)	Predominantly food stores	Household goods stores	Predominantly automotive fuel	Textile, clothing and footwear stores	Non-store retailing
Predominantly food stores	1	-4%	-9%	-27%	-1%
Household goods stores	-4%	1	84%	71%	3%
Predominantly automotive fuel	-9%	84%	1	69%	-13%
Textile, clothing and footwear stores	-27%	71%	69%	1	-10%
Non-store retailing	-1%	3%	-13%	-10%	1

2.3 Impact on the stock market - FTSE 100

As COVID-19 catalyzed the severe slowdown of economic activities, the impact on the GDP growth and the stock market performance was catastrophic. In early April, it was predicted that unemployment could rise to 3.4 million and the GDP could fall by 35% during the second quarter. Indeed, the GDP only fell about 20% during the second quarter, but this was enough to establish it as the worst reduction of quarterly growth since records began in 1955. The UK stock market also fell sharply at the beginning of the pandemic, although later rebounded substantially.

To exam the behavior and performance of the UK stock market, in this article we utilise the FTSE 100 Index as the proxy of the overall UK stock market. The FTSE 100 comprises the largest 100 qualifying UK companies by market value, many of which focus internationally and therefore represents the UK economic less than other indices such as the FTSE 250. Nevertheless, since FTSE 100 is by far the most recognized UK stock market indicator, we adopt it in our analysis.

The FTSE 100 index only captures market prices of the underlying stocks, while the incomes such as dividend from the stocks are not incorporated into the index level. As a direct consequence, the index value does not represent the total return of holding the underlying assets. Henceforth, this article chooses the 'iShares FTSE 100 ETF GBP Acc' to characterize the total return of the FTSE 100, which is very liquid in trading and its Net Asset Value (NAV) has been closely matching the actual total return of the FTSE 100. From now on, the NAV of the FTSE 100 ETF and the total return of the FTSE 100 are used throughout this article interchangeably.

Fig. 4 displays the NAV time series of the FTSE 100 ETF since the inception of the pandemic until recent days. While the stock market had suffered record loss, the sell-off only started on 24 February 2021, when coronavirus had already forced China into a dreadful lockdown and spread around the world. Since January 2021, there had been enormous studies which suggested that a disastrous global pandemic was imminent and calamitous economic slowdown was almost unavoidable. However, despite all those formidable warnings, the UK stock market had been peculiarly calm until late February. This indicates that the widely available and largely accurate information at the time was not incorporated into the stock market valuation.

2.4 Relation between the FTSE 100 and the retail sales

Aiming to further investigate the stock market behaviour, Fig. 2 shows the monthly FTSE 100 return against the monthly change of the retail sales and the COVID-19 death cases. As evidenced by the figure, retail sales by and large had been in sync with the death cases, i.e., higher death toll typically led to a slump of retail sales. On the contrary, the stock market initially followed the similar pattern as the retail sales, but during the period of the second and third lockdowns, the FTSE 100 grew remarkably while deaths ascended to a record high, and the retail sales plunged dramatically. This again hints that

Figure 2. Retail sales value change vs FTSE 100 total return

the stock market might not factor in all available information and acted irrationally.

3 STATISTICAL TESTS FOR THE EFFICIENCY OF THE FTSE 100

3.1 Efficient Market Hypothesis

As discussed in the last section, the UK stock market did not seem to act upon all available information. In this section, we endeavor to explore this by applying statistical tools.

One of the most prominent theory of the stock market is the Efficient Market Hypothesis (EMH) [1], which states that stock prices reflect all information at any given time. According to the theory, in an efficient market, investors are rational and consider all available information relevant to the future profitability of any company and are only willing to hold a stock at its intrinsic value which is measured by the future discounted value of cashflows benefiting the investors. Any added information which alters the expectation of a company's profitability leading to amendment of future cashflows to the investors, must be immediately embedded into the stock price, as any delay would yield irrationality.

Consequently, if the stock market is efficient, the market price of a stock must reflect its intrinsic value. Hence, at any time in an efficient market, stock prices only change according to the relevant latest information. Because information generally arrives unpredictably, the stock price fluctuation should manifest a random walk and the returns resemble white noises in an efficient market. Reference [2] studied this theory in the context of European stock markets.

3.2 Autocorrelation test of EMH for the FTSE 100

With the aim of testing whether the UK stock market satisfied with EMH during the pandemic, we can exam whether the FTSE 100 return time series in that period amounted to a random walk. To this end, we employ the autocorrelation analysis to statistically study the returns. Denote the FTSE 100 return time series as r_t, the k-lag autocorrelation ρ_k of r_t is defined by

$$\rho_k = \frac{\sum_{t=1}^{N-k}(r_t - \bar{r})(r_{t+k} - \bar{r})}{\sum_{t=1}^{N}(r_t - \bar{r})^2} \tag{2}$$

where $\bar{r} = \frac{1}{\mathrm{N}}\sum_{t=1}^{N} r_t$ is the sample average. Intuitively, the autocorrelation signifies whether the time series data is correlated to its previous values with k-lag. Based on the formula above, the autocorrelations from 1 to 30 lags are revealed in Fig. 3.

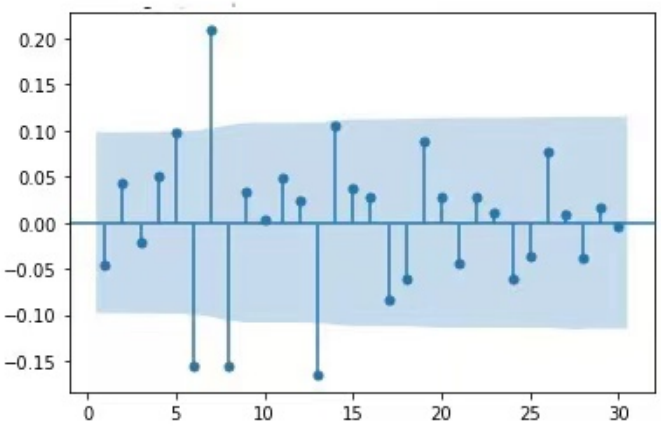

Figure 3. Autocorrelation of FTSE 100 Return

Now we apply the Ljung-Box test to statistically verify whether autocorrelation exists in the FTSE 100 return time series. Usually the time series entering into the Ljung–Box test is not the original one, but the residuals from a calibrated Autoregressive Integrated Moving Average (ARIMA) model. Here we first fit an ARIMA (1,0,1) model to the FTSE 100 return time series, and then apply the following hypotheses in the Ljung-Box test:

- H_0 : the residuals of the FTSE 100 return are independently distributed
- H_A : the residuals are not independently distributed which exhibit autocorrelation

The Ljung-Box test result is recorded in Table 3, and the p-value of no autocorrelation is much smaller than 0.05, and therefore the result suggests that the null hypothesis H_0 should be rejected and the FTSE 100 return during the period of the inspection is unlikely to be a random walk, which contradicts the EMH theory. In other words, the UK stock market is inefficient and irrational during the aforementioned period, in a statistical sense.

TABLE 3: LJUNG-BOX TEST

No autocorrelation exists in the residual of the FTSE 100 return time series		
Lag	**Ljung-Box test statistic**	**p-value**
30	68.894616	0.000068

4 EXPLAIN THE STOCK MARKET BY BEHAVIOUR INDEX

4.1 Behaviour measurement by searching index

As discussed in the last section, the stock market did not behave as depicted in the EMH. On the other hand, the market dynamics had been clearly connected to the health risk driven by COVID-19. The fear of the health risk from coronavirus and of the economic consequence of

lockdown would lower investors' expectation of companies' profitability which triggered downwards valuation of stock returns. This in turn precipitated the stock price plummet. So human fear, a concept in behavioural finance, would be superior to explain the stock market performance during this period, as discussed in [3]. To do that, we need to quantify the fear and create a fear index. The number of deaths caused by COVID-19 could be a candidate. However, as demonstrated in Fig. 2, the deaths ascended to a record high in earlier 2021 while the stock market made gain. Furthermore, in the summer months of 2020, deaths declined to the minimal, but the stock market sustained substantial loss. This signifies that the number of deaths may not be a good indicator of fear regarding coronavirus.

When people are afraid of something, they are psychologically driven to know more about it and to pay more attention to relevant news, which will lead to more searches on the internet, as discussed in [4]. Hence, utilising the Google search trend on coronavirus can be helpful to quantify the human fear. With that in mind, we create the Coronarius Search Volume Index (C-SVI) based on Google Trends service, which only provides 5 days aggregated interest for long periods. After scaling the index to reflect daily interest and considering the weekends when FTSE 100 were not traded, the daily C-SVI index time series aligned with the FTSE 100 return time series is established and plotted in Fig. 4 alone with the FTSE 100 ETF NAV and its returns. The biggest value of the C-SVI in a predefined period is 100 which represents the climax of the search interest. On the other hand, the lower values unveil the reduced interest proportionally.

Fig. 4 visualises a strong connection between the search interest of coronavirus and the dynamics of FTSE 100. When the search interest climbed to the top, the FTSE 100 suffered a record loss. When the search interest diminished later, the FTSE 100 recovered accordingly. From January to late February in 2020, the search index had been incredibly low which implies that people's concern to the virus in the UK remained insufficient even in the presence of numerous catastrophic warnings, which explains our earlier puzzle of why the UK stock market stayed unrattled in that period.

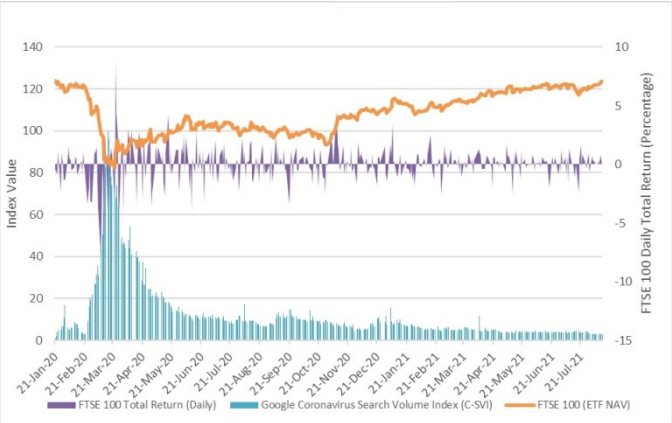

Figure 4. Fear of Covid-19 and Stock Market Reaction

As people became more knowledgeable and accustomed to coronavirus, the search interest naturally abated and became a less effective behaviour index to measure people's fear of the virus. As a result, in the subsequent study regarding the relationship between the FTSE 100

return and the C-SVI, we focus on the period from January 2020 until October 2020 when the usage of the C-SVI as a behavioural index is most appropriate.

4.2 Granger causality test to verify relationship between the behavioural index and the stock market return

In this section, we analyse the relationship between the two time series, the FTSE 100 return and the behavioural index C-SVI, during the aforementioned period, and try to draw a statistical conclusion on whether human behaviour regarding to the health risk concern, measured by the C-SVI, had been the underlying driving variable that caused the irrational and inefficient FTSE 100 returns as observed in previous sections.

To do that, we utilise the Granger causality test [5], which is used to determine if one time series will be useful to forecast another random variable by investigating the causality between them.

The intuition of the mechanism of the Granger causality is simple. For two given time series X and Y, if X causes Y, we can forecast Y better based on the previous values of both Y and X, than replying on the previous values of Yalone. Mathematically, this idea can be expressed formally as follows:

$$\mathcal{P}[Y(t+1) \in A|\mathcal{I}(Y,X)] \neq \mathcal{P}[Y(t+1) \in A|\mathcal{I}(Y)] \quad (3)$$

where $\mathcal{P}$ denotes probability, A is any set, $\mathcal{I}(Y,X)$ denote all the information available for both Y and X up to t, and $\mathcal{I}(X)$ denotes the information available only for Y up to t excluding X.

Conducting the Granger Causality statistical test generates the result shown in Table 4. As all the p-values across the lags are all below 0.05, we can conclude that the H_0 hypothseis should be rejected, and thus the C-SVI causes the FTSE 100 returns. In other words, the fear of coronavirus measured by the behavioural index based on the Google search, can be statistically stated as one of the significant underlying driving forces of the FTSE 100 dynamics during the period considered.

TABLE 4: GRANGER CAUSALITY

Causality: C-SVI does not Granger cause FTSE 100 returns		
Lags	**F statistic**	**p-value**
3	2.7697	0.0429
4	3.5575	0.0080
5	2.5339	0.0303
6	5.6577	0.0001
7	3.8214	0.0007
8	3.8531	0.0003
9	3.8478	0.0002
10	3.3850	0.0005

5 CONCLUSION

In this article, we have analysed the impact of COVID-19 on the UK retail sales and stock markets and shown the distinct pattern of the reaction of those markets. In addition, we have scrutinised the validity of the Efficient Market Hypothesis with respect to the FTSE 100 and provided evidence that the UK stock market was inefficient during the pandemic and proposed an alternative methodology based on the theory of behavioural finance to better explain the stock market dynamics. In this novel methodology, the fear index based on Google search of coronavirus is demonstrated to Granger cause the FTSE 100 returns.

REFERENCES

[1] E. F. Fama, "Efficient Capital Markets: A Review of Theory and Empirical Work." The Journal of Finance 25 (2): 383–417, 1970.

[2] M. R. Borges, "Efficient Market Hypothesis in European Stock Markets." The European Journal of Finance 16 (7): 711–726, 2010.

[3] Z. Da, J. Engelberg, P. Gao, "The Sum of All FEARS Investor Sentiment and Asset Prices." The Review of Financial Studies / v 28 n 1, 2015.

[4] V. Swamy, M. Dharani, F. Takeda, "Investor attention and Google Search Volume Index: Evidence from an emerging market using quantile regression analysis." Research in International Business and Finance Volume 50, Pages 1-17, December 2019.

[5] C. W. Granger, "Investigating Causal Relations by Econometric Models and Cross-spectral Methods." Econometrica: Journal of the Econometric Society 37 (3): 424–438, 1969.