Explain the US Stock Market's Evolution during the COVID-19 Pandemic: Using SVIX Index

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Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University, and, to the best of my knowledge and belief, contains no material published or written by another person, except where due reference is made in the thesis.

Siying Li

For Five Years at ANU (2017 – 2021)

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Abstract

I exploit Martin's (2016) proxy of the equity premium to examine the reasons behind the US stock market evolution during the COVID-19 pandemic. Based on Knox and Vissing-Jorgensen's (2021) decomposition of unexpected stock returns, I present that changes in the short-term equity premium can explain 58%–65% of the stock market evolution. I further construct an index (CARS) to reveal households' concerns about coronavirus using Google search as in Da et al. (2014). Results show that a standard deviation increase in CARS coincides with an increase of 7.05 basis points of contemporary change in the 1-month equity premium. My findings indicate that policymakers and investors should pay attention to aggregate market fears about the pandemic or other crisis events in the future. Additionally, the equity premium from 1996 to 2020 illustrates that the US stock market has different regimes during crisis and non-crisis periods, and the term structure of equity premium is procyclical.

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CHAPTER 1 – Introduction

The COVID-19 pandemic – the first caused by a coronavirus – has had a globally overwhelming impact. The World Bank stated that the economic recession induced by the COVID-19 pandemic is the worst global financial crisis since World War II (World Bank, 2020) – it only took the S&P 500 index 22 days since February 19, 2020 to fall 30%. The fastest 30% drop in US market history undoubtedly has attracted scholars' interest in investigating the causes behind the crash. A strand of recent literature has begun to document the evolution in stock returns during the pandemic (see Ding et al., 2020; Ramelli and Wagner, 2020); however, few researchers have examined direct factors affecting the stock market. Hence, I aim to find explicit evidence that variations in the discount rate had considerable effects on the stock market and investigate why the equity premium fluctuated over the COVID-19 pandemic.

Classical asset pricing theories conventionally assume that discount rates are constant or at least stable. As the stock price is defined as the value of future dividends discounted by expected returns, it was long believed that future dividends' changes are the only reason for the fluctuations in the stock price. However, Shiller (1981) points out that the volatility of the stock price is too high to be merely attributed to varied cash flows. As the equity premium is unobservable, Shiller (1981) does not prove that the stock price variance is associated with the equity premium. Campbell and Shiller (1988) derive an approach to measure the equity premium using the dividend-price ratio. Then Campbell (1991) decomposes the unexpected stock return into future cash flow variations and discount rate changes. Campbell's decomposition of stock returns guides scholars to find the causes of the US stock market's significant decline in February 2020. Gormsen and Koijen (2020) measure expected dividend growth using dividend futures, concluding that changes in expected dividends are not the reasons why the stock market crashed. Therefore, changes in discount rates may markedly account for the downturn.

The equity risk premium, or expected excess return, is a part of the discount rate, measuring the compensation investors require to take equity risks, hence reflecting investors' expectations. The equity premium is one of the key factors in financial research and is relevant to psychology. Economists have developed different methods of estimating the equity premium as it cannot be observed directly. Most existing approaches rely on past accounting data, but it is not reasonable to assume that the future market would be the same as the previous one. Martin (2016) derives a measure to estimate equity premium on the market. Based on asset pricing theory, the measure is proxied by a risk-neutral variance index, the SVIX index, and does not require any parameter estimation. Martin computes the equity premium over 1996–2012, arguing that the expected excess return is more volatile than previously known.

Knox and Vissing-Jorgensen (2021) demonstrate that Martin's (2016) measure of the equity premium is tight enough and decompose unexpected stock returns into cash flow news, equity risk premium news and riskless rate news. The authors exploit the SVIX index to prove that cumulative stock returns are primarily driven by shifts in the 1- to 2-year equity premium. This thesis indicates that the realised stock return is mainly attributed to variations in the short-term equity premium. I examine the effect of the equity premium in higher frequencies, and my finding complements Knox and Vissing-Jorgensen's.

I extend Martin's (2016) equity premium to 2020, and analysis regarding descriptive statistics of the equity premium illustrates two findings. First, I hypothesise that the US stock market has a normal regime and a crisis regime. In the normal regime, I find investors require less than the 5% – the equity premium conventionally presumed by financial institutions. However, in a crisis regime, the equity premium increases to more than 5%. Second, the term structure of equity premium is procyclical, that is, downward-sloping during bad times and upward-sloping during good times. This finding is consistent with the arguments of Martin (2016) and Chabi-Yo and Loudis (2020).

Next, I regress daily realised S&P 500 returns on changes in the equity premium at different time horizons. The results indicate that about 58%–65% of the stock market evolution in the COVID-19 pandemic can be explained by changes in the equity premium. The enormously significant relationship holds even if I run regressions over other periods, for example, the two half years of 2020 or the post-crash period. Moreover, the explanatory power of changes in the equity premium is downward sloping. I run a bivariate regression with indicators for short-term equity premium variations and differences in the corresponding forward equity premium up to 12 months. For instance, differences between the daily 1-month equity premium and differences between the daily 1-month–12-month forward equity premium. Regardless of the horizons of short-term expected excess returns or periods, the results show that changes in the short-term equity premium can explain more variation in stock returns than changes in the long- equity premium, and their explanatory power is greater in magnitude. For instance, over 2020, the standardised coefficient of changes in the 1-month equity premium is 0.476, while the coefficient of the forward 12-month equity premium's changes is 0.391. Moreover, additional changes in the forward equity premium increase the model fitness by 6.9%, but additional 1-month equity premium changes improve the model by 10.2%. These findings indicate that during the COVID-19 pandemic, investors' expectations over the short term are a nontrivial factor explaining the US stock market fluctuations. Tests over other periods further demonstrate that changes in the equity premium can explain the stock market fluctuations by 52%–63% over the past 25 years.

Finally, I demonstrate that changes in the equity premium were driven by investor sentiment. Existing literature proposes that various factors may influence stock returns, such as the spread of the coronavirus (Ding et al., 2020) and Federal Reserve announcements (Cox et al., 2020). The authors probably presume that those factors account for investors' fears; therefore, panic caused the COVID-19 recession. In this thesis, I supplement evidence that fluctuations in the equity premium are significantly correlated with investors' fears regarding the COVID-19 pandemic. Similar to Da et al. (2014), I construct a COVID-19 Attitudes Revealed by Search (CARS) index to quantify investors' anxieties. The baseline model purports that a standard deviation increase in CARS coincides with an increase of 7.05 basis points in contemporary changes in the 1-month equity premium, an increase of 0.38 basis points in changes in the 1- to 6-month forward equity premium, and a rise of 0.006 basis points in changes in the 6- to 12-month forward equity premium. The specification results show that investors' panic about the pandemic has a strongly significant relationship with fluctuations in the short-term equity premium. Still, the correlation is smaller in magnitude than with the long-term equity premium. Additionally, robustness tests illustrate that the variance of CARS can explain 61.0% of the changes in the 1-month equity premium during the crash but 46.7% of the variations of the dependent variable after the collision. That is, over the short term, investors worried about the pandemic, but they might be confident that the recession would not last for years. This finding coincides with the previous discovery that investors' expectations over the short term were the key during the crash.

This thesis provides an out-of-sample test for Martin's (2016) measure of the equity premium, and his outcomes hold over the COVID-19 recession. In addition, I also demonstrate that the results are robust in other crisis periods and in times without a crisis. As scant literature has examined the fluctuation of equity premium over 2020, this thesis contributes to existing research to fill the gap, delivering a supplementary conclusion to Knox and Vissing-Jorgensen's (2021). The results notably declare that the US stock market evolution was driven by variations in the short-term equity premium, which reflect investors' expectations over the near future. This thesis further supports that the shift in investors' short-term expectations was driven by investors' fears about the COVID-19 pandemic. I provide direct evidence using Google trends data on the relationship between the equity risk premium and anxiety about the pandemic. My evidence also shows that the relationship is stronger for the short-term- than the long-term equity risk premium. Overall, the discoveries explain the stock market evolution during 2020 and provide another indication to answer the excess volatility puzzle. The empirical importance of the short-run equity premium for the stock market can be used to verify whether a specific theoretical asset pricing model is correct.

The thesis continues as follows. Chapter 2 reviews literature that motivates the research questions, recent papers focusing on the US stock market in 2020, Martin’s (2016) new approach to measure the equity premium, and Da et al.’s (2014) index proxying investor sentiment. Chapter 3 discusses the motivations and hypotheses in detail. I describe the methods and data in Chapters 4 and 5, respectively. Chapter 6 shows empirical results and delivers the main findings. Finally, I conclude and discuss the limitations and future research potential in Chapter 7.

CHAPTER 2 – Literature Review

One of the major puzzles in finance is the excess volatility puzzle: stock price is too volatile compared to future cash flow uncertainty. Shiller (1981) coincidently finds evidence from the bond market as LeRoy and Porter (1981) reveal the puzzle on the stock market. Conventionally, pricing models assume that stock price is the present value of future dividends discounted by “stable” rates; hence, it is believed that unpredicted cash flow news is the only factor that accounts for a sudden movement in stock price. However, the stock price is too volatile to be ascribed to any arrival of objective news. Besides, even though dividends fluctuate over a few periods, the variations end in such a short future that they should not significantly influence the market’s movements. Shiller (1981) concludes that the mismatch between variations in stock price and uncertainty in dividends is not a rational people’s forecast mistake; nevertheless, he cannot provide direct evidence because the discount rate is unobservable and hard to be measured. Later, Campbell (1991) decomposes the stock market’s movements into two components: “news about future cash flows” and “news about future discount rates”. Based on Campbell’s decomposition (1991), the variance of news about future discount rates and covariance between the two types of information always importantly account for the US unexpected stock return variance. Over 1927–1988, changes in future cash flow news only contributed a third to a half of the variation in unexpected stock returns, while the remainder of the stock return variation was attributed to changes in future expected returns. Moreover, the explanatory power of expected return variation was greater over 1952–1988. Campbell (1991) notices that his measure of expected returns by dividend-price ratio may violate the decomposition if the valuation ratio is not a forecasting variable. He mentions that it is crucial to explain the changing expected returns.

The equity premium’s measure has been a big academic question for a long while. The

Capital Asset Pricing Model[1] and the Fama-French Factor Model (1992) are the most classical methods estimating expected returns; nonetheless, those estimates relying on past accounting data are inaccurate (Black, 1993).

Being motivated by asset pricing theory, Martin (2016) derives a novel approach to measure the expected excess return on the US stock market using the SVIX index. Unlike previous techniques, this measurement aims to reveal equity premium directly using asset prices. Martin (2016) starts from an identity that associates expected return with its risk-neutral variance. Assuming no-arbitrage, the related volatility index SVIX, which Martin defines, can be measured by index option prices. Under a minimal assumption of negative correlation condition[2], the identity can educe a lower bound on the equity premium proxied by the SVIX index. It seems like that the lower bound in terms of the SVIX index is approximately tight, so he verifies the hypothesis by running predictive regressions and argues that the SVIX index can directly measure the equity premium. As the lower bound is computed without free parameters and by asset prices, this approach avoids the in-sample/out-of-sample critique of Welch and Goyal (2007) and can, in principle, be implemented in real-time. Furthermore, the approach has a particular advantage when investment beliefs shift promptly either due to the sudden arrival of information or because of a shift in market sentiment or risk aversion. Compared with the conventional method based on valuation ratios, the equity premium measured by the SVIX index is more right-skewed and fluctuates more dramatically, especially in higher frequency. Martin (2016) suggests that the SVIX index is designed for short-run expected excess returns, while valuation ratios are used to predict very long-run expected excess returns.

Knox and Vissing-Jorgensen (2021) exploit Martin's approach (2016) to reveal the substantial effect of changes in the equity premium on stock returns during the COVID-19

[1] See Sharpe (1964), Lintner (1965), and Mossin (1966).

[2] The first definition in Martin (2016), "Given a gross return R_T and stochastic discount factor M_T, the negative correlation condition (NCC) holds if $cov_t(M_T R_T, R_T) \leq 0$."

pandemic. They test Martin's measure for the lower bound of the equity premium, arguing that variations in the lower bound are unbiased estimates of changes in the actual equity premium. To overcome the issue that Campbell and Shiller's (1988) decomposition of unexpected return is sensitive to the predictors included (Chen and Zhao, 2009), Knox and Vissing-Jorgensen (2021) newly decompose unexpected return into cash flow news, risk premium news, and risk-free rate news. The decomposition outcome indicates that the rise in risk premia over 2020 resulted in -4% of realised return and the decrease in the risk-free rate during the first 30 years contributed to 18.3% stock return for the whole year. In contrast, as the dividends up to 10 years consist of less than 20% of stock value, the changes in their expected flow had a negligible influence on the stock return. Overall, the short-term (1-year to 2-year) equity premium difference mainly drove the stock market throughout the crash and recovery. In contrast, the decline in long-term (1-year to 30-year) real riskless rates played an important role in positively stimulating the stock market. Knox and Vissing-Jorgensen's discovery (2021) emphasises the role of the equity premium in explaining the evolution of the stock market during the COVID-19 pandemic.

Coincidentally, Gormsen and Koijen (2020) apply another frequently-updated and forward-looking tool – dividend futures – to examine the dynamic of investors' expectations about economic growth and find that changes in expected dividends are not the causes behind the crash. Taking advantage of the dividend strip, Gormsen and Koijen (2020) forecast the anticipated growth over the next year and derive a lower bound on the term structure of expected dividend growth, only assuming the expected returns had not fallen. They find that the drop in the stock market was more incredible than near-term dividend strips, which implies that the value of long-term dividends might drop more than the value of short-term dividends. However, if discount rates do not fluctuate and the economic impact on dividends ends in 10 years, a 30% decline in the stock market would indicate that firms pay no dividends in the following ten years. It is unlikely that the shock is persistent, so the crash must be due to discount rates.

In addition, Cox et al. (2020) provide another evidence underlining the influence of market premium. To explain the V-shaped track of the stock price over the phases of downfall and rebound, they first decompose the changes in the stock market into undulations in aggregate economic fundamentals, corporate earnings shares, interest rates, and variances in the discount rate. They find that discount rate fluctuations, driven by risk aversion or sentiment changes, played an essential role in the stock market's fluctuations. Secondly, they conduct a high-frequency event study, detecting "unconventional" monetary policy rather than "conventional" announcements that calmed the market down. Furthermore, the Federal Reserve announcements over the early stages of the COVID-19 pandemic reached the market by sentiment instead of substance.

There exists enormous evidence that the stock market is affected by investors' sentiment. De Long et al. (1990) present a model in which noise traders can influence the stock market and earn greater expected returns than rational investors, and Bodurtha et al. (1995) demonstrate that the US market sentiment affects country fund premium. Baker and Wurgler (2007) prove that market sentiment may substantially affect the cross-section of stock prices. However, how to measure investors' sentiment and quantify its empirical impacts matters in relevant research. Scholars previously designed a survey to inquire about investors' expectations (for example, Brown and Cliff, 2004). Baker and Wurgler (2007) exploit a "top-down" approach to measure investor sentiment and its effects; almost meanwhile, Tetlock (2007) uses daily content from Wall Street Journal to quantify the mutual impact between the media and the stock market.

Da et al. (2014) extract Google search volume to disclose market sentiment. They construct a Financial and Economic Attitudes Revealed by Search (FEARS) index using search volume related to economic and financial terms related queries. They analyse the effects of sentiment proxied by the FEARS index on asset prices, volatility, and fund flows. Compared with market-based measures such as the VIX index or IPO first-day trading, internet search volume avoids the issue that forces other than investors sentiment may violate the outcome. Compared with surveys, internet search can measure the sentiment in higher frequency and show investors' attitudes rather than ask about them. Hence, the sentiment measured in real-time does not involve survey related biases. Google Trends provides search volume index in different frequencies, and the monthly search volume index correlates well with other measures of market sentiment. Da et al. (2014) find that a higher FEARS index coincides with low market returns today but forecasts an increase in market returns over the next several days. Furthermore, a rise in the FEARS index corresponds with temporary increases in market volatility. Their findings illustrate the predictive power of sentiment proxied by the internet search volume.

CHAPTER 3 – Motivation and Hypotheses

Extending upon the existing literature, I hypothesise that the evolution of the US stock market over the COVID-19 pandemic was mainly driven by fluctuations in the equity premium related to investors' sentiment. In this chapter, I discuss the facts that motivate my hypotheses and how the hypotheses develop.

On February 19, 2020, the S&P 500 reached its record high. Yet on February 28, it reported the largest single-week decline since the 2008 financial crisis; moreover, it dropped by 30% with unprecedented speed: the decrease only took 22 days, while the second-fastest 30% sell-off took 23 days in 1934 (Li, 2020). In comparison, it took 369 days to drop off 30% during the Dot Com Bubble and 250 days during the global financial crisis, which are another two major crashes in the US stock market over the past 25 years (Figure 1). It is broadly agreed that the COVID-19 recession could be the worst economic crisis since the Great Depression, and a strand of literature has documented the remarkable decline in the US stock market.

Recall that (gross) expected return is a discount factor for calculating the stock price. A rise in the equity premium means that investors require more compensation; therefore, if everything is unchanged, the stock price needs to be lower to satisfy them. Consequently, it is not unexpected that the annualised 1-month expected excess return over 2020 shows an opposite trend to the S&P 500 index price (Figure 2).

Figure 1

Comparison among the crashes of the S&P 500 Index in the Dot Com Bubble (peaked on March 24, 2000), the financial crisis (peaked on October 9, 2007), and the COVID-19 pandemic (peaked on February 19, 2020), as in Capelle-Blancard and Desroziers (2020). During the COVID-19 pandemic, the US stock market dropped by 30% unprecedentedly fastest – the decrease only took 22 days, while it took 369 days to drop off 30% during the Dot Com Bubble and 250 days during the financial crisis.

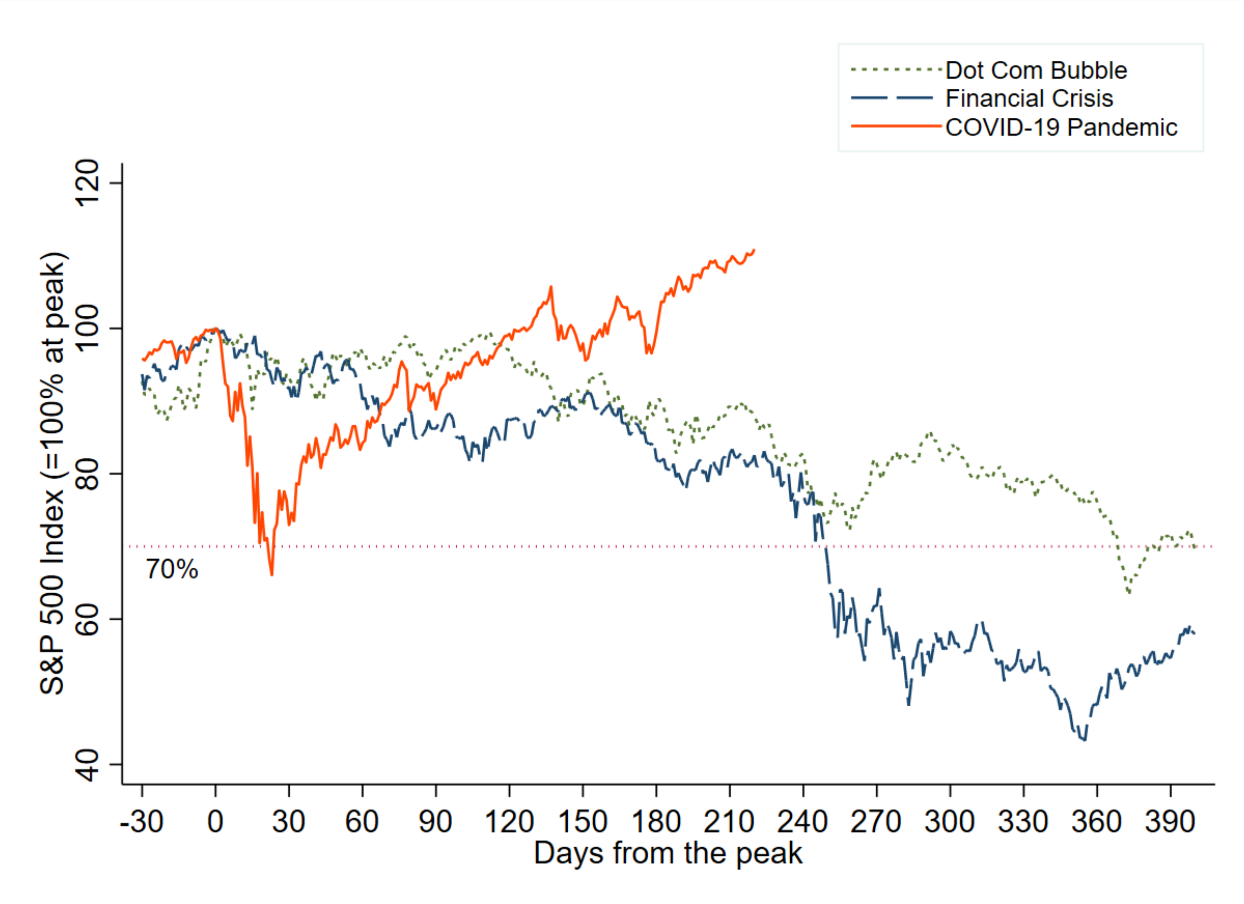
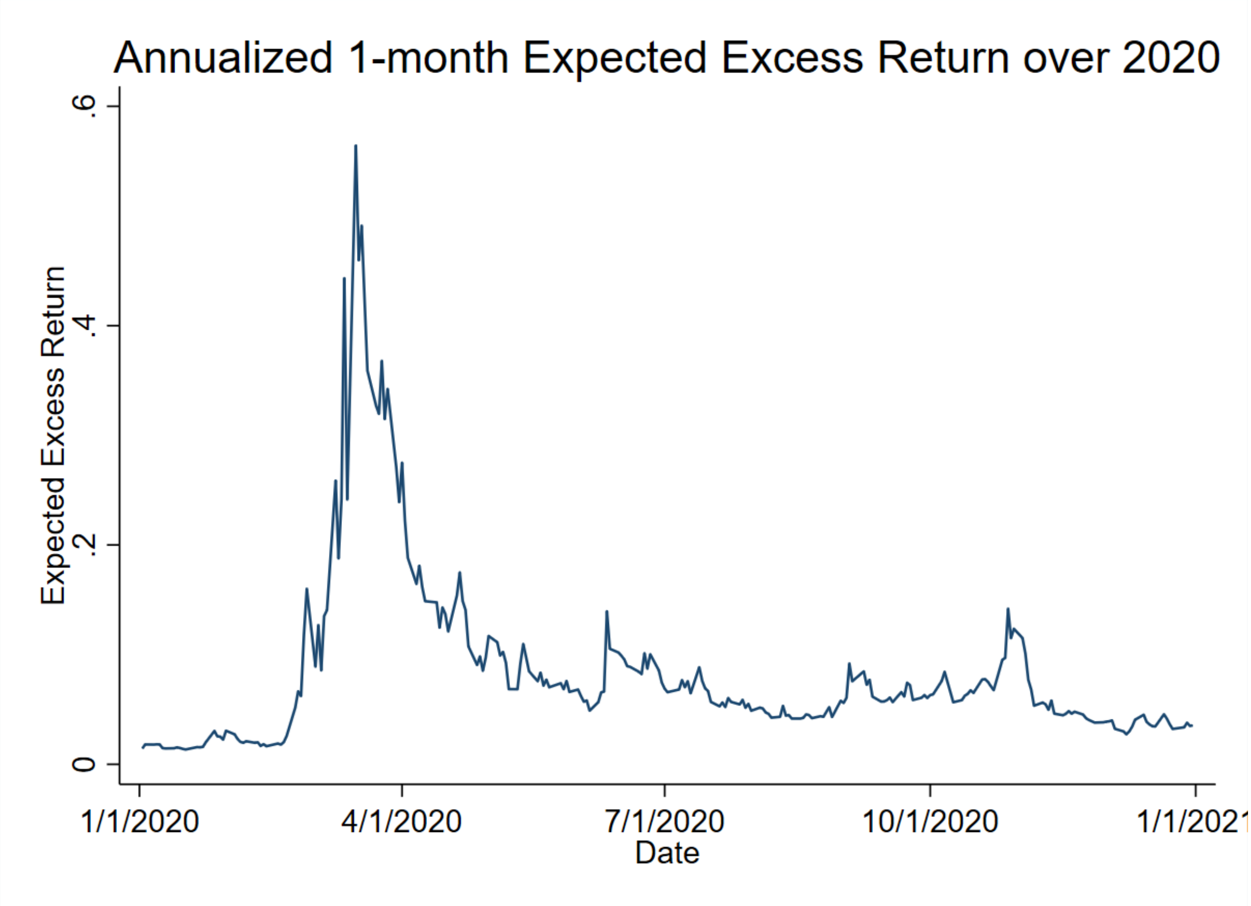


Figure 2

Fluctuations in annualised 1-month expected excess return (measured by the SVIX index) over the COVID-19 pandemic (January 2, 2020 – December 31, 2020). The expected excess return shows an opposite trend to the S&P 500 index price (in Figure 1).



Among the days with an absolute change in the daily 1-month equity premium greater than 3%, 11 days are matched with contemporaneous days of the largest absolute stock returns. I list the top five stock returns in magnitude and events potentially affecting the equity premium[3] in Table 1. It seems that most of the greatest changes in the stock market during the COVID-19 pandemic were associated with nontrivial changes in the equity premium, and the equity premium were possibly influenced by COVID-19 related news or economic announcements. For

[3] FRASER summarizes the events related to the COVID-19 Pandemic (https://fraser.stlouisfed.org/timeline/covid-19-pandemic), and a New York Times article supplements the global events related to the pandemic (https://www.nytimes.com/article/coronavirus-timeline.html). The economic new release is collected from the U.S. Bureau of Labor Statistics (https://www.bls.gov/schedule/news_release/bls.ics). I also directly search the news for a particular day in Google.

instance, the second most significant single-day S&P 500 index drop-off took place on March 16, 2020[4]. On that day, the Chicago Board Options Exchange volatility index (VIX) bumped to the historically highest level at 82.69. It was the first trading day after President Trump announced a 'Proclamation on Declaring a National Emergency Concerning the Novel Coronavirus Disease (COVID-19) Outbreak'. Beforehand, US presidents only declared one national emergency related to public health[5], and the United States had never banned travel from Europe. As the US stock market closes at 4:30 pm Eastern Daylight Time, the announcement at 3:00 pm on March 13 (Friday) might affect the following Monday, March 16. Thus, it is sensible to assume that the sudden message caused a great panic in the US stock market, and investors feared near-term risks, hence dramatically shifting their expectations. As a result, the equity premium rose by more than 32%.

Another example of the influence of policy can be illustrated on March 13, 2020. The House Democrats passed a significant amount in a coronavirus relief bill to stimulate the economy. The package covered relief to businesses, organisations, and individuals. That stimulus policy might calm investors down so that they did not worry about their financial situation as before. Consequently, the equity premium dropped by 20.16%.

In summary, I aim to find a direct factor that substantially affected the stock market during the COVID-19 pandemic and investigate what affected the factor. The (alternative) hypotheses are that variations in equity premium drove the stock market evolution and that those variations were related to investors' fears concerning the COVID-19 pandemic.

[4] The greatest single day drop-off happened on October 19, 1987. The S&P 500 Index decreased by 20.47%.
[5] The previous one was "Declaration of a National Emergency With Respect to the 2009 H1N1 Influenza Pandemic", signed by President Obama.

Table 1

Top five stock returns in magnitude (R, measured in %) with associated 1-month equity premium's changes (ΔEP_{1mo}, annualised and measured in %), and the events potentially affect ΔEP_{1-mth} with underlying reasons. Note that the US stock market opens between 9 am – 4:30 pm, EDT. The influence of messages that arrived at the end of the calendar week may extend to the beginning of the following week. Note: Ordered by absolute values of the stock returns.

R	ΔEP_{1mo}	Date	Ex-ante News	Potential Reason
-11.98	32.26	3/16 Mon.	3/13 (Fri.) President Trump declares a National Emergency at 3 pm.	The United States unprecedently banned travel from European countries, and it was the second National Emergency related to public health.
-9.51	20.16	3/12 Thur.	3/11 After 9 pm (Wed.) President Trump mispresents a travel ban to ALL European countries, excluding the UK.	This misinformation caused great panic in the US.
9.29	-20.16	3/13 Fri.	3/13 Before 10:35 am (Fri.) Pelosi states that the US House passed the coronavirus relief bill.	A policy aimed to stimulate the economy.
-7.60	11.80	3/9 Mon.	3/8 (Sun.) Italy extends lockdown, covering most states and population.	The first western country announced an almost nationwide lockdown.
6.00	-10.43	3/17 Tues.	3/16 4:30 pm (Mon.) Federal Reserve Board approves actions decreasing discount rate.	A direct action lowered the discount rates.

CHAPTER 4 – Methodology

This chapter describes the methodology used to investigate changes in the equity premium and their effects on the US stock market (Chapter 4.1). Chapter 4.2 discusses the method used to examine the relationship with investor sentiment.

4.1 Explanatory power of changes in the equity premium

I develop my empirical specifications based on Knox and Vissing-Jorgensen's (2021) decomposition of stock returns. The theoretical framework is delineated in Chapter 4.1.1, and I demonstrate my model designs to illustrate the impacts of changes in equity premium in Chapters 4.1.2 and 4.1.3.

4.1.1 Theoretical basis

A stock price is defined as the present value of future cash flows ($E_t D_{t+k}$) discounted by future expected returns ($E_t R_{t+k}$). Furthermore, expected returns $E_t R_{t+k}$ can be decomposed into the riskless rate rf_{t+k} and the equity risk premium $EP_{t,t+k}$. According to Knox and Vissing-Jorgensen's (2021) decomposition of stock returns:

$$\begin{aligned} &Realized\ return_t \\ &\quad = Expected\ return_t + \sum_{k=1}^{\infty} \frac{\partial P_t/P_t}{\partial E_t R_{t+k}} \partial rf_{t+k} + \sum_{k=1}^{\infty} \frac{\partial P_t/P_t}{\partial E_t R_{t+k}} \partial EP_{t,t+k} \\ &\quad + \sum_{k=1}^{\infty} \frac{\partial P_t/P_t}{\partial E_t D_{t+k}} \partial E_t D_{t+k} \end{aligned}$$

Hence, the decomposition motivates a linear regression examining the effects of different factors on realised stock returns. Dividends depend on firm performance, and the risk-free rate is determined by the inflation rate and the treasury securities, which are influenced by government policies. As only the short-run equity premium can be measured using observable market data, I aim to show that investors' expectations over the short term – fluctuations in the equity premium within one year – are the key factor explaining the US stock market evolution during the COVID-19 pandemic.

4.1.2 Baseline model

In this thesis, the equity premium $EP_{t,t+k}$ is proxied by the SVIX index, which is defined by Martin (2016). I describe how I compute the equity premium in detail in Appendix A.

I regress the realised stock return on the difference between daily equity premia at different time horizons to analyse the impact of changes in the daily equity premium on stock returns:

$$\Delta EP_{t,t+k} = EP_{t,t+k} - EP_{t+1,(t+k)+1}$$

$$R_t = \alpha - \beta * \Delta EP_{t,t+k} + \varepsilon_{t+1}$$

where R_t is the realised stock return at time t; and

$EP_{t,t+k}$ is the annualised equity premium over period t to $t+k$.

Note that stock returns are negatively related to differences between the equity premia according to the definition of stock price. For reading ease, I take negative values of the coefficient of interest β.

The regressions exploit changes in the equity premium at different time horizons as independent variables, such as the 1-, 2-, 3- and 6-month equity premium. I am interested in an R-squared of each regression. The value of R-squared indicates how much of the stock returns' variance can be explained by variations in the equity premium. Therefore, R-squared means the explanatory power of the changes in the equity premium. The empirical results and main findings are presented in Chapter 6.2.1.

4.1.3 Specification comparing explanatory powers among the equity premia

Martin (2016) documents that much of the annual excess return is acquired in the first few months in a crash. Thus, I further assess whether changes in the shorter-term equity premium are more forceful in explaining stock return fluctuations than changes in the longer-term equity premium.

I calculate the term structure of daily equity premium over the period between times T_1 and T_2 as:

$$EP_{T_1,T_2} = \frac{1}{T_2 - T_1} \cdot (EP_{t,T_2} - EP_{t,T_1} * (T_1 - t))$$

where $t < T_1 < T_2$, and $T_2 - t = 365\ days$. For example, $T_1 - t = \frac{30}{365}\ days$, $T_2 - T_1 = \frac{365-30}{365}\ days$.

I first regress on changes in the equity premium over T_1 to T_2 using the baseline model:

$$\Delta EP_{T_1,T_2} = EP_{T_1,T_2} - EP_{T_1-1,T_2-1}$$

$$R_t = \alpha - \beta * \Delta EP_{T_1,T_2} + \varepsilon_{t+1}$$

Then, I run bivariate regressions with standardised coefficients to compare the influences of the short- and longer-term equity premia:

$$\Delta EP_{t,T_1} = EP_{t,T_1} - EP_{t-1,T_1-1}$$

$$R_t = \alpha - \beta_{short} * \Delta EP_{t,T_1} - \beta_{long} * \Delta EP_{T_1,T_2} + \varepsilon_{t+1}$$

The beta coefficients β_{short} and β_{long} and adjusted R-squared are my statistics of interest. As various term structures of equity premium have different covariances with stock returns, standardising coefficients helps quantify the magnitude of the effects of independent variables. On the one hand, if the beta coefficient associated with the shorter-term equity premium is larger than the beta coefficient of the longer-term equity premium, it is reasonable to argue that changes in the shorter-term equity premium have a greater effect on stock returns. On the other hand, adjusted R-squared increases more than expected when an additional term improves the model fit. Therefore, comparing (adjusted) R-squared with the output of a simple linear regression can provide further evidence of whether the impact of the discount rate weighs more heavily on the shorter-term equity premium. Suppose an increment in adjusted R-squared from the shorter-term equity premium is more than an increment from the forward equity premium with a longer horizon. In that case, the unexpected return is caused more by the shorter-term equity premium rather than the longer-term equity premium. The specification results and findings are shown in Chapter 6.2.2.

4.1.4 Robustness tests

Considering that the explanatory power of the short-term equity premium can be magnified during the crash,

(1) I divide the full 2020 year into two half-years – the subperiod until June 30, 2020, and the subperiod after July 1, 2020. I aim to test whether the results of the baseline model are robust to random subperiods.

(2) I further separate crash time and recovery time, namely the first subperiod of February and March 2020 and the second subperiod between April and December 2020. I aim to test whether the equity premium' variations can only play an essential role during the crash.

The whole sample period is from 1996 to 2020, and I focus on the COVID-19 recession (2020). To test whether the short-term equity premium significantly associated with stock returns in other times, I also analyse over the dot-com bubble period (2000 – 2002), the Global Financial

Crisis (2007 – 2009), and the non-crisis period (a whole sample period excluding the three crisis times). Furthermore, I conduct a robustness test to assess whether the results would be varied if recessions are defined more narrowly:

(3) The National Bureau of Economic Research (NBER) defines the COVID-19 pandemic between February and March 2020, the dot-com bubble from March to October 2001 and the Global Financial Crisis from December 2007 to May 2009. The other times of non-recession since 1996 are regarded as economic expansions. I re-test the specifications based on NBER's recessions and expansions.

The robustness tests results are presented in Chapter 6.2.3.

4.2 Interaction between changes in the equity premium and the CARS index

Following Da et al.'s (2014) approach, I define the CARS index and outline the detailed process in Appendix B. This index measures investors' concerns associated with the coronavirus, and I exploit it to investigate whether sentiments drove changes in the investors' equity premium.

4.2.1 Baseline model

The regression used to assess the potential relationship between changes in the equity premium and the CARS index is as follows:

$$\Delta EP_{t,t+30} = \alpha + \beta * CARS_t + \sum_m \gamma_m \, Control_{i,t}^m + \varepsilon_{i,t+k}$$

where control variables include:

IR: daily change in interest rates, measured in 100%;

VL: daily change in the rolling volatility of S&P 500 index return every ten days;

CASE: daily log-growth of US active coronavirus cases;

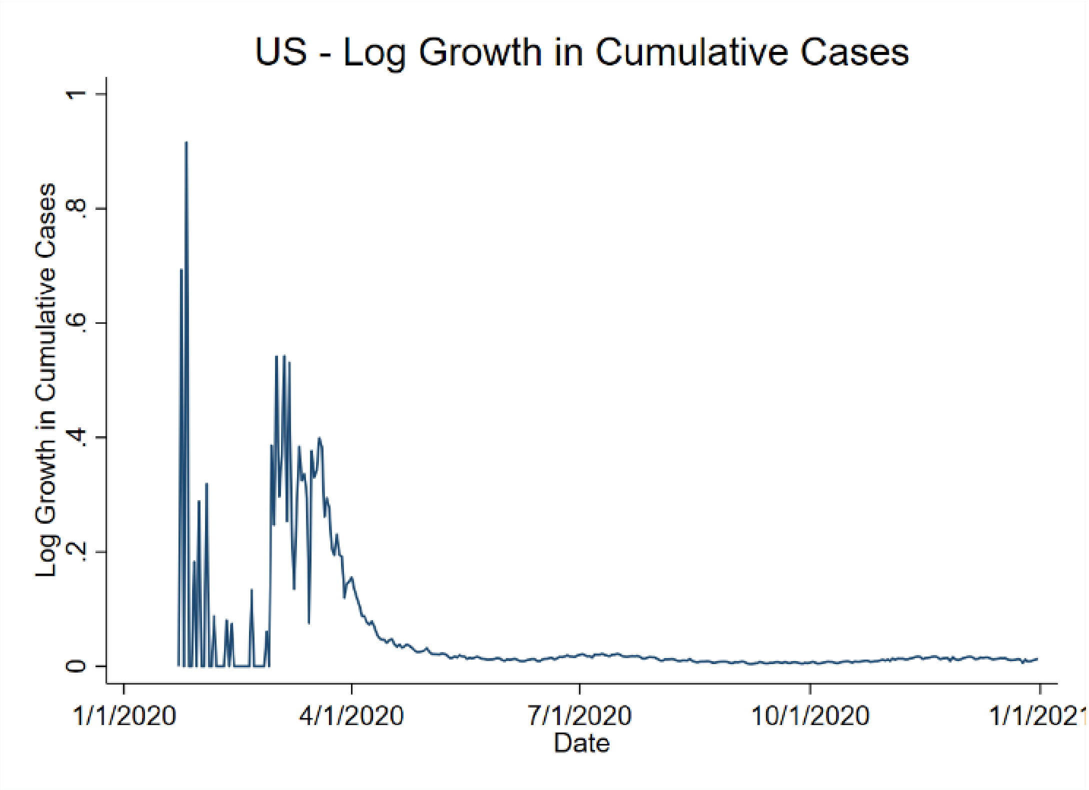
EPU: daily change in economic policy uncertainty; and

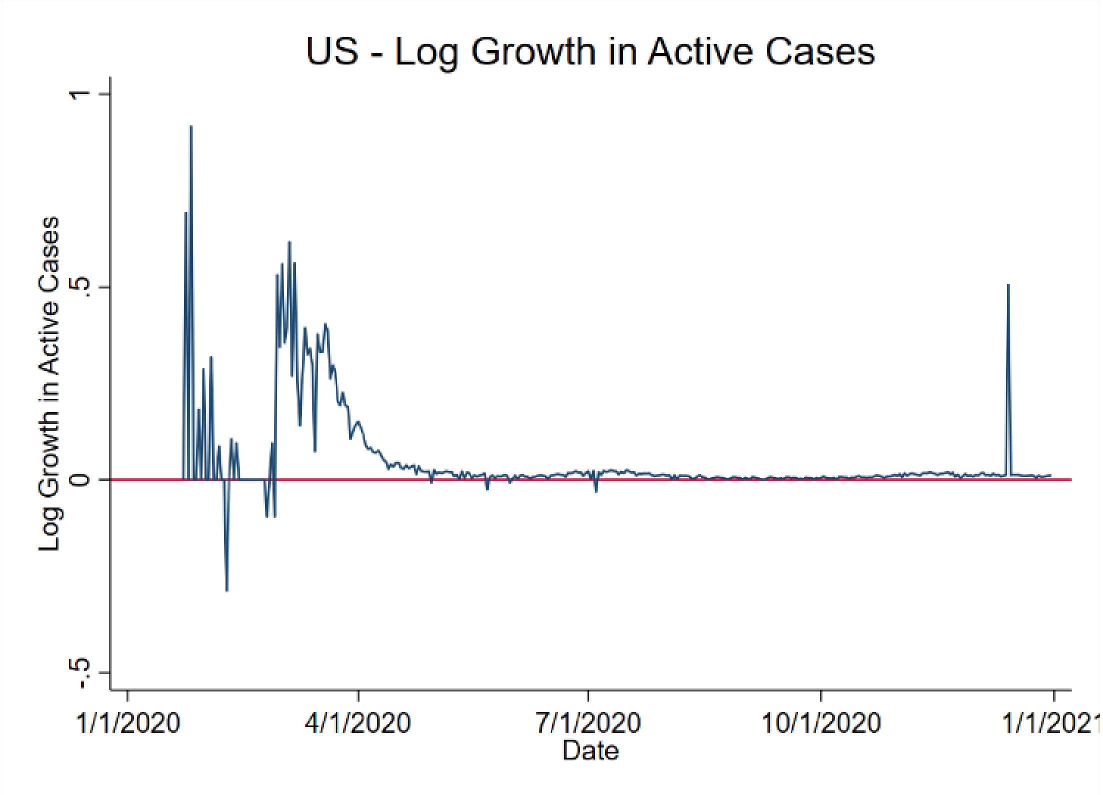
$delta_j$: lagged daily changes in the equity premium, up to five lags.

The change in the rolling volatility of stock returns captures the evolution of the market, and the difference in interest rates represents the variation in macroeconomic conditions. EPU is an index based on newspaper coverage frequency (Baker et al., 2016), covering ten major US newspapers and topics including ‘economic’, ‘legislation’, and ‘reserve’. I include this variable to consider the impacts of policy uncertainty during the COVID-19 pandemic. Ding et al. (2020) find evidence that firms’ stock returns are negatively related to the nation’s exposure to coronavirus. Ding et al. (2020) use log-growth of cumulative cases to measure the spread of coronavirus in the United States; however, I use data of active cases instead because they are not continually increasing (for example, Figure 3). I control lagged changes in the equity premium to capture autocorrelation of changes in the equity premium, and the standard errors are bootstrapped 10,000 times. To check whether the results are conservative, I calculate robust standard errors for each model. In addition, including lagged changes in the equity premium in the regression could increase the model fit more than expected. Hence, I run another regression controlling lagged index returns without rolling return volatility for each baseline model. The baseline specification results and findings are shown in Chapter 6.3.1.

Figure 3

Log growth of US coronavirus cases over 2020. The top panel graphs the cumulative cases, and the bottom panel graphs the active cases.





4.2.2 Robustness tests

(1) The CARS index used in the baseline model is constructed by extracting terms with the highest *t*-statistics, so it is sensible if the coefficient of CARS is strongly significant. Rather than running a rolling regression to find words with the most important associations with contemporaneous changes in the expected excess returns, I instead focus on six intuitive topics: ‘COVID’, ‘masks’, ‘vaccine’, ‘lockdown’, ‘travel ban’ and ‘social distancing’. I search these six keywords in Google Trends, acquiring the top five related terms for each word. Next, a CARS-N index is constructed directly using an average adjusted daily SVI change for 30 terms.

(2) Findings reveal that stock returns also relate to changes in the equity premium over several months. I re-construct CARS indexes to regress the differences in the 1-to-6-month forward equity premium and the 6-to-12-month forward equity premium changes, respectively. These tests aim to investigate the relationship between investors’ fears and investors’ expectations over the long term.

(3) I follow the same process to find terms most significantly associated with contemporaneous changes in the 1-month equity premium over the 2020 subperiods before June 30, 2020, and after July 1, 2020. I aim to test whether the results of the baseline model are robust to random subperiods.

(4) According to NBER’s definition of the COVID-19 pandemic period, I run the baseline regression over February and March 2020 and April to December 2020 to test whether the effects of sentiment revealed by Google search on the crash and recovery periods are similar in magnitude.

The robustness tests results are shown in Chapter 6.3.2.

CHAPTER 5 – Data

5.1 Data for measuring the equity premium

To measure the daily equity premium by the SVIX index from January 4, 1996 to December 31, 2020, I collect the S&P 500 index option prices and corresponding forward prices from OptionMetrics. The S&P 500 index closing prices and returns are from the Center for Research in Security Prices. All data is in daily frequency and over the whole sample period. The information on option prices includes issuance date, date of maturity, strike price, highest closing bid and lowest closing ask of all European call and put options with fewer than 550 days to expiry. I clean the data in the same way as Martin (2016). First, I drop all duplicates. Second, I select the call or put option with a lower mid-price for each strike price, where the mid-price is the average of the highest closing bid and the lowest closing ask. Thirdly, I ignore the options whose highest closing bid price is zero. Last, I delete quarterly options because Martin views these options as less liquid than regular index options. The summary statistics of equity premium over the whole sample period is shown in Table 2. More detailed constructions of the SVIX index and equity premium are delineated in Appendix A.

Table 2

Means, standard deviation, skewness, excess kurtosis, and quantiles of the equity premium, $EP_{t,T}$, at various horizons (annualised and measured in %) over January 4, 1996 – December 31, 2020

	(1)	(2)	(3)	(4)	(5)	(6)	(8)	(9)	(10)	(12)	(13)	(14)
Horizon	Mean	SD	Skew	Kurt	Min	1%	25%	50%	75%	99%	Max	N
1 mth	4.25	4.38	4.38	31.75	0.57	0.85	1.84	3.09	5.02	23.71	56.41	6,293
2 mth	4.28	3.75	3.75	22.02	0.80	1.03	2.05	3.28	5.14	20.45	45.53	6,293
3 mth	4.27	3.36	3.36	17.12	0.82	1.16	2.14	3.40	5.19	18.60	38.23	6,293
6 mth	4.26	2.74	2.74	10.75	1.24	1.47	2.38	3.59	5.28	15.67	28.46	6,293

5.2 Data for constructing the CARS index

The search volume index ranges from 0 to 100, with each number representing the search interest relative to the highest of the chart for the given region and time framework. For example, 100 indicates the term households living in a specific area were most interested in during the particular period, while 0 means the term was not a public concern. Google Trends only provides the daily search volume index up to nine months, but the weekly search volume index extends beyond nine months. Considering that the term 'COVID' was new to the public and many associated terms lacked data for January 2020, I restrict the sample period to February 1, 2020–October 27, 2020, and constrain the sample region to the United States. The Community Development & Health Network lists 100 words pertaining to COVID-19[6]. I typed each word into Google Trends, collecting at most the top-10 searched queries for each term over my sample period. The search resulted in 46 terms that have COVID-related queries, and the website returned 436 queries in total. Google Trends also shows top related topics to each searched keyword, so I remove the query if its top-5 associated topics do not include 'coronavirus' or 'COVID', resulting in 253 queries. After dropping duplicates, 239 searched terms are finally left. I download the daily search volume index for those terms to acquire the original dataset.

As changes in the equity premium theoretically vary from −1 to 1, I scale the search volume index of each term by 100. The CARS index then ranges from 0 to 1, so it is easier to read the regression results.

5.3 Data of control variables

I control for various economic factors for regression testing the relationship between changes in the equity premium and sentiment related to COVID-19. The data sources are

[6] The glossary is posted on https://www.cdhn.org/covid-19-z.

delineated in the following.

Interest rates are daily federal funds effective rates acquired from FRED[7], and I collect daily EPU data in the United States from the Economic Policy Uncertainty website[8].

The global COVID-19 data is sourced from the JHU dataset[9], which was built by Dong et al. (2020). The dataset coincides with OWID-coronavirus data, but it provides daily recovery cases in addition to confirmed cases and death cases. Hence, I can attain the number of active cases by subtracting death and recovery cases from cumulative cases.

[7] https://fred.stlouisfed.org/series/FEDFUNDS.
[8] https://www.policyuncertainty.com/us_monthly.html.
[9] https://github.com/CSSEGISandData/COVID-19.

CHAPTER 6 – Empirical Results

In this chapter, I illustrate the main findings based on regression results. Chapter 6.1 compares equity premia at various time horizons over different periods. Chapter 6.2 focuses on the first questions examining whether changes in the equity premium substantially drove market fluctuations. Chapter 6.3 addresses whether changes in the equity premium were affected by investors' sentiments towards COVID-19.

6.1 The equity premia over crisis and non-crisis periods

I present findings about the behaviour of equity premium over the crisis and non-crisis periods. A comparison among the equity premia over different periods shows that the US stock market has different regimes in crisis and non-crisis periods (chapter 6.1.1). In addition, a comparison among the equity premia at different time horizons reveals that the term structure of equity premia is procyclical (chapter 6.1.2).

6.1.1 Two regimes in the US stock market

In the past 25 years, the US stock market has experienced three significant crashes – the dot-com bubble (2000–2002), the Global Financial Crisis (2007–2009) and the COVID-19 pandemic (2020). I regard the remaining times as non-crisis periods. I compute summary statistics for the equity premia separately over crisis and non-crisis periods and indicate means and standard deviations of equity premia in Table 3.

The average short-term equity premia of the three crisis periods are above 5%. Overall, the mean equity premium in crisis is between 5.55% and 7.16%, while the equity premium in non-crisis periods averages between 3.12% and 3.54%. Conventionally, Financial Engines estimates a short-term equity premium of approximately 6%, and McKinsey uses an equity premium averaging 5%–5.5% (Welch, 2000). Over the period 1996–2012, Martin (2016) estimates an average of the annualised equity premium of about 5%. I test hypotheses whether the equity premium in bad times is significantly different from the equity premium in good times:

The first hypothesis: H_0: $\mu(EP)_{bad} = \mu(EP)_{good}$,

$$H_a: \mu(EP)_{bad} > \mu(EP)_{good}.$$

The second hypothesis: H_0: $\sigma(EP)_{bad} = \sigma(EP)_{good}$,

$$H_a: \sigma(EP)_{bad} > \sigma(EP)_{good}.$$

Columns (1) and (2) in Panel C reveal that the tests are statistically significant to reject the null hypotheses. Column (1) illustrates that the mean compensation investors require in crises is significantly higher than the equity premium they require in a non-crisis. Column (2) demonstrates that the equity premium during crises is considerably more volatile than during non-crisis periods. For example, the standard deviation for the 1-month equity premium in a crisis (6.58) is almost three times higher than a non-crisis period (2.29), and the standard deviation for the 12-month equity premium in a crisis (2.80) is about twice as high as a non-crisis period (1.59).

I also calculate 99% confidence intervals for the equity premium over the crisis and non-crisis periods, respectively. Column (3) in Panel C indicates that I am 99% confident that in a crisis, the 1-month equity premium is between 6.75% and 7.56%, and the 12-month equity premium is between 5.38% and 5.72%. Column (4) shows the 99% confidence interval for the 1-month equity premium in a non-crisis (3.03%, 3.21%) as well as the 99% confidence interval for the 12-month equity premium (3.47%, 3.60%). The results illustrate that the equity premium in crisis periods is greater than 5% at a 1% significance level, and the equity premium in a non-crisis period is smaller than 5%.

Thus, the results indicate that the stock market has two regimes. During crisis periods, investors expect more than 5% – the equity premium that institutions assume investors want –

and investors expect less than 5% during non-crisis periods.

To show that the findings are robust, I calculate the equity premia based on NBER's definitions of economic recessions and expansions. The equity premia in columns (6) and (7) show a similar pattern. The testing results reported in Appendix C.1.1 confirm that the US stock market has different regimes in recession and expansion times.

As the equity premium is proxied by the SVIX index, a volatility measure, it is reasonable to assume that investors face more risks during a recession or maybe less risk-tolerant, asking for higher compensation. Overall, the average equity premium for decades is approximately between the mean expected excess return of a crisis period and the mean expected excess return of a non-crisis period. Therefore, I hypothesise that the significant breakdown during the COVID-19 pandemic was driven by an acute change of investors' expectations reflected in the variation in the equity premium.

Table 3

Panel A and B show means and standard deviations of the equity premium, $EP_{t,T}$, at various time horizons (annualised and measured in %) over different periods. Panel C reports the hypothesis testing results: whether the equity premium in crisis (shown in column (4) of Panel A and B) is significantly higher and more volatile than in non-crisis (shown in column (5) of Panel A and B). Columns (3) and (4) in Panel C list the 99% confidence intervals for the equity premium at different time horizons.

Panel A – Means of equity premium

Horizon	(1) Dot Com Bubble	(2) Financial Crisis	(3) COVID-19 Pandemic	(4) Crisis Period	(5) Non-Crisis Period	(6) NBER Recession	(7) NBER Expansion
1 mth	5.94	7.91	8.55	7.16	3.12	10.7	3.59
2 mth	5.70	7.60	8.22	6.88	3.27	9.80	3.71
3 mth	5.51	7.35	7.86	6.64	3.35	9.17	3.77
6 mth	5.17	6.85	6.95	6.15	3.53	8.09	3.87
12 mth	4.77	6.27	5.73	5.55	3.54	7.04	3.80

Panel B – Standard deviations of equity premium

Horizon	(1) Dot Com Bubble	(2) Financial Crisis	(3) COVID-19 Pandemic	(4) Crisis Period	(5) Non-Crisis Period	(6) NBER Recession	(7) NBER Expansion
1 mth	2.76	8.21	8.37	6.58	2.29	9.70	2.63
2 mth	2.31	6.80	6.49	5.41	2.13	7.80	2.42
23 mth	1.92	6.05	5.21	4.70	2.02	6.72	2.27
6 mth	1.30	4.87	3.35	3.64	1.83	5.12	1.98
12 mth	0.92	3.86	1.99	2.80	1.59	3.91	1.67

(Continued)

Panel C – Hypothesis testing results and 99% confidence intervals

Horizon	(1) p-value for H_a: μ(crisis) > μ(non-crisis)	(2) p-value for H_a: σ(crisis) > σ(non-crisis)	(3) 99% CI for EP in Crisis	(4) 99% CI for EP in Non-Crisis
1 mth	0.000	0.000	(6.75, 7.56)	(3.03, 3.21)
2 mth	0.000	0.000	(6.54, 7.21)	(3.19, 3.35)
3 mth	0.000	0.000	(6.35, 6.93)	(3.27, 3.42)
6 mth	0.000	0.000	(5.92, 6.37)	(3.46, 3.60)
12 mth	0.000	0.000	(5.38, 5.72)	(3.47, 3.60)

Notation: μ represents mean value, and σ represents standard deviation.

6.1.2 Procyclical term structures of equity premium

In addition, the descriptive statistics in Panel A of Table 3 demonstrate a procyclical trend in the term structure of equity premium. In a downturn, the longer-horizon expected excess returns are lower on average and less unstable than the shorter-horizon expected excess returns (shown in column (4) of Panel A and B in Table 3). For example, during the COVID-19 pandemic, the mean of the 1-month equity premium was 2.82% higher than the 12-month equity premium. Moreover, the standard deviation of the 1-month equity premium is 6.38% larger (shown in column (3) in Panel A and B of Table 3). In a non-crisis period, although the standard deviation is higher for longer-term equity premium, the mean of the equity premium decreases as the length of the time horizon increases (shown in column (5) of Panel A and B in Table 3). I therefore test whether differences between the short-term and long-term equity premia for crisis and non-crisis periods are statistically significant and show p-values in Table 4:

The first hypothesis: H_0: $\mu(EP_{1-mth} - EP_{12-mth}) = 0$,

$$H_a: \mu(EP_{1-mth} - EP_{12-mth}) > 0.$$

The second hypothesis: $H_0: \mu(EP)_{1-mth} = \mu(EP)_{12-mth}$,

$$H_a: \mu(EP)_{1-mth} > \mu(EP)_{12-mth}.$$

The third hypothesis: $H_0: \sigma(EP)_{1-mth} = \sigma(EP)_{12-mth}$,

$$H_a: \sigma(EP)_{1-mth} > \sigma(EP)_{12-mth}.$$

In columns (1) and (2) of Table 4, p-values show that the short-term equity premium is significantly greater than the long-term equity premium during a crisis, while it is significantly smaller during a non-crisis period. The p-values in column (3) show that the short-term equity premium is more volatile in crisis and non-crisis periods. I graph the equity premia at 1-, 6- and 12-month horizons over the COVID-19 pandemic and the Global Financial Crisis period, respectively (Figure 4). Although the 1-month equity premium is more volatile than the longer-term equity premium, overall, the term structure of the short-term equity premium is downward-sloping during bad times.

Table 4

Testing results for whether the differences between the short-term equity premium and the long-term equity premium are statistically significant over different periods.

	(1)	(2)	(3)
	p-value for H_a:	p-value for H_a:	p-value for H_a:
	μ (1mth - 12mth) > 0	μ (1mth) > μ (12mth)	σ (1mth) > σ (12mth)
Crisis	0.000	0.000	0.000
Non-Crisis	1.000	1.000	0.000

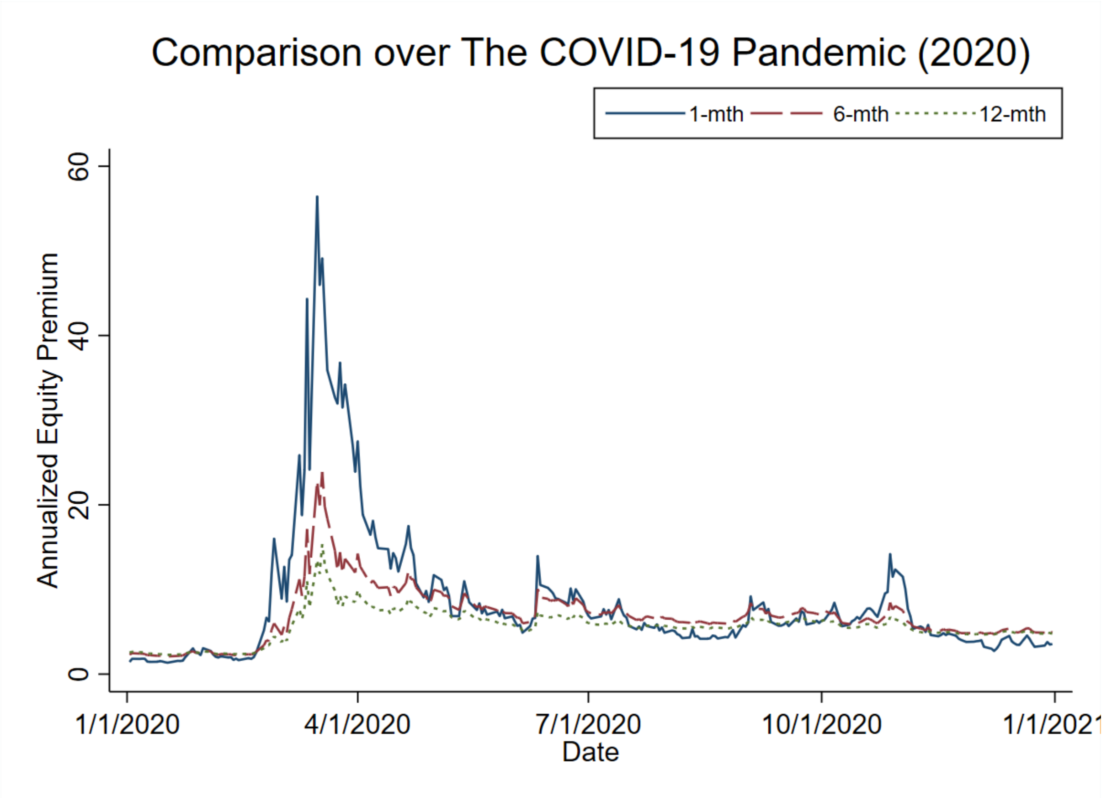
Notation: μ represents mean value, and σ represents standard deviation.

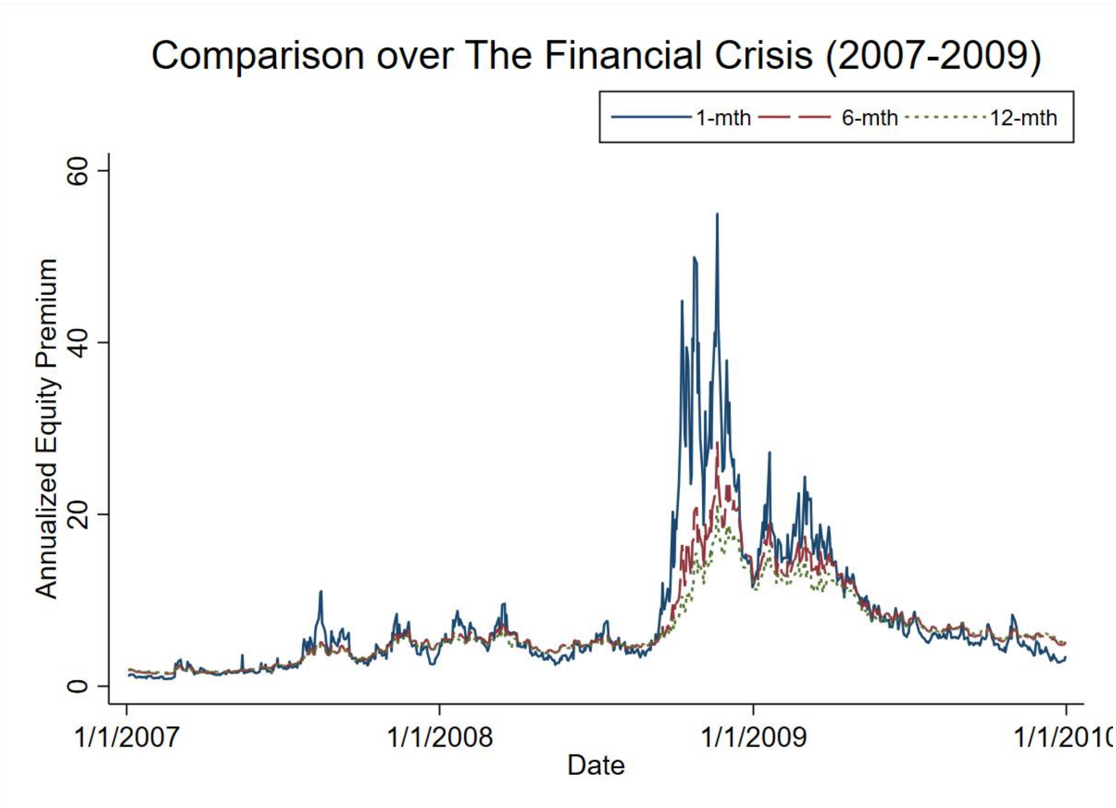
I re-test differences between term structures of equity premium over NBER's recession and expansion periods (shown in columns (6) and (7) of Panel A and B in Table 3). The testing results reported in Appendix C.1.2 show almost the same findings – I still have significant evidence that the term structure of equity premium is procyclical to reject the null hypothesis.

Overall, whether I define recessions in a wide or narrow range, the term structure of equity premium is significantly procyclical. This finding is consistent with Martin (2016) and Chabi-Yo and Loudis (2020). Martin (2016) documents that much of the annual excess return acquired in the first few months in a crash. Chabi-Yo and Loudis (2020) also show that the term structure of expected excess returns on the market decreases during turbulent times and increases during regular times. I therefore conjecture that in crises, investors worry about the short-term situation, but they are more confident about the long-term future market. In this case, the stock return should be explained more by the shorter-term equity premium rather than the expected excess returns in the longer term.

Figure 4

Comparions among 1-month, 6-month, and 12-month equity premia over the COVID-19 pandemic period (2020) and the Financial Crisis period (2007-2009).





6.2 Explanatory power of changes in the equity premium

This chapter illustrates how changes in the equity premium can substantially explain the US stock market fluctuations and that the influence does not only occur during the crash.

6.2.1 Baseline model results

I first regress the realised stock returns on the difference between the daily equity premia at different time horizons to analyse the impact of equity premium on stock returns. Summary statistics of the equity premium over the COVID-19 pandemic and the specification results with robust standard errors are reported in Table 5.

Panel A of Table 5 demonstrates that the 1-month equity premium spreads out over a wide range, while the 12-month equity premium clusters around the mean. The equity premia at different time horizons are all right-skewed and leptokurtic. The maximum of 1-month equity premium is more than three times the maximum of the 12-month equity premium.

In Panel B of Table 5, the 1-month equity premium changes explain 58.6% of the variations in the stock market, and the 12-month equity premium changes explain 5.9% more of the stock return's fluctuations. It is reasonable that the 12-month equity premium's differences result in a higher R-squared, which incorporate both short- and long-term expectations. However, the additional variance explained is relatively minor. Hence, such a high R-squared associated with the 1-month equity premium's variations indicates that the short-term equity premium's variance may significantly account for the stock market evolution over the COVID-19 pandemic.

Table 5

Panel A documents mean, standard deviation, skewness, excess kurtosis, and quantiles of the equity premium, $EP_{t,T}$, at various time horizons (annualised and measured in %) over the COVID-19 pandemic (January 2, 2020 – December 31, 2020). Panel B reports the regression of the realised stock returns on the difference between the daily equity premia at different time horizons over the COVID-19 pandemic. The dependent variables for all five columns are the daily realised stock return. The indicators for the columns are 1-month EP, 2-month EP, 3-month EP, 6-month EP, and 12-month EP, respectively.

Panel A

Horizon	Mean	SD	Skew	Kurt	Min	1%	25%	50%	75%	99%	Max	N
1 mth	8.55	8.37	8.37	10.12	1.35	1.44	4.25	6.26	9.17	45.98	56.41	253
2 mth	8.22	6.49	6.49	10.37	1.66	1.75	4.82	6.97	9.00	37.16	45.53	253
3 mth	7.86	5.21	5.21	9.54	1.82	1.90	5.01	6.91	8.82	30.59	36.76	253
6 mth	6.95	3.35	3.35	5.48	2.09	2.15	5.13	6.65	8.06	19.96	23.88	253
12 mth	5.73	1.99	1.99	3.20	2.27	2.32	4.89	5.72	6.58	12.92	15.34	253

Panel B

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.489***	0.708***	0.852***	1.457***	2.554***
	(0.0496)	(0.0870)	(0.118)	(0.188)	(0.280)
Cons.	0.000843	0.000875	0.000889	0.000953	0.00103
	(0.000882)	(0.000862)	(0.000874)	(0.000842)	(0.000826)
R^2	0.586	0.606	0.596	0.627	0.645
Obs.	252	252	252	252	252

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

To understand the explanatory power of the fluctuated equity premium over other times, I rerun the specification model over the other two crisis periods, the non-crisis period and the whole sample period. In Appendix C.2, the R-squared of regressions based on the short-term equity premium is about 45%–67% over the dot-com bubble period and 66%–78% over the Global Financial Crisis period, respectively. In Appendix C.2.4, the R-squared of regressions on changes in the short-term equity premium over the non-crisis periods are between 53% and 65%, and the R-squared of regression on the 1-year equity premium changes is 38.1%. The results in Appendix C.2.5 indicate that more than half of the stock returns can be explained by changes in the equity premium. The outcomes together show that the explanatory power of changes in the expected excess return in a crisis may be more potent than in a non-crisis time. The R-squared of regressions on the 1-month equity premium changes in different periods is all above 55%. This result is the first evidence that first differences in the short-term expected excess returns could be the main reason explaining unexpected stock returns.

6.2.2 Comparison of explanatory powers between equity premia

I further analyse the potentially distinct explanatory power of the expected excess returns at different time horizons. Summary statistics and regression output over the COVID-19 pandemic are shown in Table 6.

The summary statistics in Panel A of Table 6 verify the previous finding that the term structure of equity premium is downward-sloping during the COVID-19 pandemic. The mean of the 1-month equity premium is 8.55% with a volatility of 8.37%, while the mean of 1- to 12-month forward equity premium is 5.47% with lower volatility of 1.60%. During crisis periods, other comparisons between the short-term equity premium and the corresponding 12-month forward equity premium show a similar pattern. These findings indicate that during a crisis, investors' near-term expectations fluctuated more dramatically. However, a short-term equity premium is lower than its paired forward equity premium to 12 months during a non-crisis period (shown in Appendix C.2.8). This result is consistent with the previous finding that the expected excess return in a non-crisis period is upward-sloping.

A comparison between Table 5 and Table 6 shows that changes in the short-term equity premium can more explain variations in stock returns over the COVID-19 pandemic than differences in the forward equity premium to 12 months. For example, the R-squared for the regression on the 1-month equity premium variations is 58.6%, while the R-squared for the regression on the 1- to 12-month forward equity premium changes is 55.3%. Combining these two terms, the adjusted R-squared is 65.5%. That is, the additional variation explained by the 1-month equity premium differences is 10.2%, while the additional variation explained by the 1- to 12-month forward equity premium changes is 6.9%. Moreover, the R-squared for the regression on the 6-month equity premium variations is approximately twice that of the regression on the 6- to 12-month forward equity premium differences. For expected excess returns at other time horizons, the variation explained by changes in the short-term is always more extensive than the variation explained by the associated forward changes to 12 months.

To directly compare influences of changes in the shorter- and longer-term equity premia, I report standardised coefficients of the above multiple regression in Panel C of Table 6. For the four regressions over the COVID-19 pandemic, coefficients of the short-term equity premium (in 1, 2, 3 and 6 months, respectively) are more statistically significant and larger than coefficients of the forward equity premium (in term 1–12, term 2–12, term 3–12, and term 6–12, respectively). The strongly significant standardised coefficient of the 1-month equity premium (0.476) is about 1.22 times the less significant standardised coefficient of 1- to 12-month equity premium (0.391), which means that unexpected stock returns are more heavily due to changes in the shorter-term equity premium. It is not out of expectation that the weight on the short-term expected excess return increases as the time horizon covered by the short-term expected excess return increases. Both coefficients and R-squared illustrate that the explanatory power of equity premium is downward-sloping.

Table 6

Panel A shows mean, standard deviation, skewness, excess kurtosis, and quantiles of the term structure of the equity premium, EP_{T_1,T_2}(annualised and measured in %), over the COVID-19 pandemic (January 2, 2020 – December 31, 2020). In Panel B, the dependent variables for all four columns are the daily stock returns. The explanatory variables are 1-12 month forward EP's changes for column (1), 2-12 month forward EP's changes for column (2), 3-12 month forward EP's changes for column (3) and 6-12 month forward EP's changes for column (4). Panel C is bivariate regression output, where the dependent variables for all four columns are the daily stock returns. Similarly, the column names indicate explanatory variables for each column.

Panel A

Horizon	Mean	SD	Skew	Kurt	Min	1%	25%	50%	75%	99%	Max	N
term 1-12	5.47	1.60	1.60	1.22	2.36	2.39	4.93	5.64	6.38	9.64	12.27	253
term 2-12	5.23	1.37	1.37	0.39	2.40	2.42	4.91	5.51	6.02	7.78	9.84	253
term 3-12	5.02	1.22	1.22	0.26	2.43	2.45	4.83	5.28	5.73	7.05	8.36	253
term 6-12	4.50	0.94	0.94	0.30	2.46	2.46	4.51	4.75	5.08	5.84	6.80	253

(Continued)

Panel B

	(1)	(2)	(3)	(4)
Indicator	term 1-12	term 2-12	term 3-12	term 6-12
β	3.320***	4.143***	4.935***	4.701***
	(0.586)	(0.751)	(1.078)	(1.599)
Cons.	0.00110	0.00116	0.00122	0.00116
	(0.000927)	(0.000921)	(0.000939)	(0.00108)
R^2	0.553	0.546	0.511	0.350
Obs.	252	252	252	252

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Panel C

	(1)	(2)	(3)	(4)
Indicator	1mth + term1-12	2mth + term2-12	3mth + term3-12	6mth + term6-12
β_{short}	0.476***	0.519***	0.534***	0.688***
	(0.0786)	(0.110)	(0.125)	(0.202)
β_{long}	0.391**	0.328**	0.327**	0.169
	(0.685)	(0.802)	(0.989)	(1.023)
Cons.	0.000985	0.00101	0.00105	0.00103
	(0.000834)	(0.000838)	(0.000826)	(0.000828)
R^2	0.655	0.646	0.646	0.645
Obs.	252	252	252	252

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Knox and Vissing-Jorgensen (2021) attribute substantial variations in cumulative stock returns to changes in the 1- to 2-year equity risk premium. In this thesis, I provide direct evidence that the short-term expected excess returns' changes are crucial in explaining fluctuations in realised stock returns.

The regression results for other crisis periods, non-crisis periods and the whole sample period indicate a similar finding that the short-term equity premium's changes explain more of the variations in the stock market than the long-term equity premium fluctuations (shown in Appendix C.2).

6.2.3 Robustness tests

To rule out the possibility that the results are affected by the time point selected, I rerun the regressions over January–June 2020 and July–December 2020. Over the period before July, variations in the equity premium can explain at least 61% of the stock returns, but they clarify 46%–56% of the stock returns afterwards. Before July, the short-term equity premium had significantly stronger explanatory power, and the short- and long-term expected excess returns' changes can together explain approximately 67% of the stock market (Appendix C.4.1). After June, the adjusted R^2 is around 55%. Column (1) in Appendix C.4.2 shows that the effect of the 1-month equity premium changes (0.374) is slightly lower than the effect of the 1- to 12-month forward equity premium variations (0.434), and columns (2) to (4) illustrate a significantly larger impact of the short-term equity premium. Figure 2 shows that the expected excess return was relatively flat after June 2020; hence the regression results are sensible and could be due to measurement error.

Considering that the crash in February–March 2020 could drive the substantial explanatory power of changes in the expected excess return, I separately run the regression over those two months and April–December 2020. According to NBER, the US economy has expanded since April 2020. The results over the two periods in Appendix C.4.3 and C.4.4 show that the equity premium's changes explain more than 65% of the stock market in the crash and at least 53% of the stock returns after the collision. Although the post-crash explanatory power of the short-term equity premium's changes is slightly lower, the 12-month equity premium's differences explain more of the stock returns after the collision. In addition, the short-term equity premium changes have significantly greater effects on stock returns during the crash, but they have similar or even smaller post-crash effects than the long-term forward equity premium variations.

In Appendix C.4.4, column (1) shows that the standardised coefficient of variations in the 1-month equity premium is 0.223, while the 1- to 12-month forward equity premium differences coefficient is 0.669. Compared to the simple linear regression, the 1- to 12-month equity premium improves the model fit by 18.6% and the 1-month equity premium enhances the model by only 2.1%. Columns (2) and (3) show approaching coefficients of the short- and long-term expected excess returns. However, the 6-month equity premium changes significantly explain more stock returns than the 6- to 12-month expected excess returns' variations. These findings indicate that investors' near-term expectations are the most significant impact factor during a crash. Still, such near-future equity premium may not have a greater influence than longer-term equity premium after the collision. The reason could be that investors' near-term fears did not propagate to the distant future during the crash.

I test whether the findings only hold during the COVID-19 pandemic period. The regression output in the Appendix C.2 and C.3 indicates that the equity premium changes' explanatory power does not depend on how 'recession' is defined. Following my definitions about crisis periods, changes of the expected excess returns can explain 56%–61% of stock returns (Appendix C.2.3) in bad times and 38%–65% of stock returns in good times (Appendix C.2.4). According to NBER's definitions, fluctuations of the equity premium can explain 62%–67% of stock returns during recessions (Appendix C.2.7) and 38%–54% of stock returns during expansions (Appendix C.2.8). These findings indicate that the explanatory power of changes in the equity premium might be stronger in a downturn. As shown in Appendix C.3, most of the multiple regressions result in significantly larger coefficients of the 1-, 2-, 3- and 6-month equity premia. More specifically, the regressions over the dot-com bubble and the Global Financial Crisis return the same findings as we obtain from the regression over the COVID-19 pandemic (Appendix C.2.1 and C.2.2). Although the expected excess returns' variance explains more than 70% of the stock market over the Global Financial Crisis but 45%–67% of the stock return over the dot-com bubble, its explanatory power is always nontrivial over different periods. Moreover, the explanatory power of changes in the equity premium decreases as the time horizon increases. The main findings hold in other periods and do not violate how I select the period examined.

Overall, the term structure of expected excess returns is procyclical – decreasing in economic depression and increasing in expansion. The varied changes in the equity premium have considerable effects in explaining the US stock market's evolution, whether during bad or good times. This finding coincides with Campbell's argument (1991) that changes in the future discount rate are a critical factor in the US stock market. Moreover, the explanatory power of variations in the expected excess returns is downward-sloping for most times. These findings imply that investors' expectations over the short term are an important factor explaining the stock market evolution; hence, we can empirically verify the correctness of the specific asset pricing model.

6.3 Changes in the equity premium and the CARS index

In this chapter, I show how changes in the equity premium relate to investors' sentiments towards the coronavirus.

6.3.1 *Baseline model results*

To investigate whether changes in the equity premium are related to investor sentiment, I exploit sentiment revealed by the Google search volume to assess the potential interaction. As the dependent variable is changes in the expected excess returns, the examined question can also be stated as 'whether investors' expectations towards the market are associated with their sentiment'. The results might provide evidence of what drove investors' expectations during the COVID-19 pandemic. The outcomes are reported in Table 8.

Table 7

The summary statistics of dependent variable 1-month equity premium's changes and independent variable CARS index for the baseline model.

Horizon	Mean	SD	Skew	Kurt	Min	1%	25%	50%	75%	99%	Max
Δ1-mth EP	0.00	0.04	0.04	31.53	-0.20	-0.10	-0.01	-0.00	0.01	0.20	0.32
CARS	0.09	1.00	1.00	6.39	-2.80	-2.78	-0.41	-0.05	0.50	3.68	4.26

The coefficient of CARS in column (1) is strongly significant, which is not out of expectation, as I extract the most significantly related terms to construct the index. The variance in the CARS index explains about 44% of the variance of changes in the equity premium. Through columns (2) to (4), the coefficients of CARS are all positive and significant at the 1% level, independent of what type of standard error is used and what factors are controlled. The baseline model (column (2)) suggests that a standard deviation increase in CARS coincides with an increase of 7.05 basis points in contemporary changes in the 1-month equity premium [10], after controlling changes in equity premium up to five lags, changes in interest rate, changes in the rolling return volatility, log-growth of active coronavirus cases in the United States and changes

[10] Recall that I scale the daily SVI for each term by the standard deviation of daily 1-month equity premium's changes, which is 0.03919. It is necessary to multiply the estimated parameter by the scaling number when interpreting the coefficient corresponds to CARS.

in EPU. I calculate robust standard errors for the baseline model, and column (3) does not vary parameters estimated in column (2). The standard error (0.00554) in column (3) is larger, which indicates that the result using the bootstrapped standard error (0.00502) is conservative. Column (4) reports the regression model controlling lagged index returns but without market return volatility. The coefficient of CARS implies that a standard deviation increase in CARS corresponds to an increase of 7.64 basis points in contemporary changes in the equity premium.

Including various factors does not mitigate the significant effect of CARS on expected excess returns' changes. As the CARS index is investor sentiment quantified by the Google search volume, variations in the equity premium may be significantly and positively related to investors' sentiments.

Table 8

Results of regression relating changes in equity premium to CARS Index. The dependent variables for the four columns are contemporaneous changes in 1-month expected excess returns, and the independent variables are CARS Index (ranges from 0 to 1). In columns (2) and (3), the variables controlled are the changes in interest rate (IR, measured in 100%), the changes in rolling volatility of S&P 500 Index return every ten days (VL), the changes in Economic Policy Uncertainty (EPU) Index, the changes in active coronavirus cases in the United States (EXS), and the changes in equity premium up to five lags (delta1 – delta5). In column (4), I instead control lagged index returns up to five days (delta1 – delta5) but without changes in rolling market return's volatility (VL). The standard errors in columns (1), (2), and (4) are bootstrapped 10000 times, and the standard error in column (3) is the robust standard error.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS	0.0271***	0.0180***	0.0180***	0.0195***
	(0.00654)	(0.00502)	(0.00554)	(0.00579)

(Continued)

IR		-0.139	-0.139*	-0.167
		(0.407)	(0.0708)	(0.303)
VL		1.284	1.284	
		(1.172)	(0.975)	
EPU		6.40e-06	6.40e-06	1.09e-05
		(1.73e-05)	(1.61e-05)	(1.61e-05)
EXS		-0.0269	-0.0269	-0.0325
		(0.0467)	(0.0359)	(0.0395)
delta1		-0.273	-0.273*	0.429**
		(0.176)	(0.139)	(0.202)
delta2		0.129	0.129	-0.0782
		(0.180)	(0.110)	(0.177)
delta3		0.0804	0.0804	-0.166
		(0.180)	(0.152)	(0.162)
delta4		-0.163	-0.163	0.107
		(0.157)	(0.114)	(0.172)
delta5		-0.0999	-0.0999	-0.00305
		(0.127)	(0.0788)	(0.137)
Constant	-0.00291	-0.00157	-0.00157	-0.00193
	(0.00214)	(0.00164)	(0.00163)	(0.00185)
R-squared	0.437	0.628	0.628	0.617
Observations	168	168	168	168
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.3.2 Robustness tests

It might be argued that the CARS index is constructed using the terms with the greatest *t*-statistics, so it is natural that the coefficient of CARS is statistically significant. Therefore, I build another CARS-N index focusing on the topics ‘COVID’, ‘masks’, ‘vaccine’, ‘lockdown’, ‘travel ban’ and ‘social distancing’. Based on my experience, these terms are intuitive to represent the public’s interests. Column (1) in Table 9 illustrates a strongly significant relationship between the CARS-N index and 1-month expected excess returns’ variations, although the R-squared (0.227) is much lower. After controlling for various factors, the relationship between the dependent and independent variables is significant at the 5% level. In the baseline model, a standard deviation increase in CARS-N coincides with a 10.78-basis-point rise in the 1-month equity premium changes. If I control lagged index returns rather than lagged changes in the equity premium, the coefficient of CARS-N is slightly greater and still significant at the 5% level. It is reasonable that the coefficients are not significant at the 1% level. COVID-19 was new to society, and households received different terms at different times. For example, in the first half of the year, the ‘travel ban’ peaked and was seldom searched afterwards; in the second half-year, people were interested in ‘vaccine’, which was previously not top news. Table 9 demonstrates that although a random term can hardly be significantly related to changes in the contemporary expected excess returns, the CARS-N index does have a relationship with concurrent changes in the equity premium. Therefore, the significant results above are not due to the selection process.

Table 9

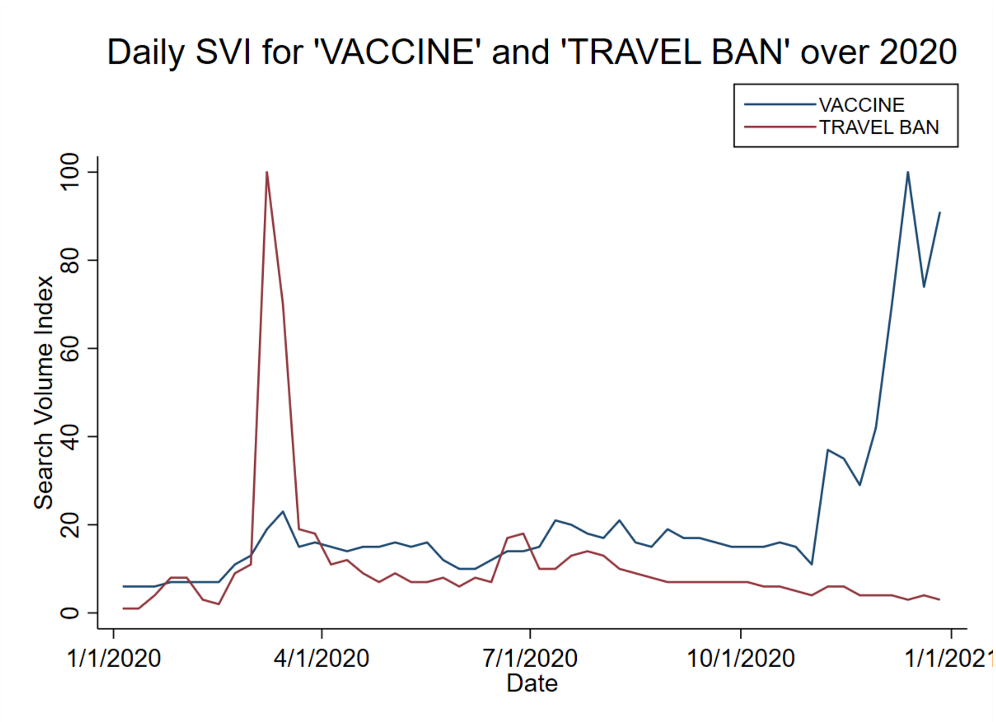
The explanatory variable CARS-N is constructed using the average daily ASVI of terms "covid", "masks", "vaccine", "lockdown", "travel ban", and "social distancing". The dependent variables for the four columns are contemporaneous changes in the 1-month equity premium. Detailed results are in Appendix C.5.1.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS-N	0.0355***	0.0275**	0.0275**	0.0321**
	(0.0129)	(0.0128)	(0.0114)	(0.0129)
R-squared	0.227	0.592	0.592	0.583
Observations	187	187	187	187
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 5

Daily search volume index for the terms "vaccine" and "travel ban" over 2020.



I repeat the process of CARS construction and regressions for changes in the 1- to 6-month forward equity premium and changes in the 6- to 12-month forward equity premium, respectively. Table 10 shows that CARS is significantly and positively related to changes in the equity premia. For 1- to 6-month equity premium' changes, column (1) of Panel A in Table 10 has an R-squared of 0.534. The coefficient of CARS in column (2) implies that a one standard deviation increase in CARS coincides with an addition of 0.13 basis points in contemporary changes in the 1- to 6-month equity premium, after including the basic control variables. The significance of CARS is not influenced by the type of standard errors used and factors controlled. For the 6- to 12-month equity premium' changes, the model only includes CARS results in an R-squared of 0.397, and the coefficient of CARS in the baseline model is much smaller (0.000196). Although the effects of investor sentiment revealed by the Google search volume are strongly significant in all models, the effects are lesser for a longer horizon of changes in the equity premium. Thus, investors' sentiments have a strong relationship with investors' expectations, which are reflected in changes in the expected excess returns. However, such a relationship is weaker for the longer-term equity premium's changes. This result is consistent with the previous finding: investors fear the near future, but their fears may not propagate to influencing their long-run expectations.

Table 10

Panel A reports the brief regression results of the 1- to 6-month equity premium's changes. The CARS Index is scaled by the standard deviation of the 1- to 6-month equity premium's changes, which is 0.01359. Panel B reports regression results of the 6- to 12-month equity premium's changes, where the CARS Index is scaled by 0.00787. Detailed results are in Appendix C.5.2 and C.5.3.

Panel A

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
$CARS_{1-6}$	0.00167***	0.00140***	0.00140***	0.00135***
	(0.000271)	(0.000182)	(0.000157)	(0.000212)
R-squared	0.534	0.696	0.696	0.645
Observations	168	168	168	168
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Panel B

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
$CARS_{6-12}$	0.000191***	0.000196***	0.000196***	0.000176***
	(4.74e-05)	(3.95e-05)	(4.27e-05)	(3.53e-05)
R-squared	0.397	0.477	0.477	0.473
Observations	168	168	168	168
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

To test whether the findings hold in different sub-periods, I re-construct the CARS index and rerun the models over January–June 2020 and July–December 2020. The regression output reported in Appendix C.5.4 and C.5.5 confirms the findings. For the first half-year of 2020, the variance of the CARS index itself has an R-squared of 0.646 (column (1) of Appendix C.5.4). The coefficient of CARS in the baseline model is greater than the coefficient of CARS over February–October 2020. Column (2) indicates that a 16.88-basis-point rise in the 1-month equity premium' changes is associated with a one standard deviation increase in CARS. For the second half-year of 2020, both R-squared (0.492) and the coefficient of CARS (0.00103) are much lower than the results over the original sample period, although they remain strongly significant and positive. The finding that changes in expected excess returns are associated with investor sentiment proxied by CARS is not violated. Still, the effect of sentiment probably concentrates on the crash time – February and March 2020.

Aiming to check whether the impact of sentiment on investors' expectations is more substantial during the crash, I run the regressions over February to March 2020 and April to November 2020. The findings are shown in Appendix C.5.6 and C.5.7. The regression without control variables shows that the variance of CARS can explain 61.0% of changes in the 1-month equity premium during the crash but only 46.7% of variations of the dependent variable after the collision. From February to March 2020, a one-standard-deviation increase in CARS is related to a 51.14-basis-point increase in the 1-month equity premium's changes during February and March. It corresponds to 0.34 basis points of the 1-month equity premium's variations since April. Although there is a statistically significant correlation between CARS and changes in the 1-month equity premium, the relationship is stronger during the crash. It makes sense that when the new messages about the novel coronavirus arrived, investors' panic sharply changed their expectations.

In summary, investors' expectations over the COVID-19 recession, which are reflected in changes in the equity risk premium, are effectively associated with investors' fears regarding the pandemic. This observation answers Campbell's (1991) question about the nature of changes in discount rates: fluctuations in the equity premium are affected by psychological behaviours and then influence the stock market. By some estimates, institutional investors hold about a half of the equities in the United States, and their trading consisted of 70% of the overall trading volume in 1989 (Lakonishok et al., 1992). The Google search volume index is based on households' concerns; therefore, the finding also implies that the noise traders play a nontrivial role in the US stock market.

CHAPTER 7 – Conclusions

The comparison among the equity premia over different periods indicates that the US stock market has two schemes: the equity risk premium is higher than 5% during crises and lower than 5% during non-crisis periods. The comparison among the equity premia at different time horizons demonstrates that the term structure of equity premium is procyclical. The findings coincide with existing arguments; hence, this thesis provides and out-of-sample test to validate Martin's (2016) measure of expected excess returns and results.

Changes in the equity premium, especially changes over the short term, are the key reason why the US stock market fluctuated during the COVID-19 pandemic – they explain at least 58.6% of the realised stock returns. Even over the whole sample period 1996–2020, changes in the expected excess returns can explain more than 50% of the stock market evolution. This empirical finding not only answers the excess volatility puzzle but also helps confirm the correctness of a specific asset pricing theory. Conventionally, asset pricing models assume that discount rates are stable; however, I argue that investors' expectations over the near future are not negligible.

Furthermore, the fluctuated expected excess returns are significantly related to investors' anxiety about the COVID-19 pandemic. This thesis supplements analysis of this implied relationship, which is not documented in contemporary literature. This finding guides me to explain a stock market crash from psychology: the health risk itself may not substantially influence investors' expectations, but it does so mentally. Even though an incredible amount of trading volume is held by sophisticated institutional investors, noises played a part during the COVID-19 recession.

This thesis shows that investors' longer-term expectations cannot explain as much variance of the realised returns as the short-term expectations. It could be because that investors fear the impacts of health risks over the near future, but they may believe the influences would not last long. The relationship between the CARS and the longer-term expectations is also weaker, so there could have been something other than the health risks that affected investors' expectations over the distant future. Cox et al. (2020) propose that the Federal Reserve played a role in the stock market fluctuations, and Table 1 also indicates that the significant changes in the equity premium may correspond to prominent Fed policies. I do not investigate the effects of policy announcements in this thesis, but the subject is worthy of research.

In addition, Knox and Vissing-Jorgensen (2021) examine the effects of the cash flows, the equity premium and the risk-free rate on cumulative stock returns. This thesis only focuses on the impacts of changes in the equity premium on daily realised stock returns. I do not investigate the other two factors due to the lack of data. However, Campbell (1991) emphasises that both future dividends and expected returns are essential for explaining the stock market. Future research about firm performance or Federal Reserve policies could investigate the effects of changes in future dividends or variations in the riskless rate.

Appendix

A: Computation of the equity premium proxied by the SVIX index

Martin (2016) defines the annualised SVIX index as:

$$SVIX_{t\to T}^2 = \frac{2}{(T-t)(1+R_{f,t})S_t^2}\left[\int_0^{F_{t,T}} put_{t,T}(K)dK + \int_{F_{t,T}}^{\infty} call_{t,T}(K)dK\right]$$

where t: the issuance date of the option;

T: the maturity date of the option;

$put/\,call$: the price of the option;

K: the strike price;

F: the forward price;

S_t: the corresponding index price of the option at time t; and

$R_{f,t}$: the simple riskless rate at time t.

The lower bound of equity premium is constructed as:

$$EP_{t,T} \geq SVIX_{t\to T}^2 \cdot (T-t)(1+R_{f,t})$$

I follow Martin's procedure[11] (2016) to measure equity premium. Because the strike price can only be observed at finite and discrete times, the integration of option prices is approximately estimated using discrete strikes. Apply the same notations as Martin's (2016), $\Omega_{t,T}(K)$ is the price of an out-of-the-money option with strike K:

$$\Omega_{t,T}(K) \equiv \begin{cases} put_{t,T}(K) & if\ K < F_{t,T} \\ call_{t,T}(K) & if\ K \geq F_{t,T} \end{cases}$$

$K_1, \dots, K_N$ notate the observable strikes, and K_j is the strike that most approaches to the forward

[11] Martin (2016) follows the same procedure as Chicago Board Options Exchange.

price $F_{t,T}$.

Define the delta strike price as:

$$\Delta K_i = \begin{cases} \dfrac{(K_{i+1} - K_{i-1})}{2} & for\ i \neq 1, N \\ K_{i+1} - K_i & for\ i = 1 \\ K_i - K_{i-1} & for\ i = k \end{cases}$$

Then the integral is replaced by the observable sum:

$$\int_0^{\infty} \Omega_{t,T}(K)\, dK \approx \sum_{i=1}^{N} \Omega_{t,T}(K) \Delta K_i$$

For each issuance date of the options, I compute the lower bound of equity premium at various time horizons depending upon the maturity dates, requiring the shortest maturity to be longer than seven days. Next, I estimate the lower bound T = 30, 60, 90, 180, and 360 days by linear interpolation and extrapolation, and I annualise the equity premia at different time horizons.

I replicated Martin's summary statistics of the equity premium over 1994 – 2012 (2016), getting correlations of the equity premia at different time horizons greater than 99%[12]. Panel A is Martin's Table, and Panel B is my replication result.

[12] My replication code refers to the code calculating the VIX index in the Chapter 3 of Master Python for Finance, 2nd edition (James Ma Weiming).

Comparison between Martin's results and my replication result

Panel A – Martin's result

Horizon	Mean	SD	Skew	Kurt	Min	1%	25%	50%	75%	99%	Max
1 mth	5.00	4.60	4.60	24.6	0.83	1.03	2.44	3.91	5.74	25.7	55.0
2 mth	5.00	3.99	3.99	17.5	1.01	1.20	2.61	4.11	5.92	23.5	46.1
3 mth	4.96	3.60	3.60	14.0	1.07	1.29	2.69	4.24	5.95	21.4	39.1
6 mth	4.89	2.97	2.97	9.13	1.30	1.53	2.88	4.40	6.00	16.9	29.0
12 mth	4.64	2.43	2.43	8.99	1.47	1.64	2.81	4.36	5.72	13.9	21.5

Panel B – Replication result

Horizon	Mean	SD	Skew	Kurt	Min	1%	25%	50%	75%	99%	Max	Corr
1 mth	4.99	4.58	4.03	24.9	0.57	0.96	2.44	3.88	5.73	25.0	55.0	0.998
2 mth	4.98	3.93	3.25	16.2	0.93	1.14	2.60	4.10	5.88	22.8	44.1	0.999
3 mth	4.92	3.55	2.91	13.1	1.05	1.24	2.68	4.22	5.89	20.8	38.2	0.999
6 mth	4.84	2.95	2.35	8.85	1.31	1.49	2.89	4.37	5.92	16.9	28.5	0.999
12 mth	4.55	2.44	1.88	5.99	1.22	1.59	2.72	4.25	5.58	13.9	21.2	0.998

B: Construction of the CARS index

I collect the daily search volume index for each keyword over the full year 2020. Same as Da et al.'s definition (2014), the daily change in search term i is:

$$\Delta SVI_{i,t} = \ln\left(SVI_{i,t}\right) - \ln\left(SVI_{i,t-1}\right)$$

Similarly, to mitigate variation across terms, I standardise the daily change for each term by dividing each time-series data by the standard deviation of daily change in the 1-month equity premium over the sample period, getting a standardised daily change of search volume index, $\Delta ASVI_{i,t}$.

Then, I conduct expanding rolling regressions of $\Delta ASVI$ on change in the equity premium every 25 days. As in Da et al. (2014), this step is to recognise the terms that are significantly associated with contemporaneous changes in the equity premium. For each regression, I rank the t-value of each word, so the top thirty terms are the most important to the 1-month equity premium's changes during that period. The CARS index on day t is defined as:

$$CARS_t = \sum_{i=1}^{30} R^i(\Delta SVI_t)$$

where $R^i(\Delta SVI_t)$ is the ΔSVI_t for the search term that had ith largest positive t-value from the beginning of 2020 through the most recent thirty days. During the procedure, it is clear that the most important terms are consistently positively correlated with changes in the equity premium. In the following Table, I list the thirty keywords with leading positive t-statistics over the entire sample period, totally getting 48 terms with negative t-statistics. So, I extract the terms with the largest positive t-statistics to construct CARS Index.

Because the initial minimum observation of the rolling window is twenty, the CARS index starts from March 2, 2020. For example, on March 16, 2020, I run the regression of $\Delta ASVI$ of expected excess return's changes over February 3, 2020 – March 16, 2020, ranking t-values for the 239 terms. I average $\Delta ASVI$ on March 16, 2020, of the top 30 terms to be the CARS index for March 16, 2020.

In the following Figure, I graph the daily search volume index for the keyword "CORONA VIRUS", the term with the top positive statistics over the sample period February 1, 2020 – October 27, 2020. The trend of "CORONVA VIRUS" is similar to the movement of the annualised 1-month equity premium.

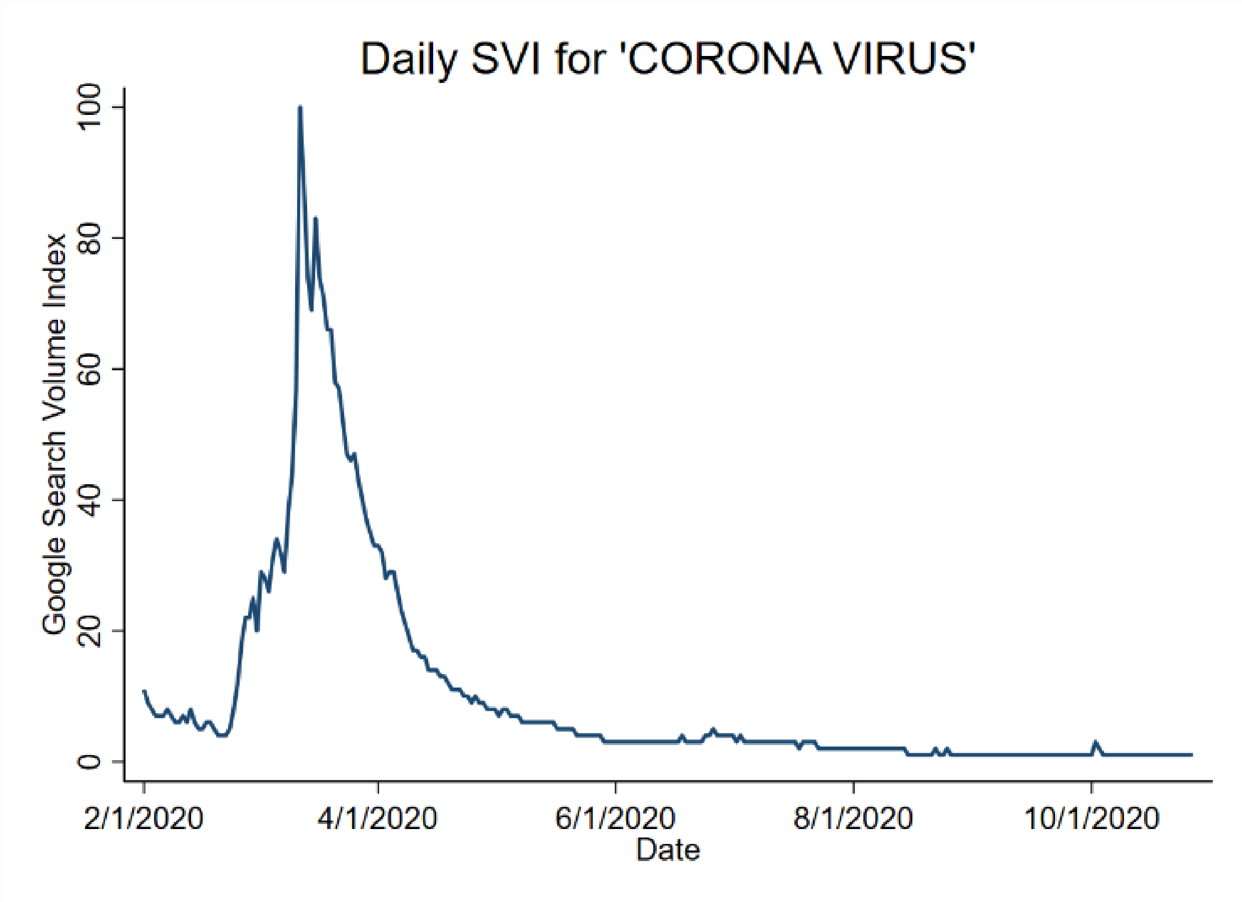
The thirty keywords with leading positive t-statistics

Rank	Term	t-value
1	CORONA VIRUS	10.57
2	COVID SYMPTOMS	9.964
3	SYMPTOMS	9.654
4	QUARANTINE CORONAVIRUS	9.600
5	CORONAVIRUS DISEASE	9.426
6	CORONA	9.242
7	CDC	8.286
8	US QUARANTINE	8.037
9	WHAT SYMPTOMS OF CORONAVIRUS	7.173
10	US CORONAVIRUS	6.984
11	CORONAVIRUS VIRUS	6.969
12	SYMPTOMS OF THE CORONAVIRUS	6.937
13	MOTALITY CORONAVIRUS	6.870
14	CORONA SYMPTOMS	6.789
15	WHO CORONAVIRUS	6.680
16	COORONAVIRUS CHINA	6.551
17	CORONA VIRUS SYMPTOMS	6.535
18	WHAT THE SYMPTOMS OF THE CORONAVIRUS	6.626
19	CORONAVIRUS OUTBREAK	6.375
20	COVID 19	6.301
21	COVID 19 SYMPTOMS	6.255
22	SPREAD OF CORONAVIRUS	6.252
23	CORONA VIRUS SPREAD	6.174
24	WHAT IS CORONAVIRUS	6.101

(Continued)

25	WHAT ARE THE SYMPTOMS OF THE CORONSVIRUS	6.095
26	MORTALITY RATE OF CORONAVIRUS	6.034
27	LOCKDOWN US	6.022
28	VIRUS SYMPTOMS	5.988
29	THE SYMPTOMS OF THE CORONAVIRUS	5.743
30	CORONAVIRUS AT RISK GROUPS	5.724

The daily search volume index for the keyword "CORONA VIRUS" over February 1, 2020 – October 27, 2020



C: Supplementary Tables

C.1 – Two regimes in the US stock market

C.1.1: This table reports the hypothesis testing results: whether the equity premium in recession (N-R, shown in column (6) of Panel A and B in Table 3) is significantly higher and more volatile than the equity premium in expansion (N-E, shown in column (7) of Panel A and B in Table 3). Columns (3) and (4) list the 99% confidence intervals for the equity premia at different horizons.

	(1)	(2)	(3)	(4)
Horizon	p-value for H_a: μ(N-R) > μ(N-E)	p-value for H_a: σ(N-R) > σ(N-E)	99% CI for EP in N-R	99% CI for EP in N-E
1 mth	0.000	0.000	(9.63, 11.71)	(3.50, 3.68)
2 mth	0.000	0.000	(8.96, 10.64)	(3.63, 3.80)
3 mth	0.000	0.000	(8.46, 9.89)	(3.69, 3.84)
6 mth	0.000	0.000	(7.54, 8.64)	(3.80, 3.94)
12 mth	0.000	0.000	(6.62, 7.46)	(3.74, 3.86)

Notation: μ represents mean value, and σ represents standard deviation.

C.1.2: Testing results for whether the differences between the short-term equity premium and the long-term equity premium are statistically significant over different periods (recessions are defined by NBER).

	(1)	(2)	(3)
	p-value for H_a: μ (1mth - 12mth) > 0	p-value for H_a: μ (1mth) > μ (12mth)	p-value for H_a: σ (1mth) > σ (12mth)
Recession	0.000	0.000	0.000
Expansion	1.000	1.000	0.000

C.2 – Explanatory power of changes in the equity premium

Regression of the realised stock returns on the difference between the daily equity premia at different time horizons over various periods. The dependent variables for all five columns are the daily realised stock return. The indicators for the columns are 1-month EP, 2-month EP, 3-month EP, 6-month EP, and 12-month EP, respectively.

C.2.1: Dot Com Bubble Period (January 3, 2000 – December 31, 2002)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	1.376***	2.172***	2.569***	4.105***	4.303***
	(0.0927)	(0.0831)	(0.103)	(0.167)	(0.582)
Cons.	-0.000537	-0.000501	-0.000483	-0.000448	-0.000499
	(0.000332)	(0.000311)	(0.000338)	(0.000328)	(0.000398)
R^2	0.618	0.664	0.604	0.625	0.454
Obs.	751	751	751	751	751

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.2.2: Financial Crisis Period (January 3, 2007 – December 31, 2009)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.718***	1.076***	1.404***	2.182***	3.309***
	(0.0424)	(0.0498)	(0.0602)	(0.0873)	(0.223)
Cons.	-0.000118	-0.000102	-8.55e-05	-4.44e-05	9.57e-06
	(0.000396)	(0.000355)	(0.000340)	(0.000326)	(0.000350)
R^2	0.668	0.732	0.755	0.774	0.738
Obs.	755	755	755	755	755

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

C.2.3: Crisis Period (combining 2000–2002, 2007–2009, and 2020)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.669***	0.982***	1.211***	1.935***	2.934***
	(0.0532)	(0.0808)	(0.115)	(0.154)	(0.229)
Cons.	-0.000186	-0.000186	-0.000186	-0.000184	-0.000188
	(0.000278)	(0.000268)	(0.000271)	(0.000266)	(0.000276)
R^2	0.566	0.596	0.585	0.603	0.572
Obs.	1,760	1,760	1,760	1,760	1,760

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.2.4: Non-Crisis Period (1996 to 2019 excluding 2000-2002, 2007-2009)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	1.090***	1.546***	1.672***	2.844***	2.430***
	(0.0437)	(0.0674)	(0.0742)	(0.132)	(0.361)
Cons.	0.000575***	0.000577***	0.000578***	0.000581***	0.000581***
	(9.01e-05)	(8.78e-05)	(9.57e-05)	(8.35e-05)	(0.000110)
R^2	0.583	0.605	0.530	0.641	0.381
Obs.	4,531	4,531	4,531	4,531	4,531

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

C.2.5: Full Period (January 4, 1996 – December 31, 2020)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.767***	1.127***	1.359***	2.279***	2.918***
	(0.0549)	(0.0815)	(0.106)	(0.144)	(0.205)
Cons.	0.000365***	0.000368***	0.000369***	0.000374***	0.000377***
	(0.000104)	(0.000100)	(0.000102)	(9.42e-05)	(0.000107)
R^2	0.548	0.583	0.563	0.630	0.524
Obs.	6,292	6,292	6,292	6,292	6,292

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.2.6: NBER Recession Period (March 2001 – October 2001, December 2007 – May 2009, and February 2020 and March 2020)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.592***	0.869***	1.082***	1.739***	2.693***
	(0.0467)	(0.0731)	(0.109)	(0.153)	(0.271)
Cons.	-0.00100*	-0.000987*	-0.000987*	-0.000980*	-0.00102*
	(0.000606)	(0.000586)	(0.000590)	(0.000583)	(0.000616)
R^2	0.632	0.657	0.652	0.664	0.627
Obs.	582	582	582	582	582

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

C.2.7: NBER Expansion Period (1996 to 2019 excluding NBER's recession periods)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.956***	1.325***	1.486***	2.376***	2.526***
	(0.137)	(0.223)	(0.243)	(0.457)	(0.372)
Cons.	0.000523***	0.000526***	0.000528***	0.000533***	0.000533***
	(9.56e-05)	(9.41e-05)	(9.89e-05)	(9.25e-05)	(0.000107)
R^2	0.511	0.523	0.474	0.532	0.388
Obs.	5,709	5,709	5,709	5,709	5,709

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.2.8: Means of the forward equity premium, EP_{T_1,T_2}, at various horizons (annualized and measured in %) over different time periods.

	(1)	(2)	(3)	(4)	(5)	(6)
Horizon	Dot Com Bubble	Financial Crisis	Crisis Period	Non-Crisis Period	NBER Recession	NBER Recession
term 1-12	4.67	6.12	5.41	3.57	6.71	3.82
term 1-12	4.59	6.00	5.29	3.59	6.49	3.82
term 1-12	4.53	5.90	5.19	3.60	6.33	3.81
term 1-12	4.38	5.68	4.96	3.54	5.99	3.73

C.3 – Simple linear regression of forward equity premium and bivariate regression on realized stock return over different periods.

C.3.1: Dot Com Bubble Period (January 3, 2000 – December 31, 2002)

Indicator	(1) term 1-12	(2) term 2-12	(3) term 3-12	(4) term 6-12
β	3.748***	3.142***	2.577***	1.231***
	(0.748)	(0.719)	(0.618)	(0.339)
Cons.	-0.000509	-0.000525	-0.000538	-0.000560
	(0.000457)	(0.000479)	(0.000492)	(0.000517)
R^2	0.278	0.206	0.160	0.072
Obs.	751	751	751	751

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Indicator	(1) 1mth + term1-12	(2) 2mth + term2-12	(3) 3mth + term3-12	(4) 6mth + term6-12
β_{short}	0.689***	0.756***	0.722***	0.767***
	(0.101)	(0.0899)	(0.112)	(0.172)
β_{long}	0.213***	0.145***	0.187***	0.148***
	(0.352)	(0.243)	(0.311)	(0.190)
Cons.	-0.000518	-0.000493	-0.000478	-0.000451
	(0.000316)	(0.000303)	(0.000324)	(0.000319)
R^2	0.654	0.681	0.636	0.646
Obs.	751	751	751	751

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

Panel C.3.2: Financial Crisis Period (January 3, 2007 – December 31, 2009)

	(1)	(2)	(3)	(4)
Indicator	term 1-12	term 2-12	term 3-12	term 6-12
β	3.966***	4.165***	4.214***	2.950***
	(0.307)	(0.381)	(0.478)	(0.517)
Cons.	4.49e-05	5.69e-05	5.98e-05	-2.10e-06
	(0.000416)	(0.000458)	(0.000482)	(0.000584)
R^2	0.630	0.548	0.497	0.269
Obs.	755	755	755	755

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
Indicator	1mth + term1-12	2mth + term2-12	3mth + term3-12	6mth + term6-12
β_{short}	0.511***	0.667***	0.746***	0.845***
	(0.0423)	(0.0598)	(0.0826)	(0.0951)
β_{long}	0.429***	0.266***	0.173**	0.064
	(0.311)	(0.370)	(0.408)	(0.315)
Cons.	-2.66e-05	-3.99e-05	-4.43e-05	-3.10e-05
	(0.000335)	(0.000328)	(0.000326)	(0.000322)
R^2	0.758	0.767	0.770	0.777
Obs.	755	755	755	755

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

C.3.3: Non-Crisis Period (1996 to 2019 excluding 2000-2002, 2007-2009)

	(1)	(2)	(3)	(4)
Indicator	term 1-12	term 2-12	term 3-12	term 6-12
β	2.106***	1.790***	1.453***	0.724***
	(0.406)	(0.399)	(0.339)	(0.221)
Cons.	0.000580***	0.000580***	0.000579***	0.000577***
	(0.000120)	(0.000125)	(0.000129)	(0.000135)
R^2	0.257	0.196	0.150	0.064
Obs.	4531	4531	4531	4531

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
Indicator	1mth + term1-12	2mth + term2-12	3mth + term3-12	6mth + term6-12
β_{short}	0.675***	0.720***	0.672***	0.765***
	(0.0525)	(0.0766)	(0.0781)	(0.120)
β_{long}	0.186***	0.134***	0.192***	0.020
	(0.212)	(0.174)	(0.205)	(0.0614)
Cons.	0.000577***	0.000578***	0.000579***	0.000581***
	(8.72e-05)	(8.61e-05)	(9.22e-05)	(8.35e-05)
R^2	0.610	0.619	0.564	0.642
Obs.	4531	4531	4531	4531

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

C.3.4: Full Period (January 4, 1996 – December 31, 2020)

	(1)	(2)	(3)	(4)
Indicator	term 1-12	term 2-12	term 3-12	term 6-12
β	2.961***	2.729***	2.336***	1.203***
	(0.322)	(0.385)	(0.379)	(0.278)
Cons.	0.000377***	0.000376***	0.000374***	0.000368**
	(0.000122)	(0.000129)	(0.000136)	(0.000147)
R^2	0.387	0.305	0.236	0.099
Obs.	6,292	6,292	6,292	6,292

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
Indicator	1mth + term1-12	2mth + term2-12	3mth + term3-12	6mth + term6-12
β_{short}	0.572***	0.655***	0.663***	0.769***
	(0.0603)	(0.0881)	(0.108)	(0.149)
β_{long}	0.292***	0.204***	0.208***	0.079***
	(0.233)	(0.204)	(0.210)	(0.0922)
Cons.	0.000371***	0.000372***	0.000373***	0.000375***
	(9.75e-05)	(9.65e-05)	(9.82e-05)	(9.35e-05)
R^2	0.605	0.613	0.599	0.635
Obs.	6,292	6,292	6,292	6,292

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

C.3.5: NBER Recession Period (March 2001 – October 2001, December 2007 – May 2009, and February 2020 and March 2020)

	(1)	(2)	(3)	(4)
Indicator	term 1-12	term 2-12	term 3-12	term 6-12
β	3.116***	3.278***	3.320***	2.478***
	(0.491)	(0.631)	(0.718)	(0.510)
Cons.	-0.00106	-0.00109	-0.00111	-0.00117
	(0.000721)	(0.000767)	(0.000801)	(0.000891)
R^2	0.490	0.420	0.365	0.208
Obs.	582	582	582	582

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
Indicator	1mth + term1-12	2mth + term2-12	3mth + term3-12	6mth + term6-12
β_{short}	0.595***	0.691***	0.718***	0.800***
	(0.0642)	(0.0990)	(0.145)	(0.176)
β_{long}	0.291***	0.175*	0.137	0.027
	(0.454)	(0.507)	(0.597)	(0.463)
Cons.	-0.000997*	-0.000991*	-0.000993*	-0.000983*
	(0.000570)	(0.000572)	(0.000582)	(0.000581)
R^2	0.677	0.673	0.662	0.665
Obs.	582	582	582	582

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

C.3.6: NBER Expansion Period (1996 to 2019 excluding NBER's recession periods)

	(1)	(2)	(3)	(4)
Indicator	term 1-12	term 2-12	term 3-12	term 6-12
β	2.355***	2.087***	1.749***	0.899***
	(0.374)	(0.376)	(0.336)	(0.235)
Cons.	0.000533***	0.000531***	0.000529***	0.000524***
	(0.000116)	(0.000121)	(0.000125)	(0.000132)
R^2	0.281	0.220	0.173	0.075
Obs.	5,709	5,709	5,709	5,709

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
Indicator	1mth + term1-12	2mth + term2-12	3mth + term3-12	6mth + term6-12
β_{short}	0.610***	0.654***	0.620***	0.711***
	(0.125)	(0.214)	(0.240)	(0.460)
β_{long}	0.186***	0.134***	0.180***	0.062***
	(0.232)	(0.163)	(0.192)	(0.0566)
Cons.	0.000527***	0.000529***	0.000531***	0.000534***
	(9.30e-05)	(9.26e-05)	(9.61e-05)	(9.22e-05)
R^2	0.534	0.536	0.501	0.535
Obs.	5,709	5,709	5,709	5,709

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.4 – C.4.1 and C.4.2 are results of the first robustness test – whether the results are affected by time point selected. C.4.3 and C.4.4 are results of the second robustness test – whether the results only hold during the crash.

C.4.1: (January 2, 2020 – June 30, 2020)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.478***	0.689***	0.830***	1.424***	2.493***
	(0.0485)	(0.0860)	(0.118)	(0.190)	(0.286)
Cons.	0.000258	0.000352	0.000411	0.000622	0.000756
	(0.00164)	(0.00162)	(0.00164)	(0.00158)	(0.00156)
R^2	0.611	0.626	0.617	0.650	0.666
Obs.	124	124	124	124	124

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
Indicator	term 1-12	term 2-12	term 3-12	term 6-12
β	3.243***	4.070***	4.835***	4.558***
	(0.610)	(0.785)	(1.124)	(1.632)
Cons.	0.000919	0.00107	0.00117	0.000787
	(0.00177)	(0.00173)	(0.00177)	(0.00207)
R^2	0.567	0.565	0.522	0.354
Obs.	124	124	124	124

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

Indicator	(1) 1mth + term1-12	(2) 2mth + term2-12	(3) 3mth + term3-12	(4) 6mth + term6-12
β_{short}	0.496***	0.526***	0.552***	0.708***
	(0.0807)	(0.112)	(0.126)	(0.205)
β_{long}	0.384**	0.333**	0.322**	0.160
	(0.721)	(0.854)	(1.024)	(1.013)
Cons.	0.000629	0.000706	0.000805	0.000754
	(0.00159)	(0.00160)	(0.00157)	(0.00157)
R^2	0.677	0.667	0.667	0.666
Obs.	124	124	124	124

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.4.2: (July 1, 2020 – December 31, 2020)

Indicator	(1) 1-mth EP	(2) 2-mth EP	(3) 3-mth EP	(4) 6-mth EP	(5) 12-mth EP
β	0.788***	1.181***	1.400***	2.197***	3.870***
	(0.0861)	(0.0966)	(0.136)	(0.224)	(0.368)
Cons.	0.00132*	0.00126**	0.00121*	0.00111*	0.00114*
	(0.000684)	(0.000624)	(0.000651)	(0.000651)	(0.000629)
R^2	0.466	0.551	0.513	0.518	0.554
Obs.	127	127	127	127	127

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

Indicator	(1) term 1-12	(2) term 2-12	(3) term 3-12	(4) term 6-12
β	4.783***	5.428***	6.546***	7.236***
	(0.554)	(0.759)	(0.802)	(0.967)
Cons.	0.00113*	0.00113	0.00116	0.00147*
	(0.000677)	(0.000720)	(0.000706)	(0.000743)
R^2	0.490	0.426	0.451	0.367
Obs.	127	127	127	127

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Indicator	(1) 1mth + term1-12	(2) 2mth + term2-12	(3) 3mth + term3-12	(4) 6mth + term6-12
β_{short}	0.374***	0.583***	0.486***	0.558***
	(0.134)	(0.191)	(0.195)	(0.283)
β_{long}	0.434***	0.209	0.307***	0.263***
	(0.806)	(1.101)	(0.898)	(0.897)
Cons.	0.00116*	0.00119*	0.00114*	0.00118*
	(0.000625)	(0.000617)	(0.000634)	(0.000624)
R^2	0.559	0.570	0.554	0.561
Obs.	127	127	127	127

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

C.4.3 (February 3, 2020 – March 31, 2020)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.443***	0.630***	0.756***	1.301***	2.279***
	(0.0448)	(0.0845)	(0.116)	(0.200)	(0.324)
Cons.	-0.00239	-0.00221	-0.00223	-0.00171	-0.00137
	(0.00425)	(0.00444)	(0.00455)	(0.00454)	(0.00454)
R^2	0.653	0.637	0.622	0.636	0.642
Obs.	40	40	40	40	40

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)
Indicator	term 1-12	term 2-12	term 3-12	term 6-12
β	2.912***	3.685***	4.359***	3.820**
	(0.719)	(0.933)	(1.346)	(1.618)
Cons.	-0.00145	-0.00117	-0.000984	-0.00236
	(0.00528)	(0.00510)	(0.00523)	(0.00600)
R^2	0.504	0.500	0.441	0.283
Obs.	40	40	40	40

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

	(1)	(2)	(3)	(4)
Indicator	1mth + term1-12	2mth + term2-12	3mth + term3-12	6mth + term6-12
β_{short}	0.625***	0.639***	0.641***	0.736***
	(0.0888)	(0.120)	(0.131)	(0.207)
β_{long}	0.246	0.202	0.207	0.106
	(0.869)	(1.039)	(1.154)	(0.895)
Cons.	-0.00178	-0.00170	-0.00153	-0.00147
	(0.00450)	(0.00474)	(0.00475)	(0.00464)
R^2	0.680	0.653	0.643	0.644
Obs.	40	40	40	40

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Panel D (April 1, 2020 – December 31, 2020)

	(1)	(2)	(3)	(4)	(5)
Indicator	1-mth EP	2-mth EP	3-mth EP	6-mth EP	12-mth EP
β	0.793***	1.160***	1.417***	2.182***	3.746***
	(0.0809)	(0.0934)	(0.108)	(0.155)	(0.244)
Cons.	0.00131**	0.00121**	0.00123**	0.00123**	0.00129**
	(0.000654)	(0.000571)	(0.000575)	(0.000555)	(0.000525)
R^2	0.539	0.649	0.653	0.684	0.723
Obs.	190	190	190	190	190

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

(Continued)

Indicator	(1) term 1-12	(2) term 2-12	(3) term 3-12	(4) term 6-12
β	4.736***	5.573***	6.460***	7.976***
	(0.296)	(0.379)	(0.433)	(0.660)
Cons.	0.00144***	0.00154***	0.00161***	0.00189***
	(0.000548)	(0.000583)	(0.000582)	(0.000660)
R^2	0.704	0.667	0.671	0.578
Obs.	190	190	190	190

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Indicator	(1) 1mth + term1-12	(2) 2mth + term2-12	(3) 3mth + term3-12	(4) 6mth + term6-12
β_{short}	0.223**	0.416***	0.418***	0.584***
	(0.0958)	(0.143)	(0.146)	(0.165)
β_{long}	0.669***	0.475***	0.477***	0.330***
	(0.534)	(0.698)	(0.707)	(0.761)
Cons.	0.00132**	0.00130**	0.00134**	0.00137***
	(0.000529)	(0.000529)	(0.000525)	(0.000523)
R^2	0.725	0.723	0.728	0.734
Obs.	190	190	190	190

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.5 – The results of robustness tests. In each panel, the dependent variables for the four columns are contemporaneous changes in particular expected excess returns. In column (2) and (3), the variables controlled are the changes in interest rate (IR, measured in 100%), the changes in rolling volatility of S&P 500 Index return every 10 days (VL), the changes in Economic Policy Uncertainty (EPU) Index, the changes in active coronavirus cases in the US (EXS), and the changes in expected return up to five lags (delta1 – delta5). In column (4), I instead control lagged index returns up to five days (delta1 – delta5) but without changes in rolling market return's volatility (VL). The standard errors in column (1), (2), and (4) are bootstrapped 10000 times, and the standard error in column (3) is robust standard error.

C.5.1: The explanatory variable CARS-N is constructed using the average daily ASVI of terms "covid", "masks", "vaccine", "lockdown", "travel ban", and "social distancing". Note that the time series data is scaled by 0.03919.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS-N	0.00287***	0.00261***	0.00261***	0.00281***
	(0.000435)	(0.000313)	(0.000285)	(0.000539)
IR		-0.171	-0.171	-0.177
		(0.150)	(0.145)	(0.182)
VL		1.970**	1.970***	
		(0.795)	(0.734)	
EPU		5.02e-06	5.02e-06	7.00e-06
		(8.14e-06)	(8.06e-06)	(9.09e-06)
EXS		-0.128	-0.128	-0.162*
		(0.0826)	(0.0783)	(0.0897)
delta1		0.0620	0.0620	0.00827
		(0.115)	(0.105)	(0.0790)

(Continued)

delta2		0.0688	0.0688	0.00663
		(0.0800)	(0.0742)	(0.0661)
delta3		-0.0786	-0.0786	0.101*
		(0.0713)	(0.0688)	(0.0577)
delta4		-0.139***	-0.139***	0.0880
		(0.0507)	(0.0453)	(0.0578)
delta5		-0.157***	-0.157***	0.0657
		(0.0554)	(0.0501)	(0.0494)
Constant	-0.00114*	0.000430	0.000430	0.000359
	(0.000674)	(0.000947)	(0.000890)	(0.00113)
R-squared	0.467	0.612	0.612	0.503
Observations	149	149	149	149
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.5.2: The explanatory variable is constructed for the 6-month equity premium's changes. Note that the time series data is scaled by 0.00940.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS	0.00167***	0.00140***	0.00140***	0.00135***
	(0.000271)	(0.000182)	(0.000157)	(0.000212)
IR		-0.0317	-0.0317***	-0.0336
		(0.0635)	(0.00833)	(0.0734)

(Continued)

VL		-0.0238	-0.0238	
		(0.322)	(0.279)	
EPU		5.28e-06	5.28e-06	7.89e-06**
		(3.91e-06)	(3.87e-06)	(3.90e-06)
EXS		-0.00366	-0.00366	-0.00186
		(0.00795)	(0.00629)	(0.00861)
delta1		0.0519	0.0519	0.0559
		(0.114)	(0.110)	(0.0351)
delta2		0.291**	0.291***	-0.0152
		(0.131)	(0.111)	(0.0383)
delta3		-0.159	-0.159	0.0531
		(0.127)	(0.110)	(0.0353)
delta4		-0.237**	-0.237***	0.0216
		(0.0973)	(0.0782)	(0.0386)
delta5		0.0346	0.0346	-0.00131
		(0.112)	(0.0943)	(0.0437)
Constant	-0.000419	-0.000260	-0.000260	-0.000409
	(0.000503)	(0.000421)	(0.000421)	(0.000456)
R-squared	0.534	0.696	0.696	0.645
Observations	168	168	168	168
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

C.5.3 – The explanatory variable is constructed for the 12-month equity premium's changes. Note that the time series data is scaled by 0.00315.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS	0.000191***	0.000196***	0.000196***	0.000176***
	(4.74e-05)	(3.95e-05)	(4.27e-05)	(3.53e-05)
IR		-0.00274	-0.00274	0.000136
		(0.0253)	(0.00178)	(0.0221)
VL		-0.254*	-0.254*	
		(0.152)	(0.143)	
EPU		4.08e-06**	4.08e-06**	4.26e-06**
		(1.67e-06)	(1.69e-06)	(1.81e-06)
EXS		0.00154	0.00154	-0.000324
		(0.00457)	(0.00360)	(0.00360)
delta1		-0.0515	-0.0515	0.0154
		(0.116)	(0.0626)	(0.0117)
delta2		-0.106	-0.106	0.00121
		(0.130)	(0.0900)	(0.0179)
delta3		-0.135	-0.135	0.0233*
		(0.158)	(0.108)	(0.0138)
delta4		-0.0211	-0.0211	0.00251
		(0.208)	(0.162)	(0.0191)
delta5		-0.00835	-0.00835	-0.0193
		(0.105)	(0.0728)	(0.0207)
Constant	-5.60e-05	-3.08e-05	-3.08e-05	6.00e-05
	(0.000176)	(0.000167)	(0.000162)	(0.000215)
R-squared	0.397	0.477	0.477	0.473

(Continued)

Observations	168	168	168	168
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.5.3 – The sample period is from January 2020 to June 2020. Note that the time series data is scaled by 0.04754.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS	0.0442***	0.0355***	0.0355***	0.0357***
	(0.00835)	(0.00811)	(0.00815)	(0.00767)
IR		-0.130	-0.130**	-0.135
		(0.266)	(0.0582)	(0.190)
VL		-0.0456	-0.0456	
		(1.203)	(1.107)	
EPU		-1.08e-05	-1.08e-05	-7.22e-06
		(2.45e-05)	(2.26e-05)	(2.13e-05)
EXS		-0.0129	-0.0129	-0.0257
		(0.0351)	(0.0290)	(0.0315)
delta1		-0.139	-0.139	0.303*
		(0.148)	(0.107)	(0.169)
delta2		0.0672	0.0672	-0.0217
		(0.151)	(0.0993)	(0.164)
delta3		0.0474	0.0474	-0.207
		(0.138)	(0.104)	(0.133)

(Continued)

delta4		-0.102	-0.102	-0.00833
		(0.128)	(0.0873)	(0.152)
delta5		-0.0739	-0.0739	0.00271
		(0.108)	(0.0654)	(0.117)
Constant	-0.00387	-0.00379	-0.00379	-0.00281
	(0.00276)	(0.00303)	(0.00324)	(0.00296)
R-squared	0.646	0.738	0.738	0.744
Observations	106	106	106	106
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.5.5 – The sample period is from July 2020 to December 2020. Note that the time series data is scaled by 0.00904.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS	0.00106***	0.00103***	0.00103***	0.00106***
	(0.000166)	(0.000165)	(0.000160)	(0.000186)
IR		-0.179	-0.179	-0.0985
		(0.202)	(0.171)	(0.239)
VL		1.455*	1.455**	
		(0.756)	(0.561)	
EPU		4.31e-07	4.31e-07	4.90e-06
		(6.69e-06)	(6.16e-06)	(8.87e-06)

(Continued)

EXS		-0.0201	-0.0201***	-0.0153
		(0.104)	(0.00539)	(0.136)
delta1		0.102	0.102	0.00553
		(0.136)	(0.134)	(0.0821)
delta2		0.272***	0.272***	-0.161*
		(0.0963)	(0.0906)	(0.0886)
delta3		-0.0566	-0.0566	0.0306
		(0.0945)	(0.0901)	(0.0675)
delta4		-0.115	-0.115	0.0501
		(0.0855)	(0.0816)	(0.0561)
delta5		-0.112	-0.112	0.113*
		(0.103)	(0.0909)	(0.0612)
Constant	-0.000901	-0.000556	-0.000556	-0.000626
	(0.000606)	(0.00112)	(0.000626)	(0.00145)
R-squared	0.492	0.638	0.638	0.555
Observations	108	108	108	108
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.5.6 – The sample period is from February 2020 to March 2020. Note that the time series data is scaled by 0.08003.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS	0.0921***	0.0639**	0.0639***	0.0706***
	(0.0220)	(0.0300)	(0.0156)	(0.0261)
IR		-0.0904	-0.0904	-0.110
		(0.555)	(0.0612)	(0.356)
VL		2.144	2.144	
		(3.734)	(2.409)	
EPU		-6.73e-05	-6.73e-05	-6.92e-05
		(0.000142)	(8.96e-05)	(0.000132)
EXS		-0.0748	-0.0748	-0.0979*
		(0.0599)	(0.0556)	(0.0565)
delta1		-0.357	-0.357*	0.634**
		(0.285)	(0.190)	(0.289)
delta2		0.0347	0.0347	-0.0367
		(0.339)	(0.153)	(0.337)
delta3		0.100	0.100	-0.362
		(0.306)	(0.185)	(0.336)
delta4		-0.0721	-0.0721	-0.241
		(0.332)	(0.165)	(0.352)
delta5		-0.0982	-0.0982	-0.0108
		(0.253)	(0.0943)	(0.295)
Constant	-0.00590	0.00776	0.00776	0.00949
	(0.00736)	(0.00739)	(0.00783)	(0.00685)
R-squared	0.610	0.768	0.768	0.800

(Continued)

Observations	41	41	41	41
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C.5.7 – The sample period is from April 2020 to December 2020. Note that the time series data is scaled by 0.01319.

	(1)	(2)	(3)	(4)
VARIABLES	Without Control	Baseline Model	Robustness Test1	Robustness Test2
CARS	0.00287***	0.00261***	0.00261***	0.00281***
	(0.000435)	(0.000313)	(0.000285)	(0.000539)
IR		-0.171	-0.171	-0.177
		(0.150)	(0.145)	(0.182)
VL		1.970**	1.970***	
		(0.795)	(0.734)	
EPU		5.02e-06	5.02e-06	7.00e-06
		(8.14e-06)	(8.06e-06)	(9.09e-06)
EXS		-0.128	-0.128	-0.162*
		(0.0826)	(0.0783)	(0.0897)
delta1		0.0620	0.0620	0.00827
		(0.115)	(0.105)	(0.0790)
delta2		0.0688	0.0688	0.00663
		(0.0800)	(0.0742)	(0.0661)
delta3		-0.0786	-0.0786	0.101*
		(0.0713)	(0.0688)	(0.0577)

(Continued)

delta4		-0.139***	-0.139***	0.0880
		(0.0507)	(0.0453)	(0.0578)
delta5		-0.157***	-0.157***	0.0657
		(0.0554)	(0.0501)	(0.0494)
Constant	-0.00114*	0.000430	0.000430	0.000359
	(0.000674)	(0.000947)	(0.000890)	(0.00113)
R-squared	0.467	0.612	0.612	0.503
Observations	149	149	149	149
Control	No	Lagged ER	Lagged ER	Lagged R
SE	Bootstrapped	Bootstrapped	Robust	Bootstrapped

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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