COVID-19 Uncertainty and Its Impact on Stock Prices

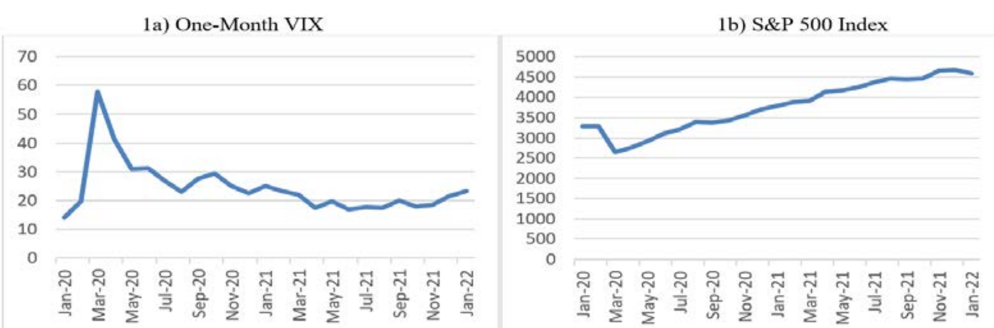
Abstract

This paper develops a stock-pricing model to investigate how the COVID-19 induced uncertainty affects stock prices. Through utilizing a series of mathematical techniques and conducting a comparative static analysis, we find that when economic uncertainty intensifies, the future payouts of firms, such as dividend payments to stockholders, tend to diminish, indicating a deterioration of firms' stability and prospect. As a result, investors expect a reduction in the future payoffs of the stocks issued by firms. Given that the price of a stock reflects the present values of its expected future payoffs, the rising level of COVID-19 uncertainty, which undermines the future payoffs of the stocks that investors expect to receive, decreases stock prices.

Introduction

In December 2019, scientists detected the first case of COVID-19 in Wuhan, China. Approximately four months later, the World Health Organization (WHO) declared the 2019 novel coronavirus outbreak a global pandemic ("Archived," 2020). Since COVID-19's sudden introduction onto the world stage, international production and consumption capabilities have deteriorated, investors have stopped their investments and withdrawn new investment decisions, and various social and economic strategies, such as school closures, work-from-home policies, mask-wearing, and lockdowns, have been implemented in an attempt to stop the spread of the virus (Vinelli et al., 2020). In addition, unprecedented economic uncertainty has surged in every aspect of the world economy. Individuals are uncertain about their income, future work prospects, the value of their savings, and the pattern of their consumption spending. Firms are uncertain about rapidly changing customer bases, alternate sources for essential production inputs, and what new regulations they will have to follow. Meanwhile, governments of all levels struggle to maintain relative order in an international backdrop of uncertainty (McMahon, 2020).

The COVID-19 pandemic has also caused financial markets across the world to tumble and fluctuate in chaotic, unpredictable patterns. In regard to the US stock market, the one-month VIX, which is one of the important indicators of COVID-19 uncertainty in Altig et al. (2020), rose from about 14 In January 2020 to a peak value of 57.7 in March before falling below 30.8 by May. However, the average stock price measured by the S&P 500 index displayed a completely opposite trend to the VIX (Figure 1), strongly indicating that the COVID-19 pandemic brought upon the stock market a significant amount of uncertainty and volatility. In view of the stock market phenomena over the past two years, we are interested to explore how the COVID-19 induced uncertainty affects stock prices and what major mechanisms are at work.



Note: VIX is the ticker symbol and the popular name for the Chicago Board Options Exchange's CBOE Volatility Index, a popular measure of the stock market's expectation of volatility based on S&P 500 index options. Data on VIX is collected from https://www.cboe.com/tradable_products/vix/vix_historical_data/. Data on S&P 500 index is collected from https://www.wsj.com/market-data/quotes/index/SPX/historical-prices.

Fig. 1. VIX and S&P 500 Index

In theory, the price of a stock reflects the present values of its expected future payoffs (Dividend Discount Model, 2022). When economic distress occurs, economic uncertainty significantly increases, leading to a general decline in the future profitability and stability of firms. With such a decrease in both observed and expected revenues, firms are likely to re-evaluate their financial positions and slash or suspend their future payouts, such as dividend payments to stockholders (Langager, 2021). Naturally, investors expect a reduction in the future payoffs of the stocks issued by firms, and as a result, the fundamental nature of the stocks' intrinsic values alters, leading to a drop in stock prices (Sholichah et al., 2021). In light of the unprecedented impact of COVID-19 pandemic on world economic activity, it is reasonable to anticipate a significant reduction in the future payoffs of the stocks that investors expect to receive. Thus, we hypothesize that the COVID-19 induced uncertainty causes stock prices to decline.

This paper develops a stock-pricing model grounded in economic theories and solves it by utilizing a series of mathematical and economics techniques. The model specifies a representative investor's desire to maximize their utility as a function of current and future consumption. The current consumption depends on the difference between the investor's current endowment and the cost of purchasing financial stocks, while the future consumption is dependent on the sum of the investor's future endowment and the payoffs on financial stocks. Maximizing the investor's lifetime utility subject to their budgetary constraints derives a stock pricing formula that guides an investor to purchase stocks. Combining this pricing formula with a stock payoff equation that justifies the linkage between the COVID-19 uncertainty and future payoffs then allows us to conduct a comparative static analysis. The result reveals that, holding everything else constant, when the degree of economic uncertainty increases due to the spread of COVID-19 pandemic, stock prices tend to decrease.

Although a few researchers (e.g., Szczygielski et al., 2021; Dai et al., 2021) have examined the effects of economic uncertainty on stock markets, their works are mainly empirical, relying on the quality and availability of data and the accuracy of quantitative modeling. In contrast, this paper utilizes a series of mathematical, economics tools to develop a theoretical model that investigates how the COVID-19 uncertainty affects stock prices, and through what mechanisms it does so. Hence, this paper is more theory-driven than empirical ones, which likely do not generalize the outside of the available labeled data well. This paper particularly contributes to the existing literature by incorporating the COVID-19 induced uncertainty into a consumption-based asset-pricing model, analyzing how a representative investor optimizes their consumption and saving decisions and how stocks are priced in the presence of COVID-19 uncertainty, and rationalizing findings with economic theories.

This paper is organized as follows: Section II reviews the related literature surrounding uncertainty and its effects on stock markets, Section III develops a theoretical model to examine the behavior of stock prices due to the COVID-19 uncertainty, Section IV conducts a comparative static analysis and analyzes the results, and Section V concludes and draws policy implications.

Literature Review

There has been considerable research on economic uncertainty and its effects on economic activities. As McMahon (2019) points out, economic decisions to consume, produce, and invest are usually made based on expected outcomes. If conditions that will obscure expected outcomes exist, firms, individuals, investors and other economic agents will likely perform with less confidence and commit fewer resources. Many studies (e.g., Giavazzi & McMahon, 2012) have found that increased uncertainty has negative effects on the economy. During periods of economic uncertainty, firms are likely to reduce their capital and labor investment, hiring activities and employment, and productivity. Moreover, uncertainty tends to slow down technological advancement, increase financial costs and household savings, and escalate asset market volatility.

As a multi-faceted global crisis, the COVID-19 pandemic has triggered an extraordinary level of economic uncertainty. To specifically measure the magnitude of COVID-19 economic uncertainty, Altig et al. (2020) consider several uncertainty indicators, such as implied stock market volatility, newspaper-based policy uncertainty, twitter chatter about economic uncertainty, subjective uncertainty about business growth, forecaster disagreement about future GDP growth, and a model-based measure of macro uncertainty. They find that in reaction to the pandemic and its induced economic uncertainty, all indicators display considerable uncertainty jumps, with most indicators reaching record high values. Barro et al. (2020) further find that the global economic practices and related policy reactions of the pandemic have also become uncertain. In general, the current literature of the economic effects of COVID-19 induced uncertainty all seem to point towards a conclusion in which such effects are likely to be bigger and more persistent than the immediate disruption.

Numerous papers further indicate that the COVID-19 induced uncertainty has negatively affected various sectors, including but not limited to finance, banking, travel, health, service, transportation and infrastructure. Barua (2020) finds that the COVID-19 uncertainty has weakened demand, supply, and productivity for households and firms, interrupted the global supply chain of capital, goods, and services, and halted businesses and productions in a large number of countries, albeit temporarily. Using the Pandemic Uncertainty Index, Wu (2020) finds that the pandemic-related uncertainty negatively affects household consumption. Chen et al. (2021) show that the pandemic-induced uncertainty has a positive influence on income inequality in 34 OECD countries but a negative influence in 107 non-OECD countries.

Other studies have focused particularly on the impact of COVID-19 pandemic on financial markets, such as oil markets, energy markets, gold markets, bond markets, and stock markets. Baker et al. (2020) compare the COVID-19 crisis to other pandemics, including the Spanish flu, Ebola, and swine flu, and find that the COVID-19 pandemic causes an unprecedented shock on the U.S. stock market. Wang et al. (2021) investigate the drivers of the S&P 500 equity returns during the COVID-19 crisis and conclude that the volatility indices (VIX) decrease equity returns.

However, compared with the themes of the studies mentioned above on the COVID-19 pandemic, little research has been done on the impact of COVID-19 induced uncertainty on stock markets. The few studies that have been conducted include Szczygielski et al. (2021), who quantitatively investigate the effect of COVID-19 uncertainty on the equity returns for six regional stock markets. Their investigation yields that global COVID-19 uncertainty negatively affects stock returns for all the regions. Dai et al. (2021) study the impact of economic policy uncertainty (EPU) on the US stock market's risk of crashing during the COVID-19 pandemic. They find a significantly negative correlation between EPU and stock market crash risk, which grew stronger after the global COVID-19 outbreak.

The papers reviewed above are mostly empirical, relying on the accuracy and quality of the data to examine the effects of COVID-19 uncertainty from different perspectives. However, while observational datasets are extremely valuable, they can be somewhat of a black box as the associations estimated within them can arise from many different mechanisms. Additionally, quantifying economic uncertainty in the measurement process is difficult and challenging. As such, we employ a unique research methodology in our paper, in which we develop a theoretical model to study how investors optimize their consumption and saving decisions and how stocks are priced in the presence of COVID-19 induced uncertainty. Using a series of math and economics tools, we mathematically solve the model, analyze how the COVID-19 uncertainty affects stock prices with well-grounded economic theories, and explain our results with concrete justifications.

Stock-Pricing Model

To study the impact of COVID-19 uncertainty on stock prices, we begin by first investigating a representative investor's consumption and saving behaviors based on the work by Cochrane (2000). When the investor decides how much to save and consume, they take into account their lifetime financial resources rather than simply the current ones; this premise is the foundation of investing, as the investor is generally insecure about their future and thus inclined to evenly distribute their resources in their lifetime. In addition, the investor desires to maximize their lifetime utility, subject to their budget constraints. To achieve this goal, the investor looks towards stock markets to leverage their current resources.

Based on the above assumptions and features associated with the representative investor's consumption and saving behaviors, we develop a theoretical model to study how stocks are priced in response to the COVID-19 uncertainty. To simplify the analysis, we further impose some assumptions into the model. First, the investor lives for two periods, the current and future periods in which the investor would like to maximize their lifetime utility in terms of their contemporaneous and future levels of consumption. Specifically, we assume that $U(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma}$ and $U(C_{t+1}) = \frac{C_{t+1}^{1-\gamma}}{1-\gamma}$, where the utility function exhibits Constant Relative Risk Aversion (CRRA) with its first derivative being positive and second derivative being negative (i.e. $U' > 0$ and $U'' < 0$). Second, the utility function captures the investor's desire for more consumption in the future and their level of impatience, $0<\beta<1$. The impatience rate is greater if the investor postpones their current consumption and shifts consumption into the future, while a lower impatience rate occurs if the investor consumes today and less in the future to maximize utility. Third, the investor receives an exogenous endowment of resources in the current period t, which is allocated between consumption and the purchase of stocks. In the future period $t + 1$, the stocks pay out X_{t+1} that can be used, along with a new exogenous endowment of resources, for consumption purposes.

Under the assumptions mentioned above, the investor's optimization behavior can be described by:

$$\max_{C_t, C_{t+1}, Q_t} U(C_t) + E_t[\beta U(C_{t+1})] , \qquad (1)$$

$$s.t. \quad C_t = Y_t - P_t Q_t ,$$

$$C_{t+1} = Y_{t+1} + X_{t+1} Q_t . \qquad (2)$$

Equation (1) is an objective function that models the investor's desire to maximize their lifetime utility as a function of current and future consumption ($U(C_t)$ and $U(C_{t+1})$). Equation (2) presents two budgetary constraints that the investor has to consider when maximizing their utility. The first constraint shows that the current consumption (C_t) depends on the difference between the investor's current endowment (Y_t) and the cost of purchasing a portfolio of financial stocks (P_tQ_t, where P_t stands for the stock price per share and Q_t represents the shares of stock portfolio). The second constraint indicates that the future consumption (C_{t+1}) is dependent on the future endowment (Y_{t+1}) and the payoff resulting from the purchased financial stocks (X_{t+1}).

Plugging Equation (2) into Equation (1) gives us

$$\max_{Q_t} \; U(Y_t - P_tQ_t) + E_t[\beta U(Y_{t+1} + X_{t+1}Q_t]. \qquad (3)$$

Differentiating the investor's lifetime utility function with respect to Q_t yields

$$P_t = \frac{\beta E_t[U'(C_{t+1})X_{t+1}]}{U'(C_t)}\;. \qquad (4)$$

Equation (4) shows that the stock price per share depends on the ratio of expected future consumption to the current consumption that the investor is willing to give up. In addition, the stock price is proportional to the future payoff of the stocks, X_{t+1}. As such, the investor will purchase more of the stocks if the payoff is expected to be higher. We further modify Equation (4) as

$$P_t = E_t(m_{t+1}X_{t+1}), \qquad (5)$$

where $m_{t+1} = \frac{\beta U'(C_{t+1})}{U'(C_t)}$. In Equation (5), m_{t+1} is referred to as a stochastic discount factor, which reveals that the current stock price equals the sum of the present values of all expected future payoffs.

Without considering economic uncertainties, the one-period stock payoff (X_{t+1}) is expected to be the next period's stock price plus dividends, described by:

$$X_{t+1} = E_t[P_{t+1} + d_{t+1}], \qquad (6)$$

where d_{t+1} stands for the future dividends. To investigate the impact of COVID-19 uncertainty on stock prices, Equation (6) is modified as

$$X_{t+1} = E_t[P_{t+1} + d_{t+1} - f(\theta_t)]\;, \qquad (7)$$

where θ_t symbolizes the COVID-19 uncertainty at time *t*, and $f(\theta_t)$ represents the incurring reduction in the payoffs of the stocks that arises from the COVID-19 uncertainty, which is featured by $f'(\theta_t) > 0$ and $f''(\theta_t) < 0$.

Equation (7) corresponds with the previous research, demonstrating that economic uncertainties negatively influence the magnitude of the payoffs that the investor expects to receive, including future dividends (d_{t+1}). Alfaro et al. (2018) find that higher economic uncertainty reduces firms' investment and hiring, leading to a cut in their future payouts, such as dividends. When economic uncertainty increases, firms with low cash flows tighten their policies on dividends to conserve cash, while firms with high cash flows become opportunistic and are inclined to pay higher dividends (Walkup, 2016). In the COVID-19 related literature, Krieger et al. (2021) conduct a quantitative research to examine the impact of COVID-19 on dividend cuts and omissions by the US firms. They find evidence of increased dividend reductions across all industries, with one out of every six industrial firms cutting their payout ratios during the second quarter of 2020. In addition, Equation (7) points to the role of future stock prices (P_{t+1}) in the expected payoffs. With high uncertainty during the COVID-19 period, factors such as inflation, unemployment, and the overall riskiness of investments dramatically increase, putting firms' sustainability in jeopardy (Baker et al, 2020). Additional factors such as a nation's reactionary policies in response to uncertainty and external influences affect this process as well (Jackson et al., 2021). From the investor's standpoint, the potential decline in the future profitability and stability of a firm will obstruct one's financial goals for investment. As such, the firm's future stock price is expected to fall, reflecting the investor's perception of the firm's ability to earn and grow its profits (Sholichah et al., 2021). Following the previous studies, we use $f(\theta_t)$ to measure the incurring reduction in the payoffs of the stocks caused by the COVID-19 uncertainty, which arise from the future payouts of firms and the future stock prices.

To summarize, we derive two important equations by modeling a representative investor's optimization behavior. Equation (5) shows how much the investor is willing to pay to acquire a share of stocks, while Equation (7) shows how stock payoffs are determined in the presence of COVID-19 uncertainty.

Results and Analysis

To study the impact of COVID-19 uncertainty on stock prices, we conduct a comparative static analysis (Comparative Statics, 2021), which is the method of analyzing the impact of a change in the variables of a model by comparing the equilibrium that results from the change with the original equilibrium. The method indicates that when a stock market reaches its equilibrium/steady state, the variables in the market do not grow in the course of time. As such,

$$P_t = P_{t+1} = P,\ d_{t+1} = d,\ m_{t+1} = m,\ \text{and}\ \theta_t = \theta.$$

Total differentiating Equations (5) and (7) at the steady state gives (See appendix in detail)

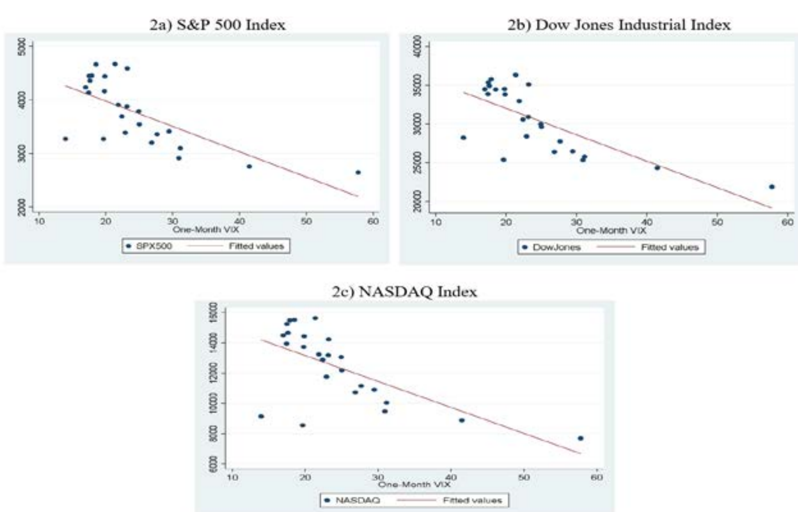
$$(1-m)dP = Xdm - mf\,'(\theta)d\theta + mdd. \qquad (10)$$

Under the assumptions that $dm = 0$ and $dd = 0$, the derivative of stock prices (*P*) with respect to the COVID-19 uncertainty (θ) yields

$$\frac{dP}{d\theta} = \frac{-mf\,'(\theta)}{(1-m)}. \qquad (11)$$

In Equation (11), *m* represents the stochastic discount factor in equilibrium, where $0 < m < 1$. Given $f\,'(\theta) > 0$, it follows that $\frac{dP}{d\theta} < 0$. The negative sign of $\frac{dP}{d\theta}$ indicates that, holding everything else constant, stock prices tend to decrease when the degree of COVID-19 uncertainty increases. The mechanism behind this equation tells us that the spread of the COVID-19 pandemic causes the intensity of economic uncertainty to rise. When a firm finds itself less profitable than before, the firm will likely decrease or eliminate its future cash flows as a means of conserving its cash in hand to prepare against future uncertainty shocks. Consequently, the firm's payouts, including dividend payments, diminish as an approximation for the overall financial stability. In addition, the worsening financial health and declining payouts of the firm make investors hold their purchases of the firm's stock, causing the future stock price to drop. Equation (5) shows that stock price is worth the present values of its expected future payoffs, which involve the firm's future dividends and the future stock price. Hence, the COVID-19 uncertainty has a negative influence on stock prices due to the decrease in the future payoffs that investors expect to receive.

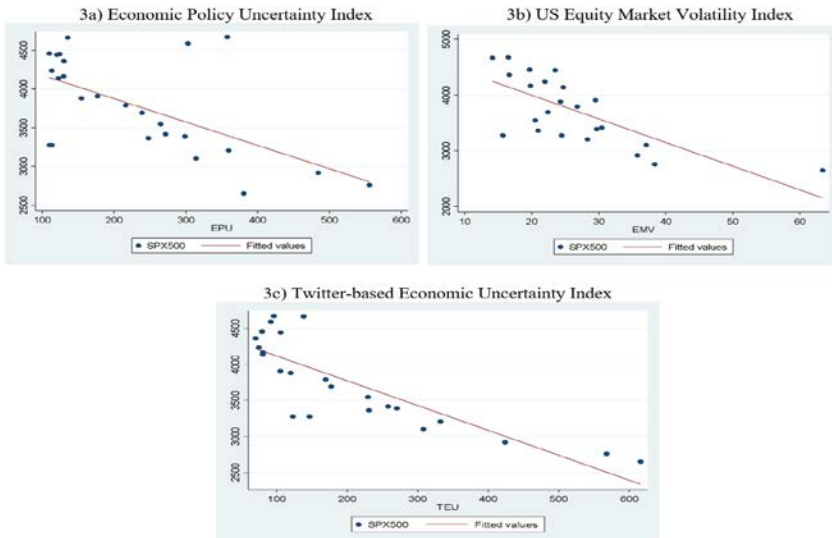
To verify if the above finding is in accordance with the real-time performance of stock markets during the COVID-19 period, we move forward by collecting the data on the US stock market, which is one of the major sources of a spillover effect to other stock markets. We start by collecting the monthly data on different measures of the US stock prices, such as S&P 500, Dow Jones Industrial Average, and NASDAQ indices from January 2020 to January 2022. Then, we plot the one-month VIX as an indicator of the level of COVID-19 uncertainty against each stock price index. Every panel in Figure 2 displays a downward sloping fitted regression line with the p-value of the stock price index far below the 1% significance level, therefore highlighting a significant, negative impact of COVID-19 uncertainty on stock prices in the US stock market.



Note: The monthly Data on S&P 500, Dow Jones Industrial Average, and NASDAQ are collected from Yahoo Finance.

Fig. 2. Different Measures of the US Stock Prices

We also collect the monthly data on the different measures of uncertainty, such as Economic Policy Uncertainty Index (EPU), US Equity Market Volatility Index (EMV) and Twitter-based Economic Uncertainty Index (TEU). The panels in Figure 3 further confirm that no matter how the COVID-19 uncertainty is measured, the significant, negative impact of COVID-19 uncertainty on stock prices still holds.



Note: The EMV index is a newspaper-based Equity Market Volatility tracker that moves with the CBOE Volatility Index (VIX) and with the realized volatility of returns on the S&P 500. The monthly data on EPU, EMV, and TEU are collected from https://www.policyuncertainty.com.

Fig. 3. Different Measures of COVID-19 Uncertainty

Conclusion

In this study, we developed a stock-pricing model to analyze how the COVID-19 uncertainty affects stock prices. Using a series of mathematical techniques supported with economic theories, we solved this theoretical model and found that the COVID-19 induced uncertainty negatively affects stock prices through a reduction in the expected future stock payoffs.

From the above finding, we can draw several policy implications. Starting at a firm level, it is clear that policy makers must communicate clearly and act decisively when facing major crisis events. Generally, investors react unfavorably to dividend cuts, signaling a deterioration of firms' financial health and prospects. In order to reduce such effects of economic uncertainty on their profitability and sustainability, firms should immediately introduce event-response policies, such as dividend policy. On the national level, policymakers promptly limiting the amount of uncertainty would avoid any build-up of uncertainty, and policy cooperation and transparency between governments and countries might further mitigate effects.

This study provides the preliminary results to understand how the COVID-19 induced uncertainty affects stock prices under a stock payoff lense. Future research will focus on a breakdown of different types of uncertainty, such as financial, policy-related, and economic uncertainties. We are also interested in extending this model by incorporating some other channels and mechanisms at work, allowing for a more intricate evaluation of the impact of COVID-19 uncertainty on stock prices.

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Appendix

Stock-Pricing Model:

A representative investor's optimization behavior is described by

$$\max_{C_t, C_{t+1}, Q_t} U(C_t) + E_t[\beta U(C_{t+1})], \qquad (1)$$

$$s.t. \quad C_t = Y_t - P_t Q_t,$$

$$C_{t+1} = Y_{t+1} - X_{t+1} Q_t. \qquad (2)$$

More specifically, the lifetime utility function is

$$\max_{C_t, C_{t+1}, Q_t} \frac{C_t^{1-\gamma}}{1-\gamma} + E_t[\beta \frac{C_{t+1}^{1-\gamma}}{1-\gamma}]. \qquad (1')$$

Plugging Equation (2) into Equation (1') yields

$$\max_{Q_t} \frac{(Y_t - P_t Q_t)^{1-\gamma}}{1-\gamma} + E_t[\beta \frac{(Y_{t+1} + X_{t+1} Q_t)^{1-\gamma}}{1-\gamma}]. \qquad (3)$$

Differentiating the individual's lifetime utility function with respect to Q_t gives

$$P_t = \frac{\beta E_t[U'(C_{t+1}) X_{t+1}]}{U'(C_t)} = \beta(\frac{C_t}{C_{t+1}})^{\gamma} X_{t+1}. \qquad (4)$$

The pricing formula is then rewritten as

$$P_t = E_t(m_{t+1} X_{t+1}), \qquad (5)$$

where $m_{t+1} = \frac{\beta U'(C_{t+1})}{U'(C_t)} = \beta(\frac{C_t}{C_{t+1}})^{\gamma}$.

As for the stocks, we define the payoff on a share of stock portfolio as

$$X_{t+1} = E_t[P_{t+1} + d_{t+1} - f(\theta_t)], \qquad (7)$$

where θ_t symbolizes the COVID-19 uncertainty, d_{t+1} denotes the future dividends received at time t+1, and $f(\theta_t)$ represents the uncertainty cost function that displays $f'(\theta_t) > 0$ and $f''(\theta_t) < 0$.

Totally differentiating Equation (5) at the market steady state gives

$$dP = Xdm + mdX. \qquad (8)$$

Totally differentiating Equation (7) at the market steady state gives

$$dX = dP + dd - f'(\theta)d\theta. \qquad (9)$$

Plugging Equation (9) into Equation (8) yields

$$(1-m)dP = Xdm - mf'(\theta)d\theta + mdd. \qquad (10)$$

Using the comparative static analysis, we assume that dm=dd=0 and derive

$$\frac{dP}{d\theta} = \frac{-mf'(\theta)}{(1-m)}. \qquad (11)$$