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Term Structure of Implied Dividend

Empirical Evidence from Hong Kong

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ABSTRACT

In the thesis, Hong Kong market data for the period Jan 2006 to Jan 2021 is used to provide empirical evidence for studying the term structure of implied dividends. The study attempts to identify the relationship between equity risk premiums and variation of dividend strips prices across two different time periods, during and after the financial crisis. Under the no-arbitrage assumption, the study replicates the prices of dividend claims of various maturities using options (HSI) by put-call parity. I further assume the variation of the dividend claim prices is primarily driven by the changes in the discount rate for dividends. Predictive regression shows that the slope obtained by regressing the dividend price on maturity is negatively correlated with the discount rate for dividends. As the stock is also a form of dividend claim, we can use the slope to predict future equity risk premium. During the process, we find the time series data are heteroscedastic and serially correlated by the ACF plot. We adjust the t-statistic with the Newey-West standard error of the coefficient and intercept. Finally, by adding fundamental ratios as control variables in multiple regression, it is shown that the slope coefficients are significantly negative, and the correlations are hardly affected by the additional aggregate predictors expect when controlling dividend yield in crisis period. The weakest result cause by controlling dividend to price ratio is because variation of the dividend claim prices is procyclical.

Keywords: Hong Kong Stock Market, HSI, equity risk premium, dividend strips, linear regression, ACF plot, Newey-West adjustment

CONTENTS

1 Introduction

Discount rates, or expected returns on an asset, are crucial in economics. This is because they permit investors and others to assess the risk of an investment and set a benchmark for upcoming investments. For instance, Gordon (1962) demonstrates that the present value of future dividends is associated with equity assets' market values. Especially, Gordon (1962) describes the intrinsic value of the aggregate stock market as the sum of the discounted future dividend payments.

Brennan (1998) indicates that a theoretical claim on a single dividend paid at a certain point in the future would be valuable for rational pricing promotion. Since then, the term structure of equity, the difference between stock returns and their corresponding dividend claims, has received substantial attention. Moreover, exploring the properties of individual terms in the sum, also called dividend strips, provides us with information about how stock prices are formed in addition to studying the sum of discounted dividends (Binsbergen et al., 2012).

The main focus is to study the relationship between the discount rate for the dividend strips and prices of dividend claims by running regressions of total index excess return on the variation of dividend strips. For the empirical part, dividend strips can be replicated using options written on the Hang Seng Index (HSI). The slope of the put-call ratio which represents the discount rate for dividend strips, serves as the independent variable in the regression model. Based on frictionless markets, our approach only requires no-arbitrage relationships without relying on any specific model. Under this condition, put-call parity for European options holds.

Since options are available in different maturities, the put-call parity allows me to calculate the prices of dividend claims of various maturities. As the level of dividend is relatively smooth, I further assume that the variation of the price of the synthetic dividend claim is primarily driven by the changes in the discount rate for the dividend. When regressing the dividend price on maturity, the slope is thus negatively correlated with the dividend discount rate. We can then use the slope as a predictor for the future equity risk premium, as the stock is also a form of dividend claim. We expect to find a negative sign in the predictive regression.

As time-series data are analyzed, regression models frequently show auto-correlation. In other words, residual errors are autocorrelated as time passes. To detect the issue, the Auto Correlation Function plot is used on the regression model. The plot reveals regression of the time series data has highly autocorrelated residuals, so the t-statistic is adjusted with the Newey-West standard error of the coefficient and intercept. By including control variables as other independent variables in multiple regression analysis, we can estimate how financial ratios affect our regression results. After all the analysis, we find all specifications have statically significant negative coefficients, and additional factors have little effect on them.

2 Literature Review

Individual investors tend to have subjective preferences regarding dividend payouts. They want to learn about the future dividend payouts of a company. Starting with the traditional approach of the cash flow method pioneered by Williams (1938), we modeled stocks and dividends together, assuming the current market price of the stock equals the present value of potential dividends in the future.

There have been a number of academic studies examining the accuracy of analyst and management forecasts of dividends and comparing them to historical data. Using an autoregressive forecasting model, Chance, et al. (2000) indicate that dividends are important for indices. Chance et al. (2002) incorporated a random component into dividend payments in order to loosen the assumption of deterministic dividends.
The method used to value dividend claims in this dissertation is closer to that of van Binsbergen et al. (2012) and van Binsbergen et al. (2013), who analyze dividend timing, pricing, and yields using options-based dividend strips. As for the usage of other

derivative instruments, Wilkens and Wimschulte (2010) and Stotz (2015) use dividend futures, a recently developed new class of derivative instruments, to analyze the valuation and performance of stock indices. Alpert (2009) examines put-call parity with and without dividend payments in light of taxation. A regression-based approach developed by Desmettre et al. (2017) integrates a variety of option data points and instantly calibrates a market-implied discount curve, which matches the pertinent market prices. The dividend discount model and equity index dividend futures which measure the risk-adjusted expectations of future dividends are used to calculate the implied equity risk premium Časta (2022).

To study the term structure of implied dividend, by using dividend strips, one can break down the equity value into its sum of dividend claims and assess the term structure of dividend risk predictions based on asset pricing models on the short-term structure. For example, Binsbergen et al. (2012), Binsbergen et al. (2013), and Binsbergen and Koijen (2017), claim that equity risk rewards in the data have a downward sloping term structure. However, many standard macro-finance models indicate a nondecreasing term structure of the discount rates. Campbell and Cochrane (1999) state that the equity risk premium of risky cash flows should increase with maturity or be flat in disaster models (Barro, 2006).

There are more discussions on consistency with standard macro-finance models and assumptions regarding dividend strip valuation. Binsbergen and Koijen (2017) suggest that the dividend strips data is difficult to reconcile with the mentioned leading theoretical models. On the other hand, by introducing a novel empirical approach and examining dividend strips with particular attention to their limitations, Bansal and Miller (2021) show that the strips are consistent with standard macro-finance models. While Binsbergen et al. (2012) used simple no-arbitrage arguments based on frictionless markets, Schulz (2016) took into account many market imperfections and concluded that the large returns on short-term dividend assets might be attributed to the fact that investors are compensated for the extra tax burden of dividends on the ex-date.

In the aggregate market, equity risk premium predictability is also a topic of controversy and intense discussion in empirical finance. Stock market returns are often predicted by factors such as dividend yields. In early research, Fama and French (1988) discovered that the price-dividend ratio is negatively correlated with the future return of US equities across time horizons ranging from one month to four years. According to Goyal and Welch (2003), all evidence for predictive power vanished since 1990. In order to avoid complications caused by overlapping returns, Lewellen (2004) concentrated on short-horizon tests-monthly returns regressed on lagged dividend-to-price ratio and included the information conveyed by autocorrelation which can increase the power of empirical tests.

Over time, empirical tests also expanded to include other fundamental variables such as interest rates, default spreads, and earnings to price ratios (e.g., Fama and Schwert, 1977; Campbell, 1987). Based on tests that also include size and market capitalization, Basu (1983) shows that earnings-price ratios (E/P) explain the cross-section of average stock return on US stocks. As Lewellen (2004) demonstrates, the earnings-price ratio predicts returns for the shorter sample of 1963 – 2000. Despite the unusual price run-up over the past few years, the evidence remains strong. The researchers related to aggregate predictability provide the motivation to investigate the impact of fundamental ratios on our topic.

3 Data

3.1 Overview of Hong Kong Stock Market

Hong Kong's stock market dates back to 1891 when the Association of Stockbrokers in Hong Kong was established. In 1980, the Hong Kong Stock Exchange (HKEX) was merged with four separate exchanges in Hong Kong to form a unified stock exchange. Hong Kong is widely acknowledged to be the most prominent financial center in the world today, serving as an influential Asian financial platform. It's Hong Kong's geographical location that sets it apart from other places in the world, as it's an ultimate connector between Mainland China and Western countries.

With a market capitalization of 42.59 trillion HKD (5.43 trillion USD), Hong Kong

Stock Exchange now ranks as the 7th largest stock exchange operator in the world as of December 2021. There were 2,571 listed companies at the end of 2021, and they were divided into 12 industry clusters with four key industries in Hong Kong's economy: financial services, trading and logistics, tourism, and producer and professional services.

3.2 Hang Seng Index (HSI) and Hang Seng Total Return Index (HSIDV)

Hang Seng Index (HSI) tracks the performance of the Hong Kong stock market overall. The index is a free-float adjusted market capitalization-weighted index (shares outstanding times stock price). The index is affected more by stocks with a higher market capitalization than those with lower market capitalizations. HSI consists of 64 constituent companies that represent approximately 58% of Hong Kong's stock market capitalization. The Index reached its highest point on 26th January 2018, closing at 33,154.12.

The Hang Seng Total Return Index Series ("TRI Series") were introduced to further enhance index services offered to market participants. The TRI Series includes Gross Total Return Index and Net Total Return Index. For the calculation of Gross TRIs and Net TRIs, dividend payments are calculated using declared gross dividends and after-tax net dividends.

The Hang Seng Gross Total Return Index (HSIDV) is used in this study, which is a accumulated daily index that is compiled and published each day after the market closes, which differs from the Hang Seng Index, which is calculated and published in real time. The calculation of the index includes cash dividends paid to shareholders by the constituent companies and it assumes that the dividends are reinvested back into the index portfolio in accordance with their respective market capitalization weightings. Share splits and consolidations without cash payments, non-cash distributions, or bonus shares will not affect the index. The formula assumes that cash dividends are available on the ex-dividend day and are reinvested into the index portfolio at the beginning of the trading day.

$$\text{Today's TRI} = \frac{\text{Today's Price Index Market Capitalization}}{\text{Yesterday's Price Index Market Capitalization} - \text{Dividend Payment}} \times \text{Yesterday's TRI}$$

HSIDV data from Thomson Reuters is comprised of 3966 daily observations, excluding weekends and public holidays, but only adjusted closing prices will be used for the following analysis. In order to convert them to monthly, I keep the price data on the last trading day of each month. The 181 final monthly observations will be used to calculate the realized future one-year HSIDV excess return.

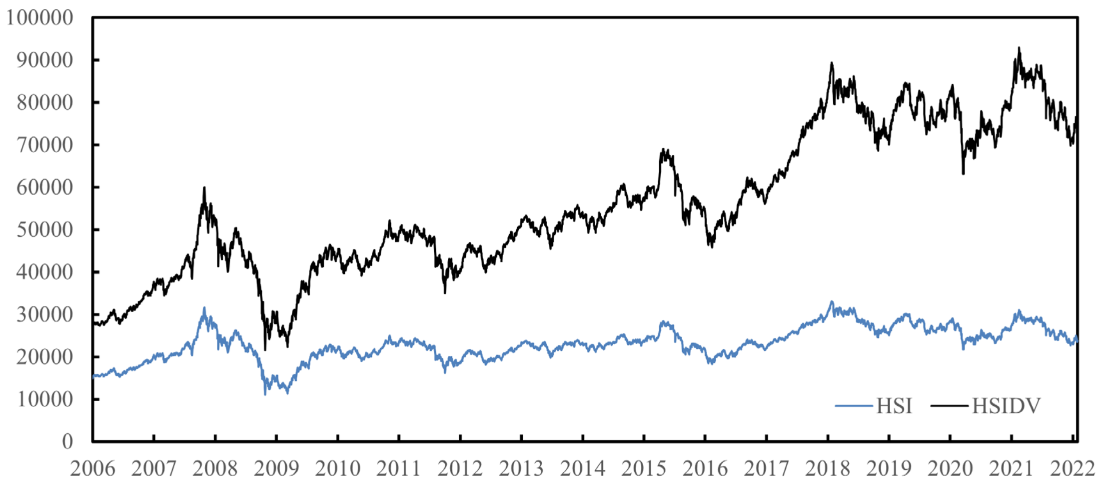


Figure 1 Hang Seng Index and Hang Seng Total Return Index from Jan 2006 to Jan 2022

3.3 Hang Seng index Options (HSI)

HSI options contracts (HKATS Code: HSI) underpin the Hang Seng index and were introduced on the Hong Kong Stock Exchange in March 1993, offering investors the opportunity to manage portfolio risk and participate in index arbitrage. In this paper, the standard HSI option item has been selected, and it is of the European type with a contract multiplier of HK$50 per index point. A contract expiry day refers to the last business day prior to the end of the contract month.

The volatility surface data of the HSI options were obtained from the IvyDB dataset of OptionMetrics, covering a period of 15 years and 1 month from January 2006 to January 2021. Both put and call options have ten different maturity dates ranging from 30 days to 730 days. Delta range between -20 and -80 for put options (20 to 80 for call options) changing by five. The data is converted to monthly by keeping the data on the last trading day of every month. By selecting Delta equal to 50 for call options and -50 for put options, we finally obtain 3620 observations (1810 observations for each).

3.4 Risk-free Rate

The risk-free rate of return refers to the theoretical rate of return of an investment with no risk attached. In practice, it is impossible to have a risk-free rate, so the risk-free rate represents the interest an investor would expect from a relatively riskless investment. The risk-free rate is used to determine the excess return on the market, which is then subtracted from the market return. Due to the paper's focus on empirical evidence from Hong Kong, we use the Hong Kong Interbank Offered Rates (1-year HIBOR) as the risk-free rate faced by institutional investors in Hong Kong.

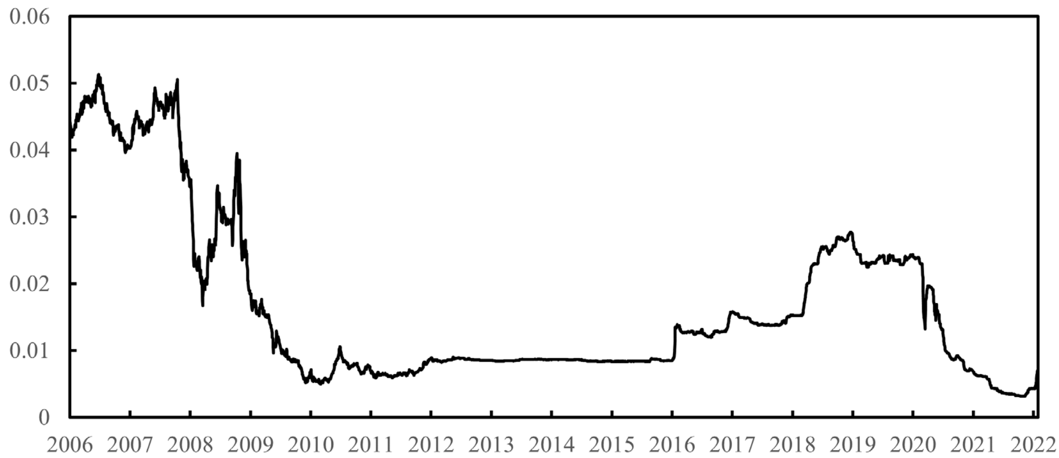


Figure 2 1 Year HIBOR (Risk free rate) from Jan 2006 to Jan 2022

4 Methodology

4.1 Realized Future One-year HSIDV Excess Return

Since we plan to perform predictive regressions monthly, I calculate them only on the last day of each month. I calculate the future one-year gross return of HSIDV using monthly data first.

$$R^{stock}_{t\to t+1} = \frac{P_{t+1}}{P_t} - 1$$

The excess return should be equal to the risk-adjusted measure that exceeds the risk-free rate or 1-Year-HIBOR.

$$R^{excess}_{t\to t+1} = R^{stock}_{t\to t+1} - R^f_t$$

4.2 Dividend Strip Prices

Options data can be used to value dividend strips. Put-call parity links the options and dividend markets, providing the academic approach that we followed in our dissertation by van Binsbergen, Brandt, and Koijen (2012a). In order to compute dividend strip prices from options data, we require only that arbitrage opportunities do not exist. Under this condition, put-call parity for European options holds (Stoll 1969):

$$VP_t + P_t - PV(Dividend) = VC_t + Ke^{-r_t*(T-t)}$$
$$VP_t - VC_t = PV(Strike) - P_t + PV(Dividend)$$

where VP_t and VC_t are the prices of a European put and call option at time t, with maturity T, and strike price K. r_t is the interest rate. We use the symbol $PV(Dividend)$ to denote the value of the short-term asset or cumulative dividends: where P_t is the spot price of the stock. By using this parity relationship, buying the dividend strips is equivalent to purchasing a put option, writing a call option, purchasing the stocks in the index, and borrowing cash.

I use the approach of Wu (2022) to focus on the slope of term structure of equity return. First, we can use options with the present value of strikes close to the spot price to cancel out these two terms. After scaling by dividing $VP_t - VC_t$ by VC_t, I consider the ratio as put-call ratio at different maturities T.

$$\frac{VP^{(T)}_t - VC^{(T)}_t}{VC^{(T)}_t}$$

The numerator $VP_t^{(T)} - VC_t^{(T)}$ is the present value of the sum of dividend strips, which rises roughly at the rate of T; whereas the denominator $VC_t^{(T)}$ measures the price of call option, which rises roughly at the rate of $\sqrt{T}$. Therefore, this put-call ratio is increasing in maturity T.

The slope of the ratio can then be used as a predictor of stock returns in the future, which is closely related to the dividend discount rate. As a result, this is a very demanding approach as the strike price must exactly match the spot price. However, with the help of the model, it is easy to map the slope into a more feasible predictor of the future one-year equity return. By assuming a smooth volatility surface, I can calculate the value of the standard at-the-money option by using implied volatility close to the money.

$$PC_t^{(T)} = \frac{V_{Put}^{BS}\left(K = 1, T, \sigma_t^{(-0.5put)}\right) - V_{Call}^{BS}\left(K = 1, T, \sigma_t^{(0.5call)}\right)}{V_{Call}^{BS}\left(K = 1, T, \sigma_t^{(0.5call)}\right)}$$

To estimate the value of the put and call options, we apply the Black-Scholes formula with zero dividends, zero interest, the strike of 1, and maturity of T. The maturity T of OptionMetrics ranges from 30 to 730 days. However, options with long maturity are usually illiquid, which will impact the prices of dividend claims, so we use only 30 to 365 days options. Theoretically, it is not absolutely necessary to work with maturity in years, but the time units should correspond with the other inputs, such as volatility, interest rate, and dividend yield, which are displayed on an annualized basis. To make the interpretation of the slope more straightforward, I will measure maturity in years. We then input the implied volatility of put options with the delta equal to -0.5 and call options with the delta equal to 0.5.

$$\mathrm{VC} = P_0 N(d_1) - Ke^{-rT} N(d_2)$$
$$\mathrm{VP} = Ke^{-rT} N(-d_2) - P_t N(-d_1)$$
$$d_1 = \frac{\ln\frac{P_0}{K} + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}}, d_2 = d_1 - \sigma\sqrt{T}$$

Due to the fact that the transformed $PC_t^{(T)}$ is approximately linear in T for short maturities, I obtain the slope spc_t by regressing on the maturity T measured in years：

$$spc_t = \frac{\sum_T PC_t^{(T)} \times T - \sum_T PC_t^{(T)} \times \sum_T T}{\sum_T T^2 - (\sum_T T)^2}$$

4.3 Predictive Regression

To investigate the implied relationship between spc_t and equity risk premium, we perform regression to get the coefficient between realized HSIDV excess return over the next one year and spc_t by regressing on the empirical slope spc_t at the end of each month from Jan 2006 to Jan 2021.

$$R_{t\to t+1}^{excess} = b_0 + b_1 \times spc_t + \epsilon_t$$

With time-series data, regression models frequently exhibit auto-correlation; that is, the errors are correlated over time. We use Auto Correlation Function ACF Plot to visualize serial correlation in data that changes over time. When the time series data are heteroscedastic or serially correlated, we apply Newey and West (1987) adjustment to control residual issues in the model, improving the robustness and precision of the estimates of the model when hypotheses are tested.

4.4 Predictive Regression with Control Variables

Control variables are included in regression analyses to estimate the causal effect of other treatments on our predictive result. The controls include the log of dividend-to-price ratio for HSI Index (dp), log of dividend-to-lagged-price ratio for HSI Index (dy), log of earnings-to-price ratio for HSI Index (ep), log of dividend-to-earnings ratio for HSI Index (de) and the sum of squared daily returns on the HSIDV (svar). The sample period for all monthly regressions is from Jan 2006 to Jan 2021.

$$R_{t\to t+1}^{excess} = b_0 + b_1 \times spc_t + control + \epsilon_t$$

5 Results

5.1 Empirical Slope and Future 1Y Excess Return

In Figure 3, I plot the time series of spc_t and realized excess return. It is apparent that the realized returns are more volatile than spc_t , especially in the period from 2016 to 2019. It is possible that the inclusion of the period will result in an inaccurate estimate of the slope coefficient. For this reason, I will discuss them separately. According to the Federal Reserve History, the global financial crisis began in December 2007 and ended in June 2009. Therefore, I divided the sample period into two parts: the first part includes 42 observations from Jan 2016 to June 2019 (during crisis) and the second part includes 139 observations from July 2019 to Jan 2021 (after crisis).

The empirical slope of the put/call ratio exhibits high frequency variations which are caused by transitory volatility, which can sometimes lead to the spc_t turning negative. The figure shows a negative correlation between $spc_t$and future stock returns, but its magnitude will require further analysis.

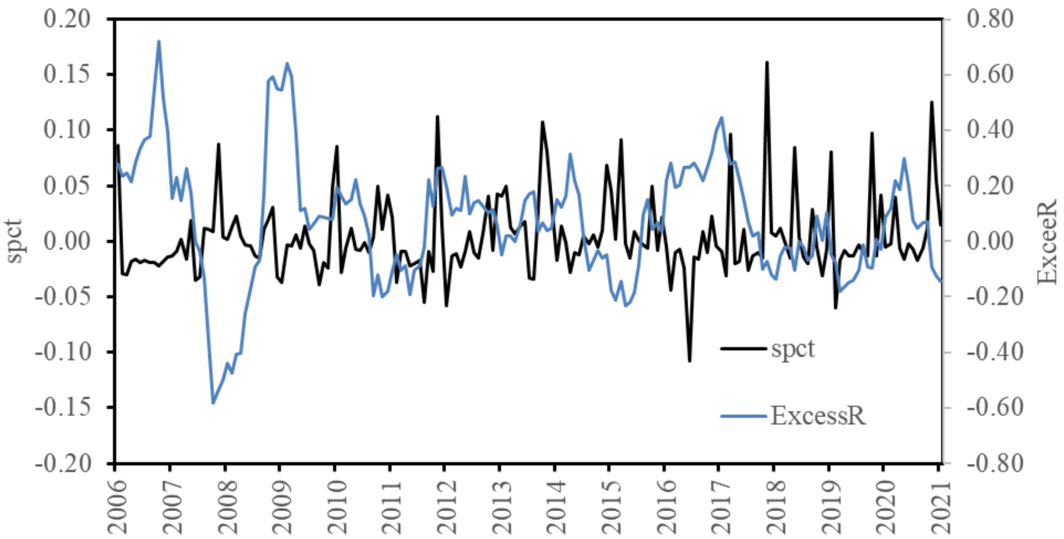
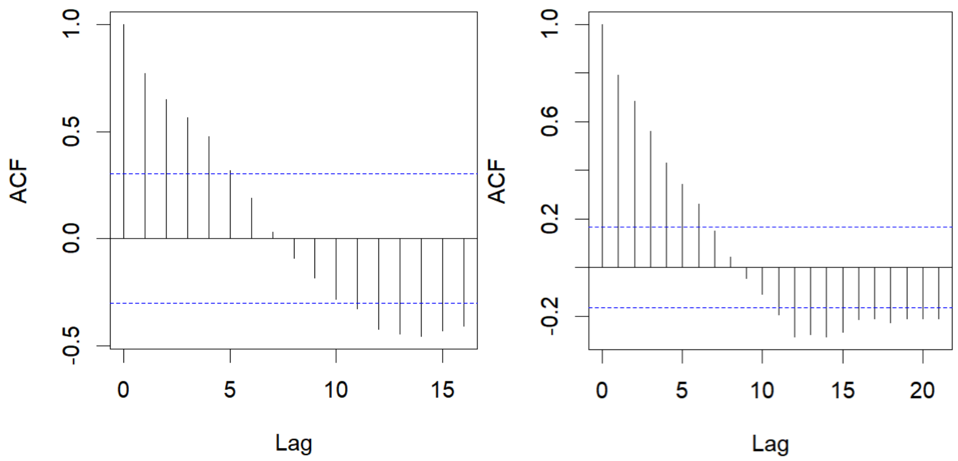


Figure 3 Time series plot of spc_t and future 1 Year HSIDV excess return $R_{t\to t+1}^{excess}$

5.2 Simple Linear Regression

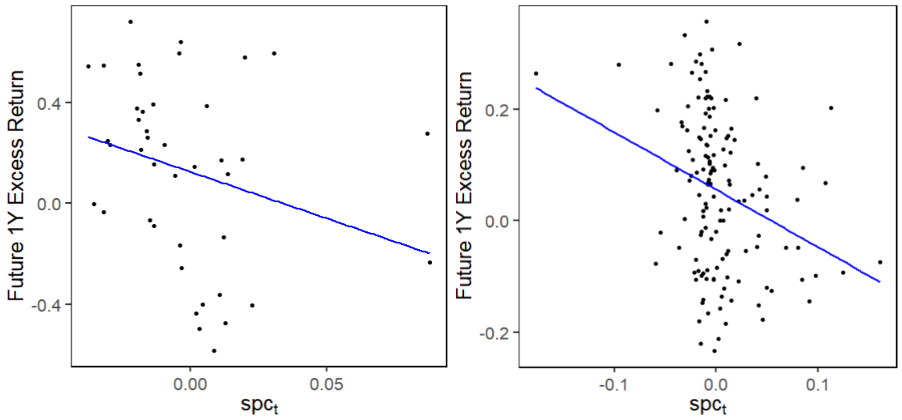
The figures below show the ACF plots of regression models with highly autocorrelated residuals. As shown in the graph below, the x-axis shows the various residual lags (lag 0, lag 1, lag 2, etc.). The y-axis shows the correlation of each lag, and the dashed blue line indicates whether the correlation is significant. As the first vertical bar (lag 0) shows the correlation of a residual with itself, it is always one. The subsequent vertical bars would drop quickly to almost zero or at least between the dashed blue lines in the absence of autocorrelation. Regression residuals clearly display a smooth pattern and do not show a rapid drop in correlations, exhibiting a slowly decaying ACF. Based on the correlations in the plot that exceed the significant lines above and below, it is evident that the current level of residual is significantly autocorrelated with its lagged values. This indicates that Newey-West adjustment is necessary.



(a) (b)

Figure 4 ACF plot for (a) during the crisis and (b) post-crisis

The below plots show the regression fitting lines for regressions between spc_t (horizontal axis) and the realized HSIDV excess return for the next one year (vertical axis). It is apparent that the change in spc_t during the crisis will lead to a greater decline in excess return than the post-crisis period.



(a) (b)

Figure 5 Regression fitting line for (a) during the crisis and (b) post-crisis

Table 1 demonstrates that the coefficients without adjustment are significantly negative for two periods at a 5% significance level. After the Newey-West adjustment, despite the standard errors becoming larger, the adjusted T-statistics for both periods are still significant. Therefore, when running the simple linear regression, we find that the slope spc_t is negatively correlated with the discount rate of the dividend.

Sample	During crisis		Post-crisis	
Adjustment	Null	Newey-West	Null	Newey-West
Slope for spc_t	-3.70	-3.70	-1.02	-1.02
T-statistic	(-1.98)	(-2.35)	(-3.59)	(-3.42)
Intercept	0.12	0.12	0.05	0.05
T-statistic	(2.31)	(0.79)	(4.91)	(1.60)
N	42	42	139	139
Adjusted R^2	0.05	0.05	0.08	0.08

Table 1 Simple regression results for two samples

5.3 Regression with Control Variables

In this section, we include several financial ratios to investigate their impact on the regressions. For the crisis sample, we can see that the coefficient of A is significantly negative across all specifications, except when controlling the dividend yields. The obvious variations of coefficients and t-statistics may result from the super volatile excess return and spc_t.

For post-crisis regression, we can see that the coefficient is significantly negative across all specifications. It is noticed that the slope is hardly affected by the additional factors and is estimated at around -1, depending on the control variables. The t-statistics using Newey-West standard errors vary between -2.94 and -3.55, which are more stable and significant than the statistics for the crisis period.

For both time frames, the intercepts are affected severely by including control factors, but we reject most of the hypotheses on whether the intercept is statistically different from zero. It is observed that controlling for the dividend-to-price ratio yields the weakest result since spc_t is procyclical.

Control Type	Null	dp	dy	ep	de	svar
Slope for spc_t	-3.70	-1.96	-4.02	-3.06	-3.92	-4.33
T-statistic	(-2.35)	(-0.93)	(-2.97)	(-1.96)	(-1.98)	(-3.06)
Controls		0.89	-0.21	0.90	0.52	4.04
T-statistic		(4.67)	(-0.27)	(6.33)	(0.75)	(1.35)
Intercept	0.12	3.21	-0.61	2.50	0.54	0.08
T-statistic	(0.79)	(5.93)	(-0.22)	(4.97)	(1.21)	(0.58)
N	42	42	42	42	42	42
Adjusted R^2	0.05	0.50	0.03	0.47	0.05	0.06

Table 2 Regression with control variables for crisis period

Control Type	Null	dp	dy	ep	de	svar
Slope for spc_t	-1.02	-0.85	-1.02	-0.98	-1.02	-0.98
T-statistic	(-3.42)	(-3.11)	(-3.55)	(-3.13)	(-3.39)	(-2.94)
Controls		0.43	0.13	0.16	-0.02	9.18
T-statistic		(3.28)	(0.64)	(1.33)	(-0.13)	(1.58)
Intercept	0.05	1.49	0.47	0.45	0.04	0.03
T-statistic	(1.60)	(3.36)	(0.72)	(1.56)	(0.30)	(0.58)
N	139	139	139	139	139	139
Adjusted R^2	0.08	0.21	0.08	0.13	0.07	0.10

Table 3 Regression with control variables for post-crisis

6 Conclusions

This dissertation aims to identify the relationship between the variation of the dividend claim prices and future equity risk premium across two different periods, namely during the crisis and post-crisis periods. After regressing the dividend price on maturity, we can then use the slope as a predictor for the future equity risk premium. My results provide evidence that the slope is negatively correlated with the discount rate of dividends, which indicates the adverse relationship between the slope and equity risk premium.

The study first replicates dividend strips of various maturities using options written on the Hang Seng Index (HSI) under the no-arbitrage assumption. When regressing the dividend price on maturity, the slope represents the variation of the price of the synthetic dividend claim. To consider both price changes and dividend payments, the Hang Seng Total Return Index (HSIDV) is used to calculate the realized excess return over the next year. From the results, it is found that these two time series are more volatile during the 2008 financial crisis. For this reason, I have further discussion over two different time frames.

To investigate the implied relationship between spc_t and discount rate for dividends, I perform simple linear regression at the end of each month from Jan 2006 to Jan 2021. Based on the correlations in the ACF plot that exceed the significant lines, we can conclude that the residuals are significantly autocorrelated with its lagged values. Therefore, I adjust the t-statistics for coefficients and intercepts with Newey-West standard errors. As a result, we find a negative sign in the predictive regression.

Finally, control variables are included in multiple regression analyses to estimate the causal effect of fundamental financial ratios on our regression result. For post-crisis regression, we can see that the coefficient is significantly negative across all specifications. It is noticed that the slope is hardly affected by the additional factors and is estimated at around -1, depending on the control variables. For crisis period, the result is only insignificant when controlling the dividend yields, because spc_t itself is procyclical.

Further research can be conducted by considering the assumptions of frictionless markets, which incorporate significant market imperfections like transaction costs or tax on dividends. Investors may receive compensation for the additional tax burden imposed by dividends with an ex-date that may impact the relationship.

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