Essays on Stock Prices and Equity Premium

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Abstract

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This dissertation studies the role of cash flow in explaining stock price variations and the determination of equity premium after correcting for the measurement error of cash flow growth. In Chapter 1, we incorporate price-total payout (dividends plus repurchases) ratio into the models of Binsbergen and Koijen (2010) and Campbell and Ammer (1993) to reassess the role of cash flow in stock price movement. We find that the existing results of a high persistence in expected returns and a strong dependence of stock price variation on discount rates are partly attributable to the use of price-dividend ratio with measurement error as a predictor of stock returns. The incorporation of price-total payout ratio enables the models i) to improve an in-sample goodness of fit for return and cash flow growth, ii) to produce a lower persistence of expected returns, which leads to a smaller shock to stock prices from the discount rate channel, iii) to show a

higher contribution of cash flow channel to stock price movement in terms of variations in price-cash flow ratio and unexpected return. These results apply to medium and large cap portfolios as well as to aggregate market index.

In Chapter 2, we explore the effects on stock market variation of other factors than stock repurchases that could account for the non-stationarity of price-dividend ratio by incorporating regime shifts in the mean of price-total payout ratio into the models of Binsbergen and Koijen (2010) and Campbell and Ammer (1993). Compared to the results of Chapter 1, we achieve i) an improvement in in-sample goodness of fit for return and cash flow growth, ii) a lower persistence and higher volatility of expected returns, iii) stronger role of cash flow channel in stock market variation, all of which show that not only stock repurchases but also other structural factors such as persistent decline in consumption volatility affecting the relationship between stock prices and cash flows should be taken into account when we attempt to investigate the sources of stock price variations.

In Chapter 3, we incorporate price-total payout ratio and endogenously generated consumption volatility with regime shifts into the dynamic asset pricing model of Bansal, Kiku, Shaliastovich, and Yaron (2014) (hereafter, "BKSY model"), which stresses the role of a sizable positive risk premium from the macroeconomic volatility channel in explaining the equity premium by introducing the volatility risk into traditional consumption-based asset pricing model. Our extension of the BKSY model provides a different identification of the consumption volatility risk by including the effects of the economic agent's revision of expectation on the volatility states on each of three channels to determine the equity premium. From annual samples of 1930 to 2015, we find that our model shows a much smaller contribution of the consumption volatility risk to the total equity premium, most of which is now explained by the cash flow risk.

This finding applies to cross-sectional portfolio returns as well as to aggregate market index return. Our model also indicates that the consumption volatility risk is not large enough to reverse a negative correlation between equity return and human capital return.

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DEDICATION

To my wife, Daerim Kim, and mother, Chunsuk Lee

Chapter 1. WHAT MOVES THE STOCK MARKET IN THE PRESENCE OF STOCK REPURCHASES?

1.1 INTRODUCTION

The traditional approach to modeling the variations in stock returns and dividend growth employs price-dividend ratio as a predictor of stock return and dividend growth in a predictive regression set-up. Campbell and Shiller (1988), Fama and French (1988), Campbell and Ammer (1993), and Cochrane (2008), among others, follow this approach. Since the price-dividend ratio is intimately linked to time variation in expected returns and in expected dividend growth rates from the perspective of the present value identity of Campbell and Shiller (1988), an enormous amount of attention in the finance literature has been focused on whether stock returns and dividend growth rates are predictable by price-dividend ratio. Although a lot of empirical evidence has been uncovered showing that returns are predictable by financial ratios, such as price-dividend ratio or price-earnings ratio, whether price-dividend ratio is appropriate as a predictor for return and dividend growth has been questioned in a non-negligible manner by other studies.

Stambaugh (1986a, 1999), Hodrick (1992), and Nelson and Kim (1993) point out that the statistical significance of return predictability can be weaker when the statistical tests are adjusted in consideration of a high persistence or near-unit root property of price-dividend ratio. Chen (2009) and Koijen and van Nieuwerburgh (2011) document a strong instability of return and dividend growth predictability sensitive to the choice of sample periods. Paye and Timmermann (2006) reports an evidence in favor of breaks in the OLS coefficient in the predictive regression of stock returns on price-dividend ratio, while Lettau and van Nieuwerburgh (2008) and Choi, Kim, and Park (2017) report some evidence for structural shifts in the mean of price-dividend ratio.

There have been a group of studies attempting to resolve this issue by correcting for the measurement error of price-dividend ratio, exacerbated by a recent strong popularity of stock repurchases as a way of transferring firms' cash flow to stockholders. Boudoukh, Michaely, Richardson, and Roberts (2007) and Robertson and Wright (2006) show that repurchase-adjusted price-dividend ratio (hereafter, price-total payout ratio) more strongly predicts U.S. stock returns and has a better statistical property such as a relatively low persistence. Kim and Park (2013) attempt to adjust a declining dividend-price ratio, using a change in the fraction of traditional dividend-paying firms so that the adjusted dividend series can have a more stable one-to-one long-run relationship with stock price.

Others try to disconnect a strong link between price-dividend ratio as a predictor for returns and expected return by adopting the latent variables approach which incorporates unobservable variables, such as expected return and expected dividend growth, and their dynamics explicitly into the model. Brandt and Kang (2004), Binsbergen and Koijen (2010), and Rytchkov (2012) follow this approach and show a strong improvement of in-sample goodness of fit for dividend growth relative to the traditional approach.

Although a lot of efforts to resolve the return predictability issue from price-dividend ratio has been made, the issue of what moves stock price did not receive much attention recently since the existing view that almost all aggregate stock return innovation is driven by discount rate news rather than cash flow news has been regarded as unquestionable. The traditional approach such as Campbell and Ammer (1993) and Cochrane (2008, 2011) document that most of or more than price-dividend variation corresponds to discount rate variation. Even the latent variables approach produces a similar result for this issue. Binsbergen and Koijen (2010) report that 117.9% and 215.3% of variations in price-dividend ratio and unexpected returns are explained by discount rates, while dividend growth accounts for only 4.9% of variation in price-dividend ratio when every month's dividends are reinvested in the stock market.

We attempt to reassess the roles of cash flow and discount rate in stock price variations since the existing dominating view seems counter-intuitive in that both fundamental and sentimental factors are likely to act on the stock price movements in a more balanced way. We extend the use of price-total payout ratio to the issue of what moves stock price although it has been mainly employed to improve the return predictability in a predictive regression. We employ the existing models of Campbell and Ammer (1993) and Binsbergen and Koijen (2010), one from the traditional approach and the other from the latent variables approach because we attribute the underestimated role of cash flow in stock price movements to the measurement error of price-dividend ratio, not to the misspecification of the model.

We use annual sample from 1946 to 2015 and quarterly sample from the first quarter of 1952 to the fourth quarter of 2015 and the main findings can be summarized as follows.

First, the incorporation of price-total payout ratio instead of price-dividend ratio into the model of Binsbergen and Koijen (2010) improves the in-sample goodness of fit for both return and cash flow growth. For the annual aggregate market index, R^2 increases from 9.1% to 10.6% for stock return and from 17.0% to 22.4% for cash flow growth. The improvement in the explanatory power also appears in medium and large cap portfolios, although not as evident in small cap portfolio.

Second, the use of price-total payout ratio reduces both persistence of expected returns and changes in stock prices from discount rate channel. For the annual aggregate market index, the persistence of expected returns declines from 0.92 to 0.83, which is translated as a 4.8%p smaller stock price change in a response to an 1% expected return shock. The reduction in stock price variation from the discount rate channel due to a lower persistence in expected returns is observed from all sizes of firms.

Third, cash flow plays a non-negligible role in stock price variation with the incorporation of price-total payout ratio into the models of Binsbergen and Koijen (2010) and Campbell and Ammer (1993). Cash flow accounts for 25% and 72% of annual variations in price-total payout ratio and unexpected returns, respectively, much higher than when using price-dividend ratio (6% and 35%, respectively). The increase in the role of cash flow is evident mainly in large cap firms. From the quarterly samples, we can observe a similar increase in the relative importance of cash flow in stock price variations from the model of Campbell and Ammer (1993). Cash flow accounts for 73% of total variation in unexpected quarterly excess returns, 23%p higher than when we use price-dividend ratio.

The remainder of this chapter is organized as follows. Section 1.2 provides a review of the models of Binsbergen and Koijen (2010) and Cambpell and Ammer (1993). Section 1.3 explains how to construct the data used to the models. Section 1.4 provides the empirical results and their implications for persistence of expected returns and stock price variations. Section 1.5 concludes.

1.2 A REVIEW OF THE MODELS

In this section, we provide a review of two models we use to derive the subsequent empirical results.

1.2.1 *Model of Binsbergen and Koijen (2010)*

Binsbergen and Koijen (2010) propose a latent variables approach within the present value framework of Campbell and Shiller (1988). They explicitly specify the dynamics for unobservable variables such as expected return and expected dividend growth, both of which are related with price-dividend ratio in the measurement equation in the state-space representation. Although we use the notations for dividend d_{t+1} and price-dividend ratio pd_{t+1} in this section, they are naturally replaced with total payout (dividends plus repurchases) and price-total payout ratio.

Their model starts from the present value identity of Campbell and Shiller (1988), which connects price-dividend ratio, future expected returns, and future expected dividend growth:

$$pd_t = \frac{\kappa}{1-\rho} + E_{t+1}\sum_{j=0}^{\infty}\rho^j \Delta d_{t+j+1} - E_{t+1}\sum_{j=0}^{\infty}\rho^j r_{t+j+1} \tag{1.1}$$

, where r_{t+1} is stock return from time t to t+1, E_{t+1} is expectation operator, conditional upon the information available up to time t+1, κ and ρ are log-linearizing constants, and Δ is the first difference operator.

They specify the dynamics of expected returns μ_t and expected dividend growth g_t as an AR(1) process:

$$\mu_{t+1} = \delta_0 + \delta_1(\mu_t - \delta_0) + \varepsilon_{t+1}^{\mu} \tag{1.2}$$

$$g_{t+1} = \gamma_0 + \gamma_1(g_t - \gamma_0) + \varepsilon_{t+1}^{g} \tag{1.3}$$

$$\Delta d_{t+1} = g_t + \varepsilon_{t+1}^{d} \tag{1.4}$$

Plugging equations (1.2)-(1.4) into equation (1.1), they obtain a linear relationship among price-dividend ratio, expected return, and expected dividend growth:

$$pd_t = A - B_1(\mu_t - \delta_0) + B_2(g_t - \gamma_0) \tag{1.5}$$

, where $A \equiv \frac{\kappa}{1-\rho} + \frac{\gamma_0 - \delta_0}{1-\rho}$, $B_1 \equiv \frac{1}{1-\rho\delta_1}$, and $B_2 \equiv \frac{1}{1-\rho\gamma_1}$.

They rearrange these equations as one transition equation:

$$\hat{g}_{t+1} = \gamma_1 \hat{g}_t + \varepsilon^g_{t+1} \tag{1.6}$$

and two measurement equations by substituting the identity equation (1.5) into equation (1.2):

$$\Delta d_{t+1} = \gamma_0 + \hat{g}_t + \varepsilon^d_{t+1} \tag{1.7}$$

$$pd_{t+1} = (1-\delta_1)A + B_2(\gamma_1 - \delta_1)\hat{g}_t + \delta_1 pd_t - B_1\varepsilon^\mu_{t+1} + B_2\varepsilon^g_{t+1} \tag{1.8}$$

This set-up allows them to compute the likelihood of the model using a Kalman Filter and estimate the parameters. With this process, they filter out expected dividend growth and expected return from the realized value of dividend growth and price-dividend ratio.

1.2.2 *Model of Campbell and Ammer (1993)*

Campbell and Ammer (1993) also start from the present value identity of Campbell and Shiller (1988) to derive an equation for unexpected excess return in terms of another news terms. With the equation, they decompose the variance for unexpected excess return into variance and covariance terms for other news terms.

By taking the operator for the revision of expectation $(E_{t+1} - E_t)$ on both sides of equation (1.1), they obtain:

$$(E_{t+1} - E_t)\sum_{j=0}^{\infty}\rho^j \Delta d_{t+j+1} = (E_{t+1} - E_t)\sum_{j=0}^{\infty}\rho^j r_{t+j+1} = (E_{t+1} - E_t)\sum_{j=0}^{\infty}\rho^j (e_{t+j+1} + i_{t+j+1}) \tag{1.9}$$

, where e_{t+1} is excess stock return and i_{t+1} is interest rate.

Rearranging equation (1.9), they express unexpected excess return in terms of other news components:

$$(E_{t+1}-E_t)e_{t+1}=(E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j \Delta d_{t+j+1}-(E_{t+1}-E_t)\sum_{j=1}^{\infty}\rho^j e_{t+j+1}-(E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j i_{t+j+1} \quad (1.10)$$

$$(N_{R,t+1}=N_{CF,t+1}-N_{DR,t+1}-N_{IR,t+1})$$

To derive the values for each news component in equation (1.10), they include excess stock return, interest rate, relative bill rate, and dividend-price ratio into a set of state variables Z_{t+1} and assume that Z_{t+1} follows a VAR(1) process:

$$Z_{t+1}\equiv\left(e_{t+1} \quad i_{t+1} \quad rb_{t+1} \quad dp_{t+1}\right)' \quad (1.11)$$

$$Z_{t+1}=A+BZ_t+u_{t+1}, \qquad u_{t+1}\sim N(0,\Sigma) \quad (1.12)$$

, where rb_{t+1} is the relative bill rate, defined as the level of the short rate relative to a 1-year backwards moving average of short rates.

Using the dynamics for Z_{t+1}, they derive the analytical solution for each of news components in equation (1.10) as follows:

$$(E_{t+1}-E_t)Z_{t+j+1}=B^j u_{t+1} \quad (1.13)$$

$$N_{R,t+1}\equiv(E_{t+1}-E_t)s_1'Z_{t+1}=s_1'u_{t+1} \quad (1.14)$$

$$N_{DR,t+1}\equiv(E_{t+1}-E_t)s_1'\sum_{j=1}^{\infty}\rho^j B^j u_{t+1}=s_1'Qu_{t+1} \quad (1.15)$$

$$N_{IR,t+1}\equiv(E_{t+1}-E_t)s_2'\sum_{j=0}^{\infty}\rho^j B^j u_{t+1}=s_2'(I_4+Q)u_{t+1} \quad (1.16)$$

$$N_{CF,t+1}=N_{R,t+1}+N_{DR,t+1}+N_{IR,t+1} \quad (1.17)$$

, where $Q \equiv \rho B(I_5 - \rho B)^{-1}$ is the matrix of the long-run responses, s_n is an $n \times 1$ indication vector with the n'th element equal to unity and the remaining elements equal to zero, and I_N is an $N \times N$ identity matrix.

1.3 Description of Data

We use annual data from 1946 to 2015 and quarterly data from the first quarter of 1952 to the fourth quarter of 2015. As Chen (2009) documents, the dynamics for stock return and dividend show a differentiated pattern between pre-war and post-war periods. To avoid a possible noise from the prewar sample, we restrict our sample for analysis to postwar period. Before the 1951 Treasury-Fed accord, the interest rates did not move much because, during the world war II, the Fed pledged to keep the interest rate on Treasury bills fixed at 0.375%. We start our quarterly sample that includes interest rates from the period when the Fed is allowed to effectively change interest rates.

We collect aggregate stock return and price-dividend ratio from monthly returns with dividend and without dividend on the value-weighted portfolio of all NYSE, AMEX, NASDAQ, and ARCA stocks in the CRSP data. We construct monthly stock price after normalizing the initial stock price to one and multiply it by monthly returns without dividend. By combining the monthly stock price with monthly return with dividend, we can obtain monthly dividend series. Monthly dividend series are aggregated over 12 months and divided by the end-of-period stock price to derive annual and quarterly dividend-price ratio. Total payout-price ratio is also constructed in a similar way. The only difference between them is that the repurchase-adjusted dividend-price ratio is constructed, using adjusted monthly returns without dividend for each firm listed in the U.S. stock market, following the methodology of Bansal, Dittmar, and

Lundblad (2005). Appendix A.1 provides technical details of the construction of stock repurchase data. For the calculation of stock returns in excess of risk-free rate, monthly yields on 30-day U.S. Treasury bill are used. For the construction of size-sorted portfolios, we update each firm's market capitalization every month and sort all listed firms in the U.S. stock market by the descending order of their updated market capitalization every month. Top 30% firms are included in large cap portfolio, the next 40% firms in medium cap portfolio, and bottom 30% firms in small cap portfolio.

1.4 EMPIRICAL RESULTS

1.4.1 *Preliminary Results*

In Figure 1.1, we provide price-dividend ratio and price-total payout ratio series constructed by the methodology given in Section 1.3. By adding stock repurchases to the original dividend series, the price-total payout ratio shows more stationary dynamics than price-dividend ratio. Price-total payout ratio for large cap portfolio moves in a similar way to price-total payout ratio for the aggregate market index, while price-total payout ratios for small and medium cap portfolios show somewhat different movements from the aggregate index series.

Until early 1980s, price-dividend ratio and price-total payout ratio had not exhibited any significant difference between each other, while the gap between them began to manifest itself after the introduction of SEC rule 10b-18 in 1982, which allows firms to more freely repurchase their own stocks traded in the stock market without stock price manipulation charges. In 2004, the Bush Administration introduced a "tax holiday" for corporations that repatriated profits they were holding abroad, which acted as another incentive for tock repurchases instead of dividend payment. Our price-total payout series in Figure 1.1 are consistent with the events which strongly affected a recent increase in stock repurchases.

The improvement in stationarity of price-total payout ratio is provided in Table 1.1, by estimating their AR(1) coefficients. Regardless of whether we include pre-war period in the sample, price-total payout ratio exhibits much lower persistence than price-dividend ratio, typically regarded as a better statistical property.

In Table 1.2, we provide the estimates for parameters of the model of Binsbergen and Koijen (2010) by comparing the estimates between using price-dividend ratio and using price-total payout ratio as one of the observable variables in the measurement equation. The parameter of our interest is the persistence and volatility of expected return (δ_1 and σ_μ) since they deliver important implications for stock market dynamics and the predictability of returns. By incorporating stock repurchases into the cash flow, the persistence of expected return declines from 0.921 to 0.827, while its volatility increases from 0.016 to 0.031. More detailed description of the persistence of expected return is given in subsection 1.4.3.

1.4.2 *In-Sample Goodness of Fit*

The incorporation of stock repurchases into cash flow from firms to shareholders improves the in-sample goodness of fit in the model of Binsbergen and Koijen (2010) for both stock return and cash flow growth.

Table 1.3 shows that, for the annual aggregate market index, the value of R^2 rises from 9.1% to 10.6% for stock return and from 17.0% to 22.4% for cash flow growth. We can also observe the improvement in the explanatory power for both stock return and cash flow growth of medium and large cap portfolios, while small cap portfolio exhibits a mixed result between stock return and cash flow growth in terms of R^2.

The better in-sample goodness of fit achieved from the incorporation of stock repurchase is graphically represented in Figure 1.2 and Figure 1.3. The bottom panels of Figure 1.2 and Figure 1.3 provide filtered series for expected return and expected cash flow growth against the realized return and the realized cash flow after stock repurchases are added to the original dividend series. They capture the variations of the realized values better than in the upper panels of Figure 1.2 and Figure 1.3, both of which are drawn without the consideration of stock repurchases.

1.4.3 *Persistence of Expected Returns*

As seen from the parameter estimates of the Binbergen-Koijen model in Table 1.2, the consideration of stock repurchases reduces persistence of expected returns. In this subsection, we provide the change in the persistence for size-sorted portfolios and its implications for the stock price variation generated from the discount rate channel.

Table 1.4 shows that the persistence of expected returns declines with the use of price-total payout ratio for medium and large cap portfolios as well as for the aggregate market index. For the annual aggregate market index, the persistence of expected returns falls from 0.92 to 0.83, which is translated as a 4.8%p smaller stock price change in a response to an 1% expected return shock. Although the persistence of expected return in small cap portfolio rises slightly from 0.930 to 0.939, an expected fall in the stock price of small-sized firms in a response to a 1% discount rate shock gets smaller since the decrease in value of ρ offsets the effect of the slight increase in the persistence of expected return for small cap portfolio.

1.4.4 *Role of Cash Flow and Discount Rate in Market Variation*

Most of the existing studies claim that cash flow growth contributes little to the variation of stock prices and returns, while most of the stock price variation is a result of time-varying discount rates. We reassess the validity of this dominating claim in this subsection by incorporating stock repurchases into the total cash flow.

In Table 1.5, we provide the variance decompositions of stock prices and unexpected returns for aggregate market index and size-sorted portfolios, based on the Binsbergen-Koijen model. As in the existing view, only a small portion of the variations in stock prices and returns are explained by the cash flow channel except for unexpected returns of small-sized firms without any consideration of stock repurchases. With the introduction of stock repurchases, however, cash flow accounts for 25% and 72% of annual variations in price-total payout ratio and unexpected returns of aggregate market index, respectively, much higher than in the case without stock repurchases considered (6% and 35%, respectively). The increase in the role of cash flow is mainly valid in large cap portfolio, while both small and medium cap portfolios do not show a stronger role of cash flow in stock market variations.

Table 1.6 shows that our result from the annual sample in the Binsbergen-Koijen model also holds in both annual and quarterly samples in the Cambell-Ammer model. From the full annual sample (1952-2015), the variation of cash flow accounts for more than 50% of unexpected return with the use of price-total payout ratio, much higher than 18% when using price-dividend ratio. From the full quarterly sample (1952.1Q-2015.4Q), the share of cash flow variation in unexpected return variation rises from 50% to 73%, while the contribution of discount rate channel does not change significantly. We can also observe a stronger role of cash flow channel in stock market with the incorporation of stock repurchases from all of three different annual and quarterly sample periods in Table 1.6.

To check the robustness of our results to the choice of sample periods, we depicts dynamic changes in the shares of cash flow and discount rate channels in the total variation of stock return, by changing the last year of annual samples from 1988 to 2015, based on recursive estimation of the Cambell and Ammer model. Figure 1.4 shows that the increase in the contribution of cash flow channel to the market variation, when we consider stock repurchase, is not affected by the choice of sample periods.

1.5 CONCLUSION

Recently, stock repurchases are being entrenched as a more popular way of distributing cash flow from firms into their shareholders than the traditional type of dividends. Therefore, the failure to account for stock repurchases could distort empirical results for the joint dynamics of expected return and cash flow growth. We reveal that the use of the traditional predictor of stock return – price-dividend ratio – can undermine the in-sample goodness of fit for the latent variables approach, overestimate the persistence of expected returns, and understate the role of cash flow channel in the stock market variations. By using a truer measure of cash flow – price-total payout ratio – instead of price-dividend ratio, we can show that the fundamentals of the U.S. economy or the profitability of the U.S. corporate sector is a non-negligible factor to explain the variation of the U.S. stock market as well as the sentiments of the market participants. Our empirical results are also robust to the choice of sample periods.

So far, we have implicitly assumed that the non-stationarity of price-dividend ratio is mainly attributable to the recent increase in stock repurchases. However, recent studies provide various possible reasons for the declining dividend-price ratio other than stock repurchases. Jank (2013) claims that the main culprit behind the non-stationary dividend-price ratio is the change in the composition of firms due to the deregulation of the requirements for listed companies. Lettau, Ludvigson, and Wachter (2008) pay attention to a persistent decline in consumption volatility as a source of the change in the stable relationship between dividend and price. If that is the case, the incorporation of stock repurchases could not provide a satifactory solution for the empirical issues that stem from the non-stationarity of price-dividend ratio. We leave this subject for our future research.

1.6 Tables and Figures

Table 1.1: Persistence of Price-Dividend Ratio and Price-Total Payout Ratio

(Aggregate Market Index)

	1926-2015		1946-2015	
	Price-Dividend	Price-Total Payout	Price-Dividend	Price-Total Payout
Persistence	0.792	0.588	0.892	0.661
(Standard Error)	(0.066)	(0.086)	(0.055)	(0.092)

Table 1.2: Parameter Estimates: Binsbergen-Koijen Model (1946-2015: Aggregate Market Index)

Parameter	Price-Dividend Ratio		Price-Total Payout Ratio	
	Estimate	Standard Error	Estimate	Standard Error
δ_0	0.087	(0.014)	0.102	(0.017)
γ_0	0.061	(0.011)	0.059	(0.016)
δ_1	0.921	(0.043)	0.827	(0.069)
γ_1	0.297	(0.119)	0.099	(0.119)
σ_μ	0.016	(0.007)	0.031	(0.012)
σ_g	0.067	(0.006)	0.120	(0.010)
σ_d	0.001	(0.008)	0.000	(0.007)
$\rho_{d\mu}$	-0.964	(0.069)	0.914	(361.300)
$\rho_{\mu g}$	0.265	(0.144)	0.399	(0.145)

Table 1.3: In-Sample Goodness of Fit: Binsbergen-Koijen Model (R^2 : 1946-2015)

	Stock Return				Cash Flow Growth			
	Total	Small	Medium	Large	Total	Small	Medium	Large
Price-Dividend	9.1%	3.6%	7.5%	9.3%	17.0%	22.0%	18.0%	15.7%
Price-Total Payout	10.6%	3.2%	9.5%	10.9%	22.4%	22.5%	20.0%	21.2%

Note: "Total", "Small", "Medium", and "Large" refer to aggregate market index, small cap portfolio, medium cap portfolio, and large cap portfolio, respectively.

Table 1.4: Expected Return Persistence and Price Effect: Binsbergen-Koijen Model (1946-2015)

	Persistence of Expected Returns				Stock Price Change from 1% Expected Return Shock			
	Total	Small	Medium	Large	Total	Small	Medium	Large
Price-Dividend	0.921 (0.043)	0.930 (0.039)	0.878 (0.055)	0.921 (0.043)	-9.4%	-11.6%	-6.7%	-9.4%
Price-Total Payout	0.827 (0.069)	0.939 (0.056)	0.819 (0.079)	0.826 (0.068)	-4.6%	-9.8%	-4.5%	-4.6%

Note: "Total", "Small", "Medium", and "Large" refer to aggregate market index, small cap portfolio, medium cap portfolio, and large cap portfolio, respectively.

Table 1.5: Variance Decomposition of Price and Return: Binsbergen-Koijen Model (1946-2015)

		Total		Small		Medium		Large	
		PD	PP	PD	PP	PD	PP	PD	PP
Price-Payout Ratio	CF	6.3%	24.6%	17.6%	11.1%	14.5%	14.6%	6.1%	25.1%
	DR	100.5%	99.4%	97.6%	96.8%	100.5%	93.9%	101.1%	100.7%
	Cov	-6.9%	-24.1%	-15.3%	-8.0%	-15.0%	-8.5%	-7.2%	-25.8%
Unexpected Return	CF	35.4%	72.2%	73.1%	59.1%	48.7%	41.3%	35.2%	75.3%
	DR	93.8%	93.3%	50.6%	57.9%	81.8%	87.3%	97.7%	97.0%
	Cov	-29.2%	-65.5%	-23.7%	-17.0%	-30.5%	-28.6%	-32.9%	-72.3%

Note: "Total", "Small", "Medium", and "Large" refer to aggregate market index, small cap portfolio, medium cap portfolio, and large cap portfolio, respectively. "CF", "DR", and "Cov" refer to variance of cash flow, variance of discount rate, and covariance between cash flow and discount rate, respectively. "PD" and "PP" refers to price-dividend ratio and price-total payout ratio, respectively.

Table 1.6: Variance Decomposition of Unexpected Return: Campbell-Ammer Model

Aggregate Market Index, Annual, VAR(1)

	1952-1988		1952-2007		1952-2015	
	Price-Dividend	Price-Total Payout	Price-Dividend	Price-Total Payout	Price-Dividend	Price-Total Payout
Var(CF)	14.8%	83.9%	14.5%	51.6%	18.2%	51.6%
Var(DR)	115.7%	210.8%	66.0%	111.4%	58.4%	68.6%
VAR(IR)	8.2%	11.9%	4.5%	6.1%	4.2%	5.7%
Cov(CF,DR)	-44.5%	-220.0%	17.0%	-66.8%	16.9%	-5.9%
Cov(CF,IR)	-7.2%	-46.5%	-0.7%	-13.9%	1.9%	-9.0%
Cov(DR,IR)	13.0%	60.0%	-1.2%	11.6%	0.3%	-11.1%

Aggregate Market Index, Quarterly, VAR(4)

	1952.1Q-1988.4Q		1952.1Q-2007.4Q		1952.1Q-2015.4Q	
	Price-Dividend	Price-Total Payout	Price-Dividend	Price-Total Payout	Price-Dividend	Price-Total Payout
Var(CF)	25.3%	43.6%	44.6%	53.3%	49.5%	73.3%
Var(DR)	80.8%	81.3%	50.3%	42.5%	28.6%	30.1%
VAR(IR)	5.9%	7.4%	4.9%	4.7%	4.1%	4.4%
Cov(CF,DR)	-12.1%	-32.1%	2.3%	3.2%	17.0%	2.5%
Cov(CF,IR)	-7.0%	-20.9%	-2.5%	-3.2%	0.1%	-12.9%
Cov(DR,IR)	7.2%	20.7%	0.4%	-0.5%	0.7%	2.5%

Note: "Var(CF)", "Var(DR)", "Var(IR)", "Cov(CF,DR)", "Cov(CF,IR)", and "Cov(DR,IR)" refer to variance of cash flow, variance of discount rate, variance of interest rate, covariance between cash flow and discount rate, covariance between cash flow and interest rate and covariance between discount rate and interest rate, respectively.

Figure 1.1: Price-Dividend Ratio and Price-Total Payout Ratio

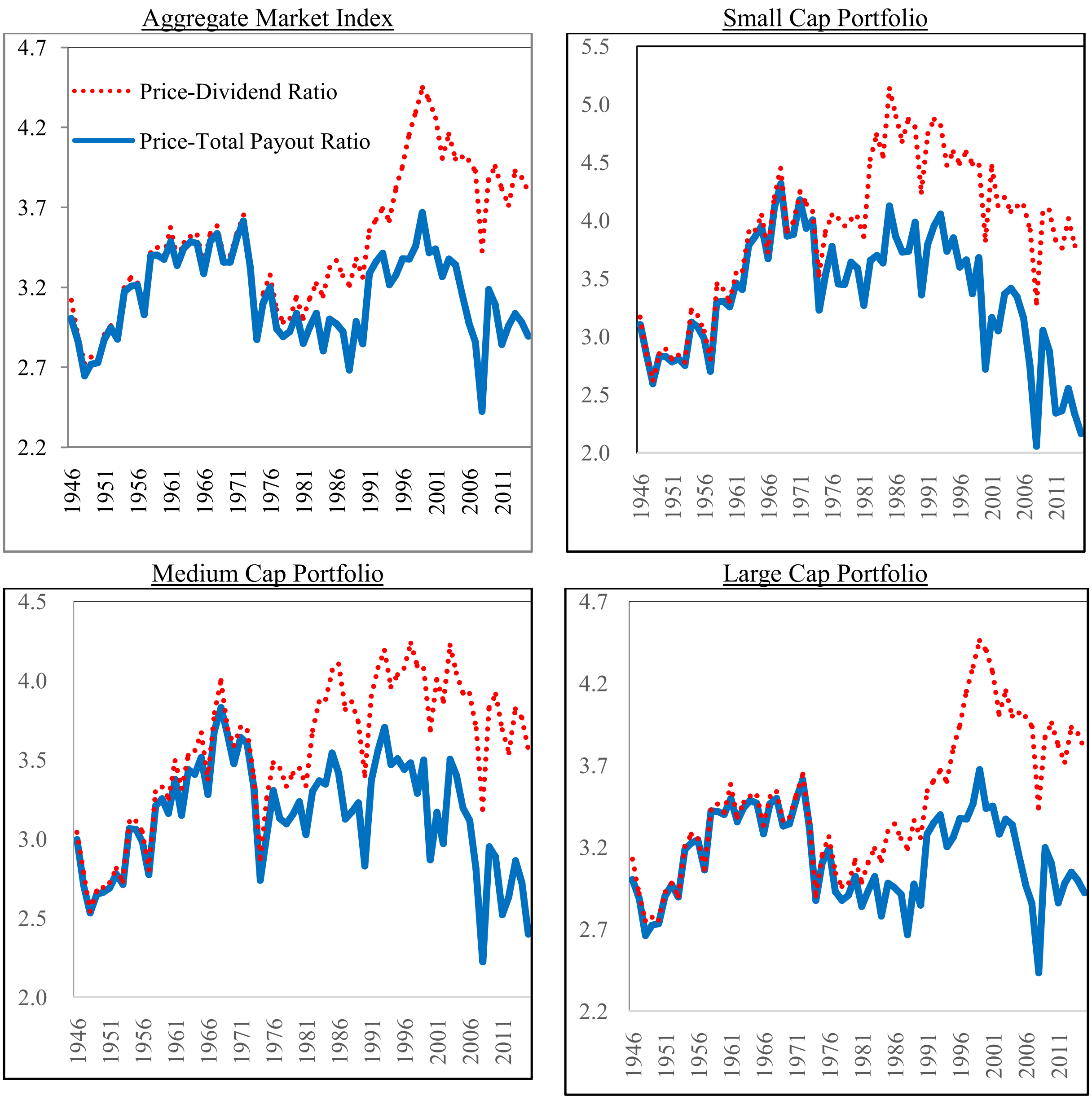
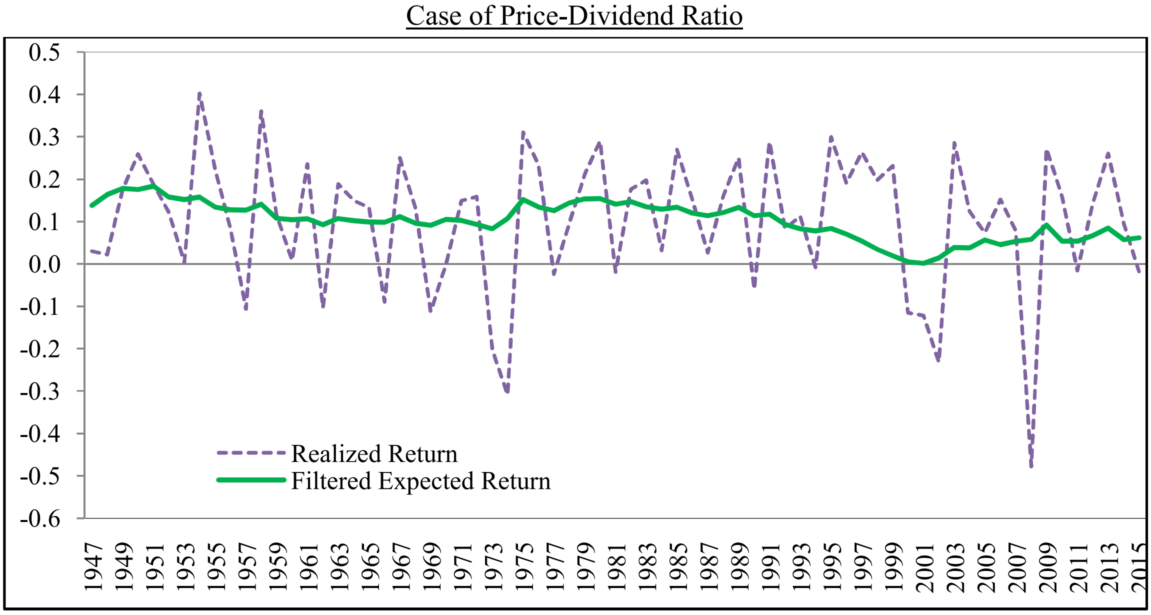


Figure 1.2: Filtered Series of Stock Return: Binsbergen-Koijen Model



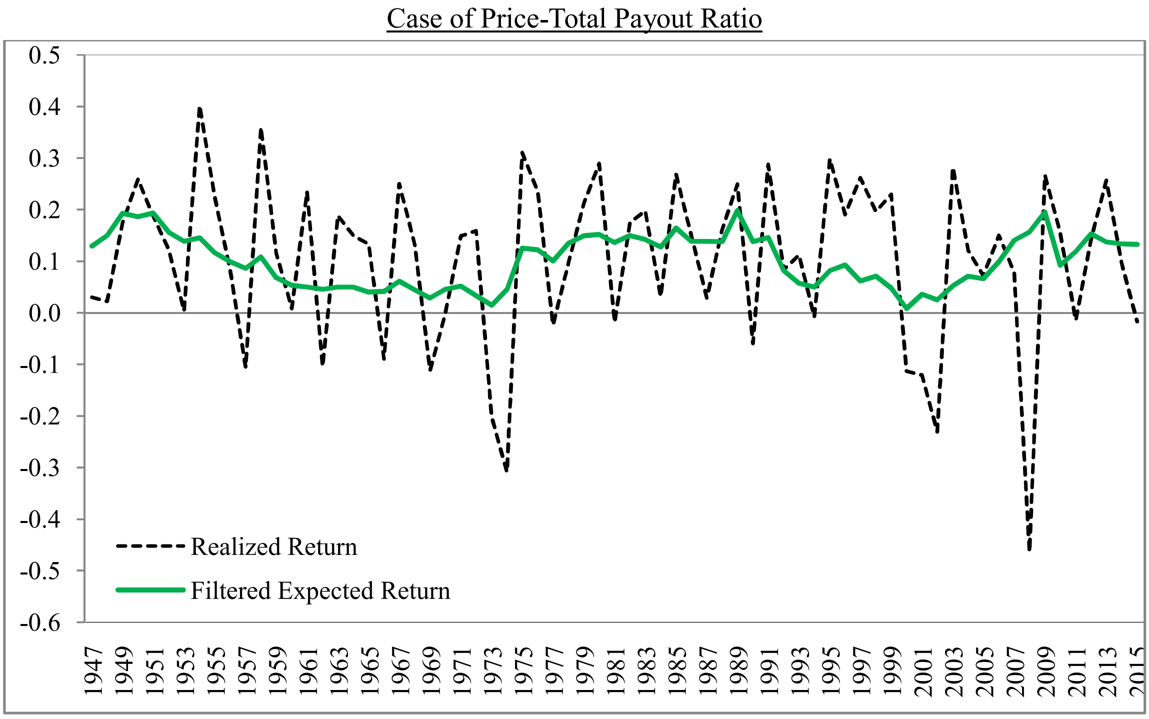
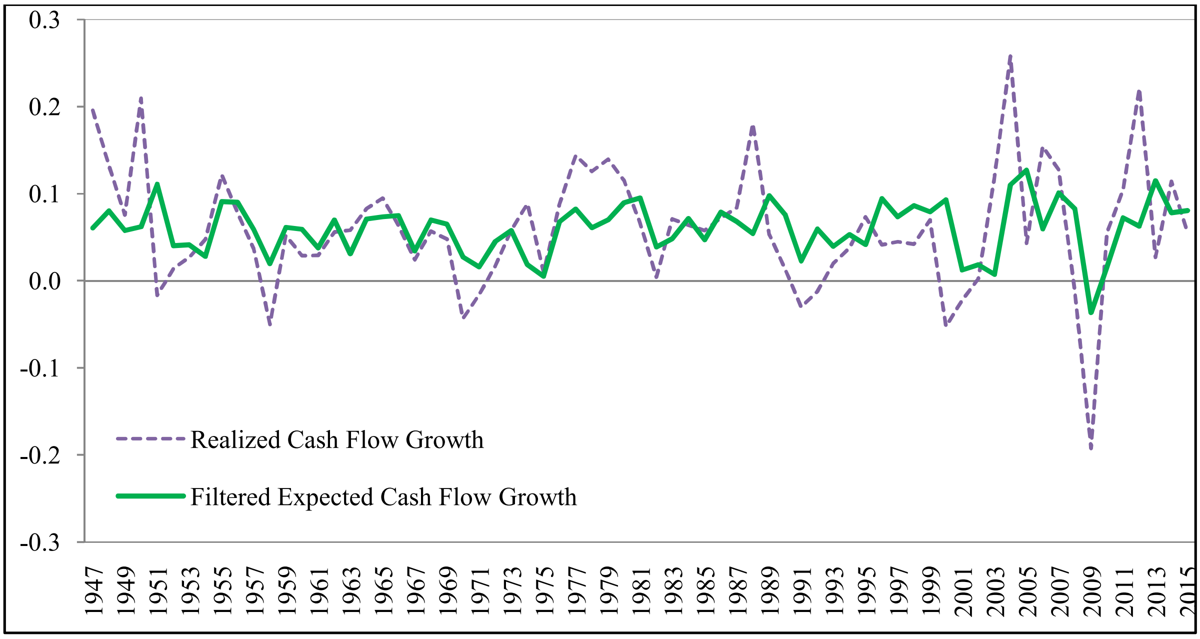


Figure 1.3: Filtered Series of Cash Flow Growth: Binsbergen-Koijen Model

Case of Price-Dividend Ratio



Case of Price-Total Payout Ratio

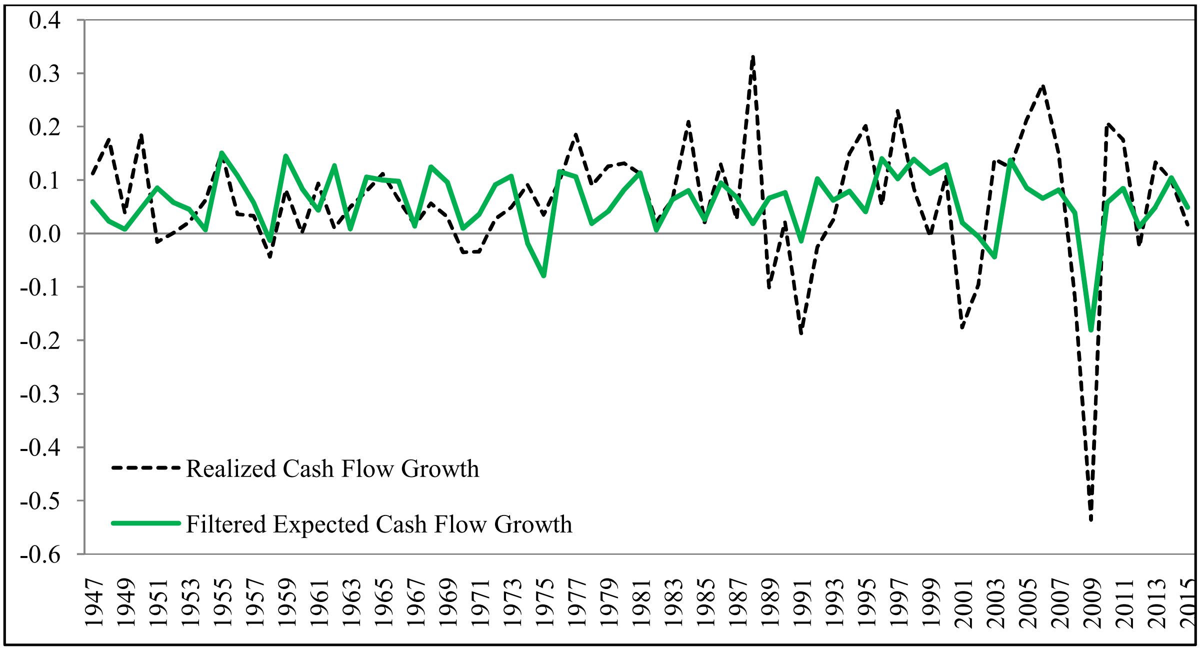
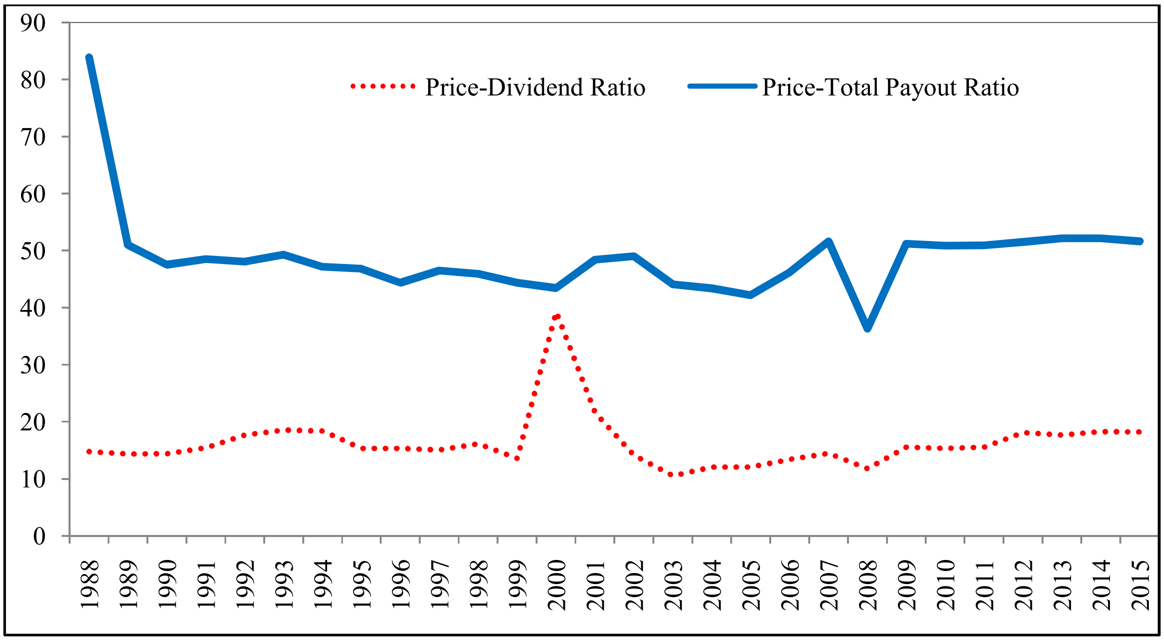
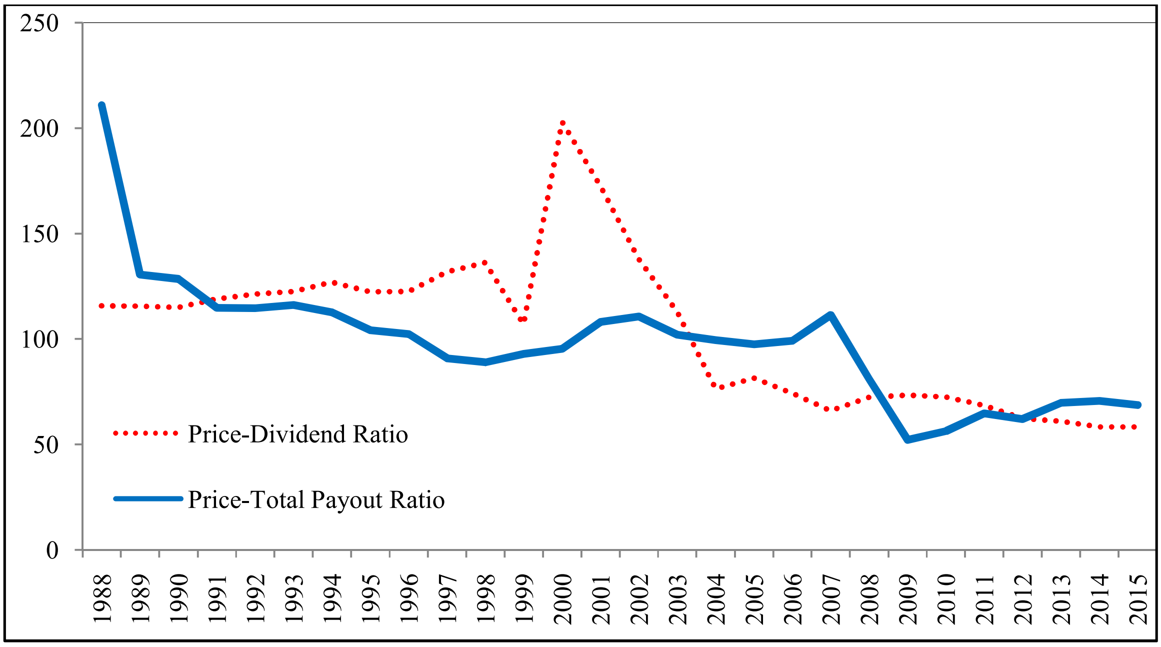


Figure 1.4: Variance Decompositions of Unexpected Excess Return
(Recursive Estimation, Campbell-Ammer Model, Annual, VAR(1))

Share of Variance of Cash Flow News



Share of Variance of Discount Rate News



Note: The recursive estimation is conducted from 1952 to the year specified on the horizontal axis.

Chapter 2. WHAT MOVES THE STOCK MARKET IN THE PRESENCE OF REGIME SHIFTS?

2.1 INTRODUCTION

Since Campbell and Shiller (1988) formulated price-dividend ratio as a linear relation between the economic agent's expectation on future dividend growth and expected future return through their present value framework, price-dividend ratio has received a lot of attention in the finance literature as a predictor of return and cash flow. As long as price and dividend maintain a stable one-to-one long-run relationship between each other, a higher price-dividend ratio than its long-run mean should predict a lower future return or a higher dividend growth or a combination of them since the higher-than-normal price-dividend ratio is destined to revert to its long-run mean.

Although a lot of empirical evidence has been uncovered showing that stock returns are predictable by price-dividend ratio, recent empirical studies document evidence of its strong persistence and non-stationarity, which undermine the validity of price-dividend ratio as an instrument to capture the joint dynamics of stock return and cash flow growth. Stambaugh (1986a, 1999), Hodrick (1992) and Nelson and Kim (1993) point out that the statistical significance of return predictability could be weaker when the statistical tests are adjusted in consideration of high persistence or near-unit root property of price-dividend ratio. They show that a typically high persistence in price-dividend ratio, coupled with a strong negative correlation between error terms in price-dividend ratio and stock return, makes conventional t-statistics unreliable since the point estimates may be biased and the OLS standard errors incorrect. Koijen and van Nieuwerburgh (2011) document a strong instability of return and dividend growth predictability by price-dividend ratio over time, while Park (2010a) attributes the difference in its predictive power between sample periods to a change in the stationarity of price-dividend ratio, claiming that return is more predictable when price-dividend ratio follows an I(0) process while its predictive power weakens when price-dividend ratio follows an I(1) process.

Some studies pay attention to the change in the dividend payout policy by firms as a source of the strong persistence in price-dividend ratio. Boudoukh, Michaely, Richardson, and Roberts (2007) and Robertson and Wright (2006) recognize that although price-dividend ratio shows a strong persistence especially during the 1990s, price-total payout (dividends plus repurchases) ratio exhibits a relatively stationary dynamics during the periods. They achieve improved out-of-sample return predictability by employing price-total payout ratio instead of price-dividend ratio. Kim and Park (2013) attempt to incorporate the effect of a recent decrease in firms with a traditional dividend-payout policy on price-dividend ratio and report that the predictive regression model that employs the adjusted price-dividend ratio as a regressor outperforms the random-walk model. Lee (2017) incorporates stock repurchases into both a more traditional VAR approach of Campbell and Ammer (1993) and a newer latent variables approach of Binsbergen and Koijen (2010) to stress the role of cash flow channel in stock market variation.

While a group of studies regard the recent increase in stock repurchases as a main culprit behind the non-stationarity of price-dividend ratio, other studies reveal another sources of the strong persistence in price-dividend ratio. Jank (2013) claims that the change in the composition of firms due to the deregulation of the requirements for listed companies makes the relationship between stock prices and dividends more unstable. Lettau, Ludvigson, and Wachter (2008) pay attention to a persistent decline in consumption volatility as a source of the exceptionally high stock valuation in the late 1990's. Abel (2003) and Park (2010b) look for the cause of the U.S.

stock market boom from a change in the demographic structure, while Jermann and Quadrini (2003) model the stock price rise from a persistent increase in U.S. productivity growth. If these sources account for a significant portion of the non-stationary dynamics of price-dividend ratio, the incorporation of stock repurchases is not enough to provide a satisfactory solution for the empirical issues that stem from the statistical property of price-dividend ratio, since they could affect price-total payout ratio in a non-negligible manner as well as price-dividend ratio.

We find a feasible solution to account for other possible sources of the non-stationarity in price-dividend ratio, typically not easy to quantify through observable data, from the incorporation of regime shifts in the mean of price-total payout ratio. Lettau and van Nieuwerburgh (2008) and Choi, Kim, and Park (2017) account for structural shifts in the mean of price-dividend ratio to provide a better explanation of return predictability and joint dynamics between expected return and expected dividend growth. Although the consideration of regime shifts in price-dividend ratio can capture a part of the change in dividend payout policy, it does not fully account for the effects of stock repurchases on the stock market dynamics. Although Lee (2017) provides a better illumination of the role of stock repurchases on the stock market by applying price-total payout ratio to the existing models, it does not take other factors affecting price-dividend ratio into full account. We find these two approaches as mutually complementary to each other and thus combine them by incorporating regime shifts in the mean of price-total payout ratio into the models of Binsbergen and Koijen (2010) and Campbell and Ammer (1993).

Compared to the result of Lee (2017) which implicitly assumes a constant mean of price-total payout ratio, we achieve i) a better in-sample goodness of fit for return, cash flow growth, and interest rate from both of the models, ii) a lower persistence and higher volatility of expected return from aggregate market index and medium and large cap portfolios, and iii) a stronger contribution of cash flow channel to the market variation from both of the models, by using annual samples from 1946 to 2015. The main findings can be summarized as follows:

First, the incorporation of regime shifts in the mean of price-total payout ratio into the models of Binsbergen and Koijen (2010) and Campbell and Ammer (1993) improves the in-sample goodness of fit for return, cash flow growth, and interest rates. For the aggregate market index of the full sample period, R^2 slightly rises from 10.6% to 11.4% for stock return and from 22.4% to 24.9% for cash flow growth. The improvement in the explanatory power is more evident from Campbell-Ammer model with regime shifts. The variations in excess stock return and interest rate are significantly better captured within the model as evidenced by higher R^2 values for three different sample periods.

Second, by accounting for regime shifts in the mean of price-total payout ratio, the Binsbergen-Koijen model produces a lower persistence and higher volatility of expected returns. For the annual aggregate market index, the persistence of expected returns declines from 0.83 to 0.62, which is translated as a 2.3%p smaller stock price change in a response to an 1% expected return shock, while the volatility of expected return rises from 0.031 to 0.049. The lower persistence in expected returns is observed from all size-sorted portfolios, while medium-sized firms show a greater decrease in expected return persistence than firms of other sizes.

Third, we find a further increase in the role of cash flow channel in explaining stock market variation by accounting for regime shifts into both of the models. Lee (2017) reveal that correcting for the measurement error of cash flow enables the cash flow channel to capture a sizable share of market variation. We show that the incorporation of other factors into the correctly measured cash flow can further strengthen the role of cash flow in the stock market. In the Binsbergen-Koijen model, the cash flow channel can account for 61% and 86% of annual variations in price-total payout ratio and unexpected returns, respectively, much higher than when we assume that the mean of price-total payout ratio is constant (25% and 72%, respectively), although the discount rate channel still act on the stock market strongly. We can also observe a similar increase in the share of cash flow channel in the stock market variations from three different sample periods.

The remainder of this chapter is organized as follows. Section 2.2 specifies how to incorporate the regime shifts in the mean of price-total payout ratio into the models of Binsbergen and Koijen (2010) and Cambpell and Ammer (1993). Section 2.3 explains the data and Bayesian estimation methodology applied to the Campbell-Ammer model with regime shifts. Section 2.4 provides the empirical results and their implications for persistence of expected returns and stock market variations. Section 2.5 concludes.

2.2 SPECIFICATION OF MODELS

In this section, we describe two models that we employ to derive empirical implications for stock market variations, using price-total payout ratio. One model is proposed by Choi, Kim, and Park (2017) which accounts for regime shifts in the mean of price-dividend ratio into Binsbergen and Koijen's (2010) latent variables approach, based on the present value framework of Campbell and Shiller (1988). We provide a review of their model in subsection 2.2.1. Additionally, we propose an extension of the model of Campbell and Ammer (1993) so that the means of state variables in their VAR setting follow a two-state, first-order Markov switching process. The introduction of the proposed model is provided in subsection 2.2.2.

2.2.1 *A Review of Choi, Kim, and Park's (2017) Model*

Following the Binsbergen-Koijen's specification of return and dividend growth, they specify return r_{t+1} and dividend growth rate Δd_{t+1} as:

$$r_{t+1} = \mu_t + \varepsilon_{t+1}^r \tag{2.1}$$

$$\Delta d_{t+1} = g_t + \varepsilon_{t+1}^d \tag{2.2}$$

, where $\mu_{t+j} \equiv E(r_{t+j+1} \mid I_{t+j})$, $g_{t+j} \equiv E(\Delta d_{t+j+1} \mid I_{t+j})$, and I_{t+j} is information available up to time *t+j*.

While the Binsbergen-Kojine's model assume that expected return μ_{t+j} and expected dividend growth g_{t+j} follow a stationary AR(1) process with time-invariant means, these means are subject to regime shifts, governed by a latent regime indicator variable S_{t+j}, which follows a two-state, first-order Markov chain where the transition probabilities between one regime at time *t* and the contiguous regime at time *t*+1 are fixed and contained in a 2×2 transition matrix P:

$$\Pr[S_{t+1} = j \mid S_t = i] \equiv p_{ij}, \quad \sum_{j=0}^{1} p_{ij} = 1, \quad i, j \in \{0,1\}, \quad P \equiv \begin{bmatrix} p_{00} & p_{10} \\ p_{01} & p_{11} \end{bmatrix} \tag{2.3}$$

$$S_{t+1} = \lambda_0 + \lambda_1 S_t + v_{t+1}, \qquad S_{t+1} - \pi = \lambda_1 (S_t - \pi) + v_{t+1} \tag{2.4}$$

, where $\lambda_0 = 1 - p_{00}$, $\lambda_1 = p_{11} + p_{00} - 1$, and $\pi \equiv E(S_{t+1}) = \dfrac{1 - p_{00}}{2 - p_{11} - p_{00}}$.

They specify the regime-dependent means for stock returns and dividend growth rate as:

$$\delta_{0,S_{t+j}} \equiv E(r_{t+j} \mid S_{t+j}) = \delta_{0,0} + (\delta_{0,1} - \delta_{0,0}) S_{t+j} \tag{2.5}$$

$$\gamma_{0,S_{t+j}} \equiv E(\Delta d_{t+j} \mid S_{t+j}) = \gamma_{0,0} + (\gamma_{0,1} - \gamma_{0,0}) S_{t+j} \tag{2.6}$$

Additionally, they assume that the economic agent observes the current state by the end of the current period. Therefore, the economic agent's information set Ψ_{t+j} contains the current state S_{t+j} as well as the econometrician's information set I_{t+j}. Then, they specify the AR(1) dynamics for de-meaned expected return and expected dividend growth as:

$$\widetilde{\mu}_{t+j} \equiv \mu_{t+j} - \delta_{0,S_{t+j}} = \delta_1 \widetilde{\mu}_{t+j-1} + \varepsilon^{\mu}_{t+j} \quad (2.7)$$

$$\widetilde{g}_{t+j} \equiv g_{t+j} - \gamma_{0,S_{t+j}} = \gamma_1 \widetilde{g}_{t+j-1} + \varepsilon^{g}_{t+j} \quad (2.8)$$

They incorporate the regime shifts in the means of stock return and dividend growth in the present value identity of Campbell and Shiller (1988):

$$pd_t = \frac{\kappa}{1-\rho} + E_t \sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j} - E_t \sum_{j=0}^{\infty} \rho^j r_{t+1+j} \quad (2.9)$$

$$pd_t = \frac{\kappa}{1-\rho} + \sum_{j=0}^{\infty} \rho^j E[\Delta d_{t+1+j} | I_t, S_t] - \sum_{j=0}^{\infty} \rho^j E[r_{t+1+j} | I_t, S_t]$$

$$= \frac{\kappa}{1-\rho} + \sum_{j=0}^{\infty} \rho^j E[g_{t+j} | I_t, S_t] - \sum_{j=0}^{\infty} \rho^j E[\mu_{t+j} | I_t, S_t]$$

$$= \frac{\kappa + \gamma_{0,0} - \delta_{0,0} + \pi\{(\gamma_{0,1} - \gamma_{0,0}) - (\delta_{0,1} - \delta_{0,0})\}}{1-\rho} + \frac{(S_{t+1} - \pi)\{(\gamma_{0,1} - \gamma_{0,0}) - (\delta_{0,1} - \delta_{0,0})\}}{1-\rho\lambda_1} + \frac{1}{1-\rho\gamma_1}\widetilde{g_{t+1}} - \frac{1}{1-\rho\delta_1}\widetilde{\mu_{t+1}}$$

$$= \overline{pd}_{S_{t+1}} - B_1 \widetilde{\mu}_{t+1} + B_2 \widetilde{g}_{t+1} \quad (2.10)$$

2.2.2 *An Extension of Campbell and Ammer's (1993) Model*

Although Campbell and Ammer (1993) assume that the mean of the vector state variables Z_{t+1} is time-invariant, we assume that they are subject to regime shifts, governed by a latent regime indicator variable S_{t+1}, whose dynamics is the same as equations (2.3) and (2.4):

$$Z_{t+1} \equiv \begin{pmatrix} e_{t+1} & i_{t+1} & rb_{t+1} & pp_{t+1} \end{pmatrix}' \quad (2.11)$$

$$Z_{t+1} = Z^*_{t+1} + \overline{Z}_{S_{t+1}} \tag{2.12}$$

$$\overline{Z}_{S_{t+1}} = \overline{Z}_0 + (\overline{Z}_1 - \overline{Z}_0) S_{t+1} \tag{2.13}$$

, where e_{t+1} is the excess stock return, i_{t+1} is the interest rate, pp_{t+1} is price-total payout ratio, and rb_{t+1} is the relative bill rate, defined as the level of the short rate relative to a 1-year backwards moving average of short rates.

We assume that the de-meaned vector of state variables follows a VAR(1) process:

$$Z^*_{t+1} = BZ^*_t + u_{t+1}, \quad u_{t+1} \sim N(0, \Sigma) \tag{2.14}$$

Solving the recursive dynamics for the latent regime indicator in equation (2.4) *j*-period forward, we can obtain the effect of a shock to the expectation on the current state on the expectation on *j*-period forward regime-dependent mean of the vector of state variables:

$$(E_{t+1} - E_t)\overline{Z}_{S_{t+j+1}} = (\overline{Z}_1 - \overline{Z}_0)\lambda_1^j \eta_{t+1} \tag{2.15}$$

, where $\eta_{t+1} \equiv (E_{t+1} - E_t) S_{t+1}$.

Following Choi, Kim, and Park (2017), we also assume that the economic agent observes the current state by the end of the current period:

$$\eta_{t+1} \equiv (E_{t+1} - E_t) S_{t+1} = S_{t+1} - \{\pi + \lambda_1 (S_t - \pi)\} \tag{2.16}$$

Therefore, the revision of expectation on *j*-period forward values of the state variables can be expressed as:

$$(E_{t+1} - E_t) Z_{t+j+1} = (E_{t+1} - E_t)\{Z^*_{t+j+1} + Z_{S_{t+j+1}}\} = B^j u_{t+1} + (\overline{Z}_1 - \overline{Z}_0)\lambda_1^j \eta_{t+1} \tag{2.17}$$

, where, in the right-hand side, the first term takes the same form as in the Campbell-Ammer model, which delivers the innovation to current de-meaned state variables (u_{t+1}) to *j*-period forward de-meaned state variables, while the second term that does not appear in the Campbell-

Ammer model plays the role of transmitting the current shock to regime probabilities (η_{t+1}) to j-period forward means of state variables.

Using the dynamics for Z_{t+1}, we can obtain the analytical solution for each of news components as follows:

$$N_{R,t+1} \equiv (E_{t+1} - E_t)s_1^{'}Z_{t+1} = s_1^{'}u_{t+1} + s_1^{'}(\overline{Z}_1 - \overline{Z}_0)\eta_{t+1} \tag{2.18}$$

$$N_{DR,t+1} \equiv (E_{t+1} - E_t)s_1^{'}\sum_{j=1}^{\infty}\rho^j B^j u_{t+1} = s_1^{'}Qu_{t+1} + s_1^{'}(\overline{Z}_1 - \overline{Z}_0)\delta\eta_{t+1} \tag{2.19}$$

$$N_{IR,t+1} \equiv (E_{t+1} - E_t)s_2^{'}\sum_{j=0}^{\infty}\rho^j B^j u_{t+1} = s_2^{'}(I_4 + Q)u_{t+1} + s_2^{'}(\overline{Z}_1 - \overline{Z}_0)(1+\delta)\eta_{t+1} \tag{2.20}$$

$$N_{CF,t+1} = N_{R,t+1} + N_{DR,t+1} + N_{IR,t+1} \tag{2.21}$$

, where $Q \equiv \rho B(I_4 - \rho B)^{-1}$ is the matrix of the long-run responses, s_n is an $n \times 1$ indication vector with the n'th element equal to unity and the remaining elements equal to zero, I_N is an $N \times N$ identity matrix, and $\kappa \equiv \dfrac{\rho\lambda_1}{1-\rho\lambda_1}$ is the constant of the long-run responses from the shock to regime probabilities.

2.3 DATA AND ESTIMATION

2.3.1 *Data*

We use annual data from 1946 to 2015 for the Binsbergen-Koijen model with regime shifts and from 1952 to 2015 for the Campbell-Ammer model with regime shifts. We collect aggregate stock return and price-dividend ratio from monthly returns with dividend and without dividend on the value-weighted portfolio of all NYSE, AMEX, NASDAQ, and ARCA stocks in the CRSP data. We construct monthly stock price after normalizing the initial stock price to one and multiply it by monthly returns without dividend. By combining the monthly stock price with monthly return with dividend, we can obtain monthly dividend series. Monthly dividend series are aggregated over 12 months and divided by the end-of-period stock price to derive annual dividend-price ratio. Total payout-price ratio is also constructed in a similar way. The only difference between them is that the repurchase-adjusted dividend-price ratio is constructed, using adjusted monthly returns without dividend for each firm listed in the U.S. stock market, following the methodology of Bansal, Dittmar, and Lundblad (2005). Appendix A.1 provides technical details of the construction of stock repurchase data. For the calculation of stock returns in excess of risk-free rate, monthly yields on 30-day U.S. Treasury bill are used. For the construction of size-sorted portfolios, we update each firm's market capitalization every month and sort all listed firms in the U.S. stock market by the descending order of their updated market capitalization every month. Top 30% firms are included in large cap portfolio, the next 40% firms in medium cap portfolio, and bottom 30% firms in small cap portfolio.

2.3.2 *Estimation Algorithm*

In this subsection, we provide only the estimation algorithm for our proposed model. We generate both the parameters of our model and the unobserved Markov-switching variables from appropriate conditional distributions using Gibbs-sampling. The priors are identical across the different regimes. This implies that the features of the regimes are not restricted and that differences arise due to the data and the identification condition that the fourth element in the mean of the vector of state variables $\overline{Z}_{S_{t+j+1}}$ is greater in state 1 ($\overline{Z}_0^{[4]} < \overline{Z}_1^{[4]}$). Appendix B.1 provides the description of the priors in detail.

The posterior distribution is obtained combining the likelihood function with the priors. Following Kim and Nelson (1998, 1999b), we employ a multi-move Gibbs sampling algorithm to draw from the posterior distribution. The Gibbs sampling proceeds with the following steps:

Step 1) Initialize $\overline{Z}_0$, $\overline{Z}_1$, B, Σ, p_{00}, and p_{11}.

Step 2) Generate $\widetilde{S}_T$, using the multi-move Gibbs sampling proposed by Carter and Kohn (1994), conditional on $\widetilde{Z}_T$, $\overline{Z}_0$, $\overline{Z}_1$, B, Σ, p_{00}, and p_{11}, where $\widetilde{S}_T \equiv \{S_1, S_2, \cdots, S_t, \cdots, S_{T-1}, S_T\}$, $\widetilde{Z}_T \equiv \{Z_1, Z_2, \cdots, Z_t, \cdots, Z_{T-1}, Z_T\}$, and T is the end of the sample period. η_{t+1} is generated as a byproduct of generating $\widetilde{S}_T$ in Carter and Kohn's (1994) multi-move Gibbs sampling.

Step 3) Generate $\overline{Z}_0$, $\overline{Z}_1$, and B, from the multivariate normal distribution, conditional on $\widetilde{Z}_T$, $\widetilde{S}_T$, and Σ. While generating $\overline{Z}_0$ and $\overline{Z}_1$, discard the draws that violate the identification condition that $\overline{Z}_0^{[4]} < \overline{Z}_1^{[4]}$ and redraw until the identification condition is satisfied. While generating B, discard the draws that violate the stationarity condition and redraw until the stationarity condition is satisfied.

Step 4) Generate Σ from the inverted Wishart distribution, conditional on $\widetilde{Z}_T$, $\widetilde{S}_T$, $\overline{Z}_0$, $\overline{Z}_1$, and B.

Step 5) Generate p_{00} and p_{11} from the beta distribution, conditional on $\widetilde{S}_T$.

Step 6) Go to step 2 and repeat until we reach a total of 30,000 iterations.

After discarding the first 10,000 draws in the Gibbs simulation, the next 20,000 draws are used to derive the posterior distribution statistics such as means, medians, and standard errors. We employ medians of the next 20,000 draws to extract the values of news components which are presented in the form of tables in this chapter.

2.4 EMPIRICAL RESULTS

2.4.1 *Preliminary Results*

In Figure 2.1, we plot filtered probabilities of state 1 (high valuation state) along with price-total payout ratio series constructed by the methodology given in Section 2.3. Both models capture well the regime changes in the mean of price-total payout ratio for aggregate market index and size-sorted portfolios. Both 1960s and 1990s are identified as high valuation periods, while the oil shocks and the global recession are characterized as low valuation periods, which is consistent with other empirical studies.

In Tables 2.1 and 2.2, we provide the estimates for parameters of the models of Binsbergen and Koijen (2010) and Campbell and Ammer with and without regime shifts in the mean of price-total payout ratio. Like in Chapter 1, the parameters of our main interest is the persistence and volatility of expected return (δ_1 and σ_μ). By incorporating the regime shifts in the mean of price-total payout ratio into the models, the persistence of expected return further declines from 0.827 to 0.618, while its volatility further rises from 0.031 to 0.049. More detailed description of the change in the persistence of expected return is given in subsection 2.4.3.

2.4.2 *In-Sample Goodness of Fit*

The incorporation of regime shifts in the mean of price-total payout ratio into the models of Binsbergen and Koijen (2010) and Campbell and Ammer (1993) improves the in-sample goodness of fit for stock return, cash flow growth, and interest rates.

For the aggregate market index over the full sample period from Binsbergen-Koijen model with regime shifts, R^2 slightly rises from 10.6% to 11.4% for stock return and from 22.4% to

24.9% for cash flow growth as can be seen from Table 2.3. Table 2.4 shows that the improvement in the explanatory power is more evident from Campbell-Ammer model with regime shifts. The variations in excess stock return and interest rate are significantly better captured within the model as evidenced by higher R^2 values over all of the three different sample periods. The better in-sample goodness of fit from the introduction of regime shifts in the mean of price-total payout ratio is also graphically represented in Figure 2.2.

2.4.3 *Persistence of Expected Returns*

By accounting for regime shifts in the mean of price-total payout ratio, the Binsbergen-Koijen model produces a lower persistence and higher volatility of expected returns.

In Table 2.5, for the annual aggregate market index, the persistence of expected returns declines from 0.83 to 0.62, which is translated as a 2.3%p smaller stock price change in a response to an 1% expected return shock, while the volatility of expected return rises from 0.031 to 0.049. The lower persistence in expected returns is observed from all size-sorted portfolios, while medium-sized firms show a sharper decrease in expected return persistence than firms of other sizes.

2.4.4 *Role of Cash Flow and Discount Rate in Market Variation*

We find a further increase in the role of cash flow channel in explaining stock market variation by accounting for regime shifts into both of the models. Lee (2017) reveal that correcting for the measurement error of cash flow enables the cash flow channel to capture a sizable share of market variation. We show that the incorporation of other factors into the correctly measured cash flow can further strengthen the role of cash flow in the stock market.

Table 2.6 shows that, in the Binsbergen-Koijen model, the cash flow channel can account for 61% and 86% of annual variations in price-total payout ratio and unexpected returns, respectively, much higher than when we assume that the mean of price-total payout ratio is constant (25% and 72%, respectively), although the discount rate channel still act on the stock market strongly.

In Table 2.7, we can also observe a similar increase in the share of cash flow channel in the stock market variations over three different sample periods from Campbell-Ammer model with regime shifts. For the aggregate market index, the share of the cash flow channel in the total variation of unexpected returns rises from 76.3% to 83.2% over 1952-1988 period, from 50.3% to 75.4% over 1952-2007 period, and from 53.7% to 70.3% over the full sample period (1952-2015), while the discount rate channel does not show significant change between with and without regime shifts in the mean of price-total payout ratio.

2.5 CONCLUSION

We incorporate regime shifts in the mean of price-total payout (dividends plus repurchases) ratio into the models of Binsbergen and Koijen (2010) and Campbell and Ammer (1993) to assess the effects of factors other than stock repurchases that could affect the non-stationarity of price-dividend ratio on stock market variation. Our results show that the understatement of the role of cash flow channel relative to that of discount rate channel is partly attributable to factors affecting the regime shifts in price-total payout ratio as well as the measurement error of cash flow data as shown by Lee (2017). Most of the existing studies that do not take into account those factors affecting the non-stationarity of price-dividend ratio have documented that the sentiments of the stock market participants account more than the variation of the market, while the fundamentals of the market such as the profitability of the corporate sector contribute nothing or little to the market variation. Our study reveals that the incorporation of both stock repurchases and other factors affecting the unstable relationship between dividends and stock prices can reilluminate the importance of the role of the fundamentals in explaining what moves the U.S. stock market.

2.6 TABLES AND FIGURES

Table 2.1: Parameter Estimates: Binsbergen-Koijen Model with 2-State Shifts

(1946-2015: Aggregate Market Index)

Parameter	No Regime Shifts		2 State-Regime Shifts	
	Estimate	Standard Error	Estimate	Standard Error
$\delta_{0,0}$	0.102	(0.017)	0.130	(0.023)
$\delta_{0,1}$	-	-	0.053	(0.030)
$\gamma_{0,0}$	0.059	(0.016)	0.066	(0.020)
$\gamma_{0,1}$	-	-	0.051	(0.025)
δ_1	0.827	(0.069)	0.618	(0.139)
γ_1	0.099	(0.119)	0.087	(0.123)
p_{00}	-	-	0.956	(0.031)
p_{11}	-	-	0.915	(0.052)
σ_μ	0.031	(0.012)	0.049	(0.019)
σ_g	0.120	(0.010)	0.118	(0.010)
σ_d	0.000	(0.007)	0.001	(0.017)
$\rho_{d\mu}$	0.914	(361.300)	-0.922	(0.267)
$\rho_{\mu g}$	0.399	(0.145)	0.383	(0.166)

Table 2.2: Posterior Distribution of Parameters: Campbell-Ammer Model with 2-State Shifts

(1952-2015: Aggregate Market Index)

	No Regime Shifts			2 State-Regime Shifts		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.
p_{00}	-	-	-	0.8978	0.9039	0.0562
p_{11}	-	-	-	0.9581	0.9635	0.0275
$\mu_{e,0}$	0.0580	0.0581	0.0649	0.0122	0.0219	0.1194
$\mu_{i,0}$	0.0079	0.0080	0.0126	0.0220	0.0241	0.0329
$\mu_{rb,0}$	-0.0000	-0.0001	0.0038	-0.0001	-0.0000	0.0009
$\mu_{pp,0}$	-3.1889	-3.1931	0.3084	-2.9173	-3.0252	0.5009
$\mu_{e,1}$	-	-	-	0.0747	0.0713	0.1067
$\mu_{i,1}$	-	-	-	0.0046	0.0044	0.0343
$\mu_{rb,1}$	-	-	-	0.0001	0.0003	0.0098
$\mu_{pp,1}$	-	-	-	-3.3739	-3.2328	0.6616
$b_{e,e}$	-0.0038	-0.0066	0.1293	0.0194	0.0165	0.1351
$b_{e,i}$	-0.3075	-0.2942	1.0796	0.5733	0.4211	1.7638
$b_{e,rb}$	-1.9377	-1.9441	1.6075	-1.9728	-1.9998	1.5901
$b_{e,pp}$	0.2050	0.2046	0.0890	0.2880	0.2724	0.1362
$b_{i,e}$	0.0158	0.0155	0.0114	0.0126	0.0123	0.0120
$b_{i,i}$	0.7473	0.7465	0.0969	0.6722	0.6804	0.1285
$b_{i,rb}$	0.1934	0.1949	0.1417	0.1776	0.1762	0.1429
$b_{i,pp}$	0.0035	0.0034	0.0079	-0.0016	-0.0014	0.0100
$b_{rb,e}$	0.0286	0.0286	0.0092	0.0279	0.0276	0.0096
$b_{rb,i}$	-0.2362	-0.2358	0.0740	-0.2947	-0.2874	0.1086
$b_{rb,rb}$	0.1920	0.1909	0.1113	0.2077	0.2053	0.1184
$b_{rb,pp}$	-0.0085	-0.0084	0.0062	-0.0133	-0.0129	0.0089
$b_{pp,e}$	0.3680	0.3674	0.1372	0.3423	0.3457	0.1382

	No Regime Shifts			2 State-Regime Shifts		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.
$b_{pp,i}$	-0.9391	-0.9262	1.1170	-2.3217	-2.1998	1.9401
$b_{pp,rb}$	2.6789	2.6643	1.7146	2.6001	2.6030	1.7026
$b_{pp,pp}$	0.7923	0.7980	0.0907	0.6957	0.7073	0.1364
$\Sigma^{[e,e]}$	0.0295	0.0291	0.0040	0.0286	0.0284	0.0040
$\Sigma^{[e,i]}$	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003
$\Sigma^{[e,rb]}$	-0.0001	-0.0001	0.0002	-0.0001	-0.0001	0.0002
$\Sigma^{[e,pp]}$	-0.0127	-0.0125	0.0032	-0.0113	-0.0112	0.0033
$\Sigma^{[i,e]}$	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003
$\Sigma^{[i,i]}$	0.0002	0.0002	0.0000	0.0002	0.0002	0.0000
$\Sigma^{[i,rb]}$	0.0000	0.0000	0.0000	-0.0000	-0.0000	0.0000
$\Sigma^{[i,pp]}$	-0.0001	-0.0001	0.0003	-0.0002	-0.0002	0.0003
$\Sigma^{[rb,e]}$	-0.0001	-0.0001	0.0002	-0.0001	-0.0001	0.0002
$\Sigma^{[rb,i]}$	0.0000	0.0000	0.0000	-0.0000	-0.0000	0.0000
$\Sigma^{[rb,rb]}$	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000
$\Sigma^{[rb,pp]}$	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002
$\Sigma^{[pp,e]}$	-0.0127	-0.0125	0.0032	-0.0113	-0.0112	0.0033
$\Sigma^{[pp,i]}$	-0.0001	-0.0001	0.0003	-0.0002	-0.0002	0.0003
$\Sigma^{[pp,rb]}$	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002
$\Sigma^{[pp,pp]}$	0.0331	0.0326	0.0045	0.0311	0.0307	0.0046

Note: The first 10,000 draws in the Gibbs simulation are discarded, and then the next 20,000 draws are used to derive the posterior distribution statistics above.

Table 2.3: In-Sample Goodness of Fit: Binsbergen-Koijen Model with 2-State Shifts (1946-2015)

	Stock Return				Cash Flow Growth			
	Total	Small	Medium	Large	Total	Small	Medium	Large
No Regime Shifts	10.6%	3.2%	9.5%	10.9%	22.4%	22.5%	20.0%	21.2%
2-State Regime Shifts	11.4%	3.5%	9.3%	11.3%	24.9%	22.4%	16.9%	23.7%

Note: "Total", "Small", "Medium", and "Large" refer to aggregate market index, small cap portfolio, medium cap portfolio, and large cap portfolio, respectively.

Table 2.4: In-Sample Goodness of Fit: Campbell-Ammer Model with 2-State Shifts

(Aggregate Market Index)

	Excess Stock Return			Interest Rate		
	1952-1988	1952-2007	1952-2015	1952-1988	1952-2007	1952-2015
No Regime Shifts	13.4%	13.8%	7.1%	50.5%	46.1%	49.8%
2-State Regime Shifts	20.2%	15.3%	10.0%	54.4%	46.6%	54.7%

Note: "Total", "Small", "Medium", and "Large" refer to aggregate market index, small cap portfolio, medium cap portfolio, and large cap portfolio, respectively. All the values above are derived from the medians for the next 20,000 draws after the first 10,000 draws in the Gibbs simulation are discarded.

Table 2.5: Expected Return Persistence and Price Effect

- Binsbergen-Koijen Model with 2-State Shifts (1946-2015) -

	Persistence of Expected Returns				Stock Price Change from 1% Expected Return Shock			
	Total	Small	Medium	Large	Total	Small	Medium	Large
No Regime Shifts	0.827 (0.069)	0.939 (0.056)	0.819 (0.079)	0.826 (0.068)	-4.6%	-9.8%	-4.5%	-4.6%
2-State Regime Shifts	0.618 (0.139)	0.918 (0.063)	0.566 (0.113)	0.624 (0.139)	-2.3%	-8.1%	-2.1%	-2.4%

Note: “Total”, “Small”, “Medium”, and “Large” refer to aggregate market index, small cap portfolio, medium cap portfolio, and large cap portfolio, respectively.

Table 2.6: Variance Decomposition of Price and Return

- Binsbergen-Koijen Model with 2-State Shifts (1946-2015) -

		Total		Small		Medium		Large	
		NS	2S	NS	2S	NS	2S	NS	2S
Price-Payout Ratio	CF	24.6%	60.5%	11.1%	13.3%	14.6%	4.6%	25.1%	61.1%
	DR	99.4%	84.9%	96.8%	95.9%	93.9%	76.7%	100.7%	87.1%
	Cov	-24.1%	-45.4%	-8.0%	-9.2%	-8.5%	18.8%	-25.8%	-48.1%
Unexpected Return	CF	72.2%	85.6%	59.1%	60.7%	41.3%	59.2%	75.3%	89.5%
	DR	93.3%	74.7%	57.9%	58.0%	87.3%	96.9%	97.0%	78.6%
	Cov	-65.5%	-60.3%	-17.0%	-18.7%	-28.6%	-56.1%	-72.3%	-68.1%

Note: “Total”, “Small”, “Medium”, and “Large” refer to aggregate market index, small cap portfolio, medium cap portfolio, and large cap portfolio, respectively. “CF”, “DR”, and “Cov” refer to variance of cash flow, variance of discount rate, and covariance between cash flow and discount rate, respectively. “PD” and “PP” refers to price-dividend ratio and price-total payout ratio, respectively. “NS” and “2S” refer to Campbell-Ammer model without regime shifts and Campbell-Ammer model with 2-state regime shifts, respectively.

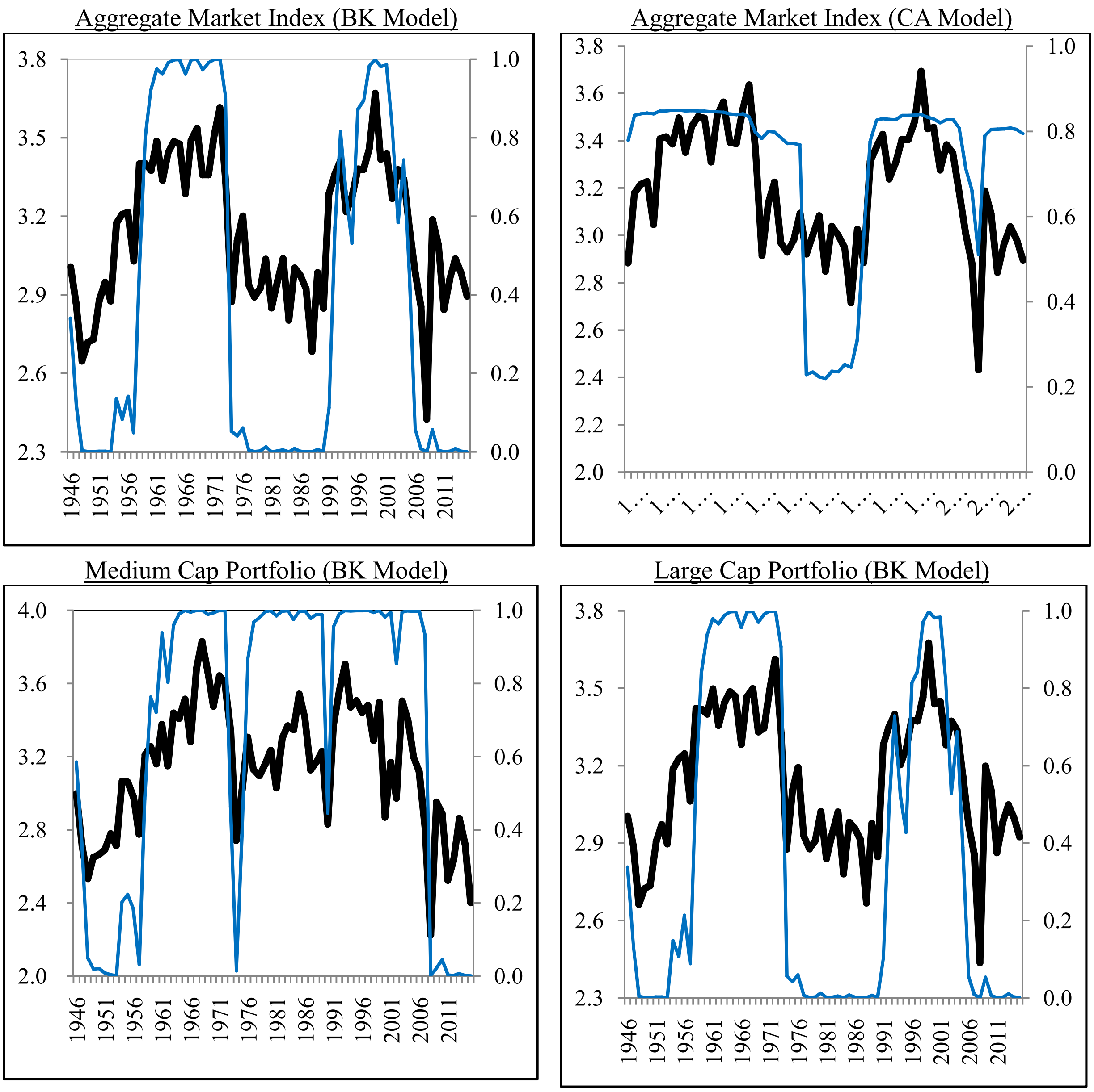
Table 2.7: Variance Decomposition of Unexpected Return: Campbell-Ammer Model

(Aggregate Market Index, Annual, VAR(1))

	1952-1988		1952-2007		1952-2015	
	NS	2S	NS	2S	NS	2S
Var(CF)	76.3%	83.2%	50.3%	75.4%	53.7%	70.3%
Var(DR)	102.9%	84.5%	103.4%	80.2%	65.9%	69.9%
VAR(IR)	3.7%	4.9%	5.7%	6.1%	4.8%	6.8%
Cov(CF,DR)	-83.2%	-76.3%	-53.2%	-43.7%	-23.4%	-40.3%
Cov(CF,IR)	12.3%	11.3%	7.5%	4.3%	12.3%	9.5%
Cov(DR,IR)	-12.3%	-7.4%	-13.3%	-22.5%	-13.5%	-15.9%

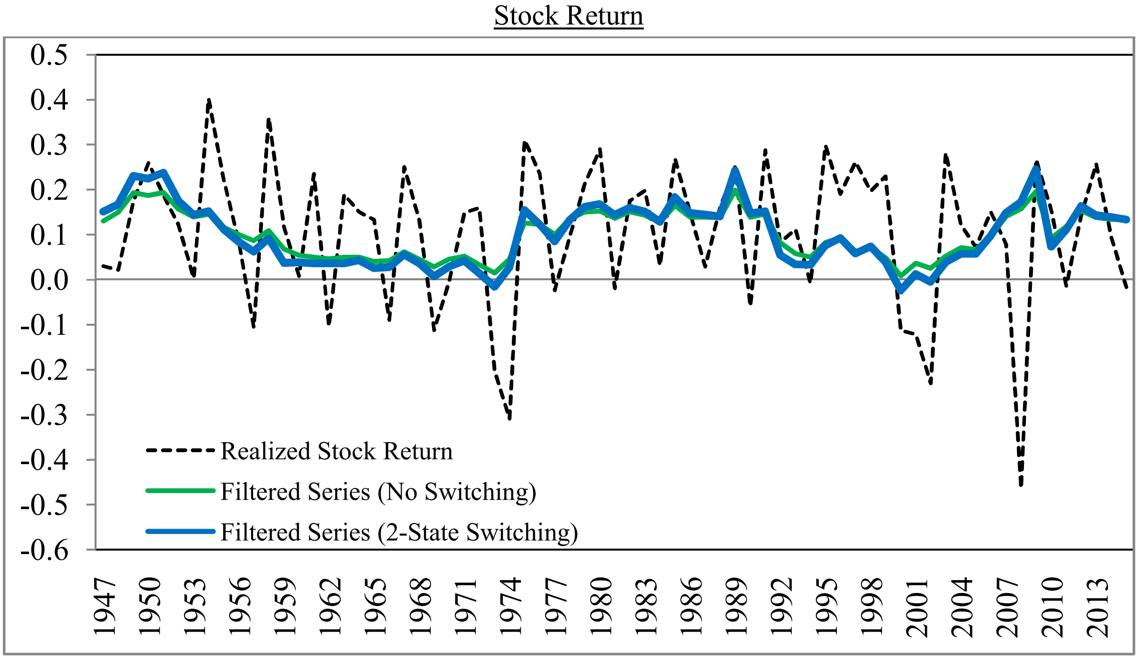
Note: "Var(CF)", "Var(DR)", "Var(IR)", "Cov(CF,DR)", "Cov(CF,IR)", and "Cov(DR,IR)" refer to variance of cash flow, variance of discount rate, variance of interest rate, covariance between cash flow and discount rate, covariance between cash flow and interest rate and covariance between discount rate and interest rate, respectively. "NS" and "2S" refer to Campbell-Ammer model without regime shifts and Campbell-Ammer model with 2-state regime shifts, respectively. All the values above are derived from the medians for the next 20,000 draws after the first 10,000 draws in the Gibbs simulation are discarded.

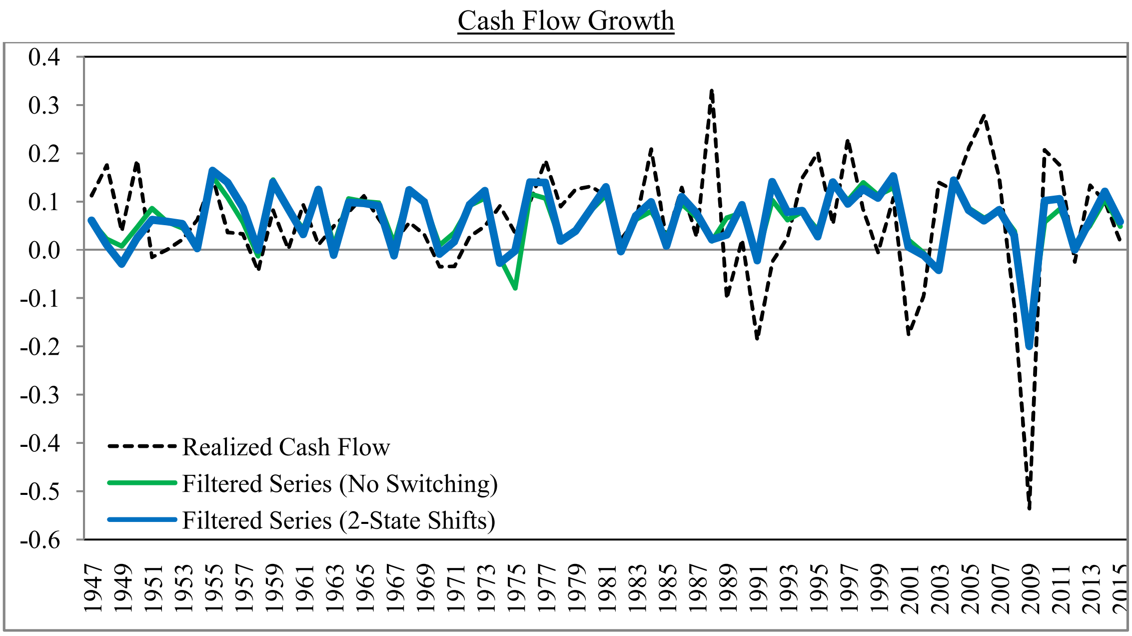
Figure 2.1: Filtered Probabilities of State 1 and Price-Total Payout Ratios



Note: "BK Model" and "CA Model" refer to Binsbergen-Koijen model with 2-state regime shifts and Campbell-Ammer model with 2-state regime shifts, respectively.

Figure 2.2: Filtered Series of Stock Return and Cash Flow: Binsbergen-Koijen Model





Chapter 3. IS CONSUMPTION VOLATILITY RISK LARGE ENOUGH TO EXPLAIN THE EQUITY PREMIUM?

3.1 INTRODUCTION

The traditional consumption-based asset pricing approach to modeling the risk premium – the expected excess return on an asset over the risk-free interest rate – explains the risk premium as a linear combination of covariances between the asset's return and each of two sources of risk: cash flow risk from the first moment of consumption growth, and market discount rate risk. Campbell (1993, 1996), Jagannathan and Wang (1996), Lettau and Ludvigon (2001), Campbell and Vuolteenaho (2004), Santos and Veronesi (2006), Lustig and van Nieuwerburgh (2008), basically follows this approach, despite some differences in model specifications and implications for asset pricing among them. Under this approach, they explicitly or implicitly assume the second moment of consumption growth is not time-varying, so it does not act as a source of risk from holding a specific class of asset.

Recently, there has been a growing interest in the role of stochastic volatility in consumption growth as a mechanism for explaining the dynamics of asset prices since the pioneering work of Bansal and Yaron (2004). In their long-run risk model, a persistent change in conditional consumption volatility as well as in expected consumption growth justifies some puzzling features of asset markets phenomena, such as the high equity premium, the low risk-free rate, and the return predictability of price-dividend ratios. Inspired by the long-run risk model of Bansal and Yaron (2004), the relation between time-varying consumption volatility and asset prices has received considerable attention in the finance literature. Bansal, Khatchatrian, and

Yaron (2005) reveal that much of the variation in asset prices can be attributed to fluctuations in consumption volatility and expected cash flow growth. Lettau, Ludvigson, and Wachter (2008) estimate a regime-switching model for the volatility and mean of consumption growth and explain a sharp run-up in asset prices during the 1990s from a persistent decline in consumption volatility. Boguth and Kuehn (2013) show that exposure to consumption volatility risk predicts future returns. More specifically, cross-sectional difference in expected returns among stock portfolios is explained by their difference in the sensitivity of dividend volatility to consumption volatility.

More recently, Bansal, Kiku, Shaliastovich, and Yaron (2014) (hereafter, "BKSY") propose a Macro-DCAPM-SV (dynamic capital asset pricing model with stochastic macroeconomic volatility) to quantify the role of the macroeconomic volatility channel for asset markets. Based on a standard VAR-based methodology on five state variables (consumption, labor income, stock return, price-dividend ratio, and realized variance), they extract the innovations to the consumption return, volatility, and the stochastic discount factor to assess the importance of the volatility channel for returns to equity and human capital. Campbell, Giglio, Polk, and Turley (2016) adopt a similar approach to the BKSY model to stress the role of volatility risk to explain the long-term equity investors' preferences of the aggregate stock index over other equity portfolios.

BKSY document that the introduction of the macroeconomic volatility channel can explain more than half of the equity premium and reverse a negative correlation between equity return and human capital return reported by Lustig and van Nieuwerburgh (2008) and Chen, Favilukis, and Ludvigson (2013). We attribute the strong role of the volatility channel in the BKSY model to their use of the realized variance measured from the industrial output, which typically shows a much more volatile variation than consumption volatility. Another issue associated with the realized variance is that it is observable by the end of every period. With the realized variance as a proxy for the consumption volatility, the economic agent is assumed to revise her expectation on the consumption volatility very sharply whenever she observes the realized variance every period, which partly accounts for a sizable risk premium from the volatility channel. This is not supported by other studies attempting to find links between consumption volatility risk and asset prices, such as Lettau, Ludvigson, and Wachter (2008) and Boguth and Kuehn (2013) who assume that the representative agent cannot observe the consumption volatility state of the economy, but instead infers it from other observable data by assigning the posterior probability of being in each state. This learning aspect allows the economic agent to only gradually discover over time the very-low-frequency changes in consumption volatility, and can more effectively capture a sustained rise in asset prices during the 1990s.

We attempt to reassess the importance of the volatility channel for returns to equity and human capital by providing an extension of the BKSY model so that the consumption volatility is generated endogenously within the model and all of the volatility risks are measured from the economic agent's revision of expectation on the unobservable consumption volatility state. First, we employ price-total payout (dividends plus repurchases) ratio instead of price-dividend ratio to adjust an unstable one-to-one long-run relationship between price and dividend. Second, we measure the size of the volatility risk from endogenously generated consumption volatility rather than from the exogenous realized variance. To provide a possible link between consumption volatility and other state variables, we allow means of the state variables to be time-varying and specify them as linear functions of the expected level of the consumption volatility. Third, we assume that consumption volatility is not constant, but switching across the states, while the economic agent cannot observe the consumption volatility states and instead infers them from other observable data by calculating the posterior probability of being in each state of the economy as a learning process.

We use annual sample from 1930 to 2015 and the main findings from the features of our model can be summarized as follows.

First, the use of price-total payout ratio instead of price-dividend ratio weakens the results of BKSY (2014) in a non-negligible manner. At a level of risk aversion that allows the model-implied equity premium to fit the data, the share of the volatility risk channel in the equity premium declines from 57% to 41% just by replacing price-dividend ratio with price-total payout ratio without changing other features of the BKSY model. We can observe much fewer book-to-market- and size-sorted portfolios where the volatility risk channel acts on the equity premium more strongly than the cash flow risk channel. A positive correlation between equity return and human capital return in the BKSY model without the adjustment of price-dividend ratio is made somewhat ambiguous with the incorporation of price-total payout ratio.

Second, the consumption volatility risk is measured through three different channels (cash flow channel, discount rate channel, and macroeconomic volatility channel) in our proposed model, since the economic agent's revision of expectation on current consumption volatility state affects directly the macroeconomic volatility channel and indirectly the cash flow and discount rate channels by changing the expectation on the means of the corresponding state variables. Although the diversified channels for the consumption volatility risk add a bit of risk premium to the consumption volatility risk, it is overwhelmed by a drastic decrease in risk premium from the macroeconomic volatility channel.

Third, we show that the BKSY model with price-dividend ratio adjusted still overstates the role of consumption volatility risk and understates that of cash flow risk in explaining the total risk premium for aggregate stock index. In our model, more than 90% of the equity premium from the annual sample is explained by cash flow risk, while consumption volatility risk accounts for less than 10% of the equity premium, much lower than 47% in the BKSY model with price-total payout ratio in the state variables. The weaker role of consumption volatility risk on the equity premium is also observed from the cross-sectional stock returns. All of five book-to-market- and five size-sorted portfolios show a bigger contribution of cash flow risk than that of consumption volatility risk in our model.

Fourth, our model reveals that the consumption volatility risk is not large enough to reverse a negative correlation between equity return and human capital return by Lustig and van Nieuwerburgh (2008). This contradicts the claim of BKSY (2014) that the incorporation of time-varying consumption volatility guarantees a positive correlation between financial and human capital returns.

The remainder of this chapter is organized as follows. Section 3.2 provides a review of the BKSY (2014) model. In Section 3.3, we extend the BKSY model to incorporate price-total payout ratio and endogenously generated consumption volatility with regime shifts. Section 3.4 explains the data and Bayesian estimation methodology applied to our model. Section 3.5 provides the empirical results and their implications for risk premium and its components. Section 3.6 concludes.

3.2 A REVIEW OF THE BKSY MODEL

In this section, we provide a review of the BKSY model (2014), which will be useful for understanding our extension and its comparison with this model.

The BKSY model assumes a representative investor who has Epstein-Zin-Weil recursive preferences (Epstein and Zin 1989, Weil 1989) and maximizes the lifetime utility subject to the budget constraint:

$$U_t = \left[(1-\delta) C_t^{1-\frac{1}{\psi}} + \delta \left(E_t U_{t+1}^{1-\gamma} \right)^{\frac{1-\frac{1}{\psi}}{1-\gamma}} \right]^{\frac{1}{1-\frac{1}{\psi}}} \tag{3.1}$$

$$W_{t+1} = (W_t - C_t) R_{t+1} \tag{3.2}$$

, where δ is the subjective discount factor, γ is the coefficient of risk aversion, ψ is the elasticity of intertemporal substitution (EIS), $\theta \equiv (1-\gamma)/\{1-(1/\psi)\}$, E_t is the expectation operator conditional on the information available up to time *t*, C_t is the aggregate consumption, and R_{t+1} is the gross return on total wealth W_t .

They apply the present value equation of Campbell and Shiller (1988) to the wealth-consumption ratio from equation (3.2) to obtain:

$$(E_{t+1} - E_t)\Delta c_{t+1} = (E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j r_{t+j+1} - (E_{t+1} - E_t)\sum_{j=1}^{\infty} \rho^j \Delta c_{t+j+1} \tag{3.3}$$

, where lowercase letters are used for logs of their uppercase counterparts, Δ is the first difference operator, and ρ denotes the average ratio of invested wealth to the total wealth. Combining the first-order condition (Euler equation) for the utility maximization and the present value equation, they express the consumption shock in terms of unexpected return, future expected return news and future macroeconomic volatility news:

$$(E_{t+1}-E_t)\Delta c_{t+1}=(E_{t+1}-E_t)r_{t+1}+(1-\psi)(E_{t+1}-E_t)\sum_{j=1}^{\infty}\rho^j r_{t+j+1}+\frac{\psi-1}{\gamma-1}(E_{t+1}-E_t)\sum_{j=1}^{\infty}\rho^j V_{t+j} \quad (3.4)$$

, where V_t is defined to be the conditional variance of the sum of the log stochastic discount factor m_{t+1} and the log return on total wealth r_{t+1}:

$$V_t \equiv \frac{1}{2}\mathrm{var}_t(m_{t+1}+r_{t+1})=\frac{1}{2}\mathrm{var}_t(m_{t+1})+\mathrm{cov}_t(m_{t+1},r_{t+1})+\frac{1}{2}\mathrm{var}_t(r_{t+1}) \quad (3.5)$$

It is worth noting that the macroeconomic volatility measure V_t stems from the second moment of Euler equation.

For notational convenience, they denote:

$$N_{C,t+1}\equiv(E_{t+1}-E_t)\Delta c_{t+1},\qquad N_{R,t+1}\equiv(E_{t+1}-E_t)r_{t+1},\qquad N_{DR,t+1}\equiv(E_{t+1}-E_t)\sum_{j=1}^{\infty}\rho^j r_{t+j+1},$$

$$N_{V,t+1}\equiv(E_{t+1}-E_t)\sum_{j=1}^{\infty}\rho^j V_{t+j},\quad N_{CF,t+1}\equiv(E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j\Delta c_{t+j+1}=N_{R,t+1}+N_{DR,t+1} \quad (3.6)$$

Substituting equation (3.4) into the log stochastic discount factor m_{t+1}, they decompose the shock to the stochastic discount factor into three different risk channels (cash flow risk channel, discount rate risk channel, and macroeconomic volatility risk channel). As a corollary, the risk premium for an asset *i* is expressed as a linear combination of covariances between the asset's return $r_{i,t+1}$ and each of three risk channels:

$$N_{M,t+1}\equiv m_{t+1}-E_t m_{t+1}=-\gamma N_{CF,t+1}+N_{DR,t+1}+N_{V,t+1} \quad (3.7)$$

$$E_t[R_{i,t+1}-R_{f,t}]=\mathrm{cov}_t(r_{i,t+1},-m_{t+1})=\gamma\,\mathrm{cov}_t(r_{i,t+1},N_{CF,t+1})-\mathrm{cov}_t(r_{i,t+1},N_{DR,t+1})-\mathrm{cov}_t(r_{i,t+1},N_{V,t+1}) \quad (3.8)$$

They assume that the macroeconomic volatility risk $N_{V,t+1}$ is homoskedastic and impose the proportionality condition, setting the ratio of variances of $N_{CF,t+1}$ and $N_{C,t+1}$ to χ, which enables them to express the measure of macroeconomic volatility, V_t, as a linear function of the conditional variance of consumption growth:

$$V_t = V_0 + \frac{1}{2}(1-\gamma)^2 \operatorname{var}_t(N_{CF,t+1}) = V_0 + \frac{1}{2}(1-\gamma)^2 \chi \operatorname{var}_t(\Delta c_{t+1}) \tag{3.9}$$

As the total wealth return r_{t+1} is not directly observed in the data, they assume that it is a weighted combination of stock return $r_{S,t+1}$ (weight: $1-\omega$) and human capital return $r_{H,t+1}$ (weight: ω) and expected return to human capital is linear in a vector of state variables Z_t which consists of real consumption growth Δc_t, real labor income growth Δy_t, real market return $r_{S,t}$, market price-dividend ratio pd_t, and the realized variance measure RV_t, constructed as the sum of squares of monthly industrial production growth over the year:

$$E_t r_{H,t+1} = \alpha + \beta' Z_t \tag{3.10}$$

$$Z_t \equiv \begin{pmatrix} \Delta c_t & \Delta y_t & r_{S,t} & pd_t & RV_t \end{pmatrix}' \tag{3.11}$$

Since they assume that the vector of state variables Z_t with time-invariant means follows a VAR(1) specification, all of risk channels, captured by the revision of expectation on *j*-period forward value of the vector, Z_{t+j+1}, can be described as linear functions of the error term u_{t+1}:

$$Z_{t+1} = A + BZ_t + u_{t+1}, \qquad u_{t+1} \sim N(0,\Sigma) \tag{3.12}$$

$$(E_{t+1} - E_t)Z_{t+j+1} = B^j u_{t+1} \tag{3.13}$$

$$N_{V,t+1} \equiv (E_{t+1} - E_t)\sum_{j=1}^{\infty} \rho^j V_{t+j} = \frac{1}{2}(1-\gamma)^2 \chi i_5' Q u_{t+1} \tag{3.14}$$

$$N_{DR,t+1} = (1-\omega)N_{DR,t+1}^S + \omega N_{DR,t+1}^H = (1-\omega)i_3' Q u_{t+1} + \omega \beta' B^{-1} Q u_{t+1} \tag{3.15}$$

$$N_{CF,t+1} = (1-\omega)N_{CF,t+1}^S + \omega N_{CF,t+1}^H = (1-\omega)i_3'(I_5 + Q)u_{t+1} + \omega i_2'(I_5 + Q)u_{t+1} \tag{3.16}$$

, where $Q \equiv \rho B(I_5 - \rho B)^{-1}$ is the matrix of the long-run responses, i_n is an $n \times 1$ indication vector with the n'th element equal to unity and the remaining elements equal to zero, and I_N is an $N \times N$ identity matrix.

3.3 AN EXTENSION OF THE BKSY MODEL

In this section, we propose an extension of the BKSY model to employ price-total payout ratio instead of a non-stationary price-dividend ratio and to incorporate endogenously generated consumption volatility with regime shifts as a source of the consumption volatility risk. In our proposed model, the economic agent's revision of expectation on current volatility states affects the macroeconomic volatility risk and the means of other state variables as well.

First, we replace price-dividend ratio pd_{t+1} with price-total payout ratio pp_{t+1} to adjust regime-shifts in the former, while excluding the realized variance RV_{t+1} from the vector of observable state variables Z_{t+1}, since we assume that the economic agent cannot observe the consumption volatility from the realized variance measure and it is endogenously generated from the second moment of error term u_{t+1} within our model:

$$Z_{t+1} \equiv \left(\Delta c_{t+1} \quad \Delta y_{t+1} \quad r_{S,t+1} \quad pp_{t+1}\right)' \tag{3.17}$$

Although we capture the consumption volatility from the second moment of Z_{t+1}, we allow means of state variables to be time-varying and specified as linear functions of the expected level of consumption volatility σ_{t+1}^2 to provide a link between consumption volatility and state variables:

$$\Delta c_{t+1} = a_{c,0} + a_{c,1} E_t(\sigma_{t+1}^2) + \Delta c_{t+1}^*$$

$$\Delta y_{t+1} = a_{y,0} + a_{y,1} E_t(\sigma_{t+1}^2) + \Delta y_{t+1}^*$$

$$r_{S,t+1} = a_{rs,0} + a_{rs,1} E_t(\sigma_{t+1}^2) + r_{S,t+1}^*$$

$$pp_{t+1} = a_{pp,0} + a_{pp,1} E_t(\sigma_{t+1}^2) + pp_{t+1}^* \tag{3.18}$$

, where variables with an asterisk indicate their de-meaned values, which are specified as functions of their own lags and lags of other de-meaned variables:

$$\Delta c_{t+1}^* = f_1(\Delta c_t^*, \Delta y_t^*, r_{S,t}^*, pp_t^*, \cdots) + u_{1,t+1}$$

$$\Delta y_{t+1}^* = f_2(\Delta c_t^*, \Delta y_t^*, r_{S,t}^*, pp_t^*, \cdots) + u_{2,t+1}$$

$$r_{S,t+1}^* = f_3(\Delta c_t^*, \Delta y_t^*, r_{S,t}^*, pp_t^*, \cdots) + u_{3,t+1}$$

$$pp_{t+1}^* = f_4(\Delta c_t^*, \Delta y_t^*, r_{S,t}^*, pp_t^*, \cdots) + u_{4,t+1} \tag{3.19}$$

Second, we assume that the error term u_{t+1} that consists of the innovations ($u_{1,t+1}$, $u_{2,t+1}$, $u_{3,t+1}$, $u_{4,t+1}$) from the de-meaned state variables follows a multivariate normal distribution with state-dependent variance-covariance matrices $\Sigma_{S_{t+1}}$, whose (1,1)'th element is consumption volatility $\sigma_{t+1}^2 = \sigma_{S_{t+1}}^2$:

$$u_{t+1} \equiv \begin{pmatrix} u_{1,t+1} & u_{2,t+1} & u_{3,t+1} & u_{4,t+1} \end{pmatrix}' \sim N(0, \Sigma_{S_{t+1}}) \tag{3.20}$$

The latent regime indicator, S_{t+1}, follows a two-state, first-order Markov chain where the transition probabilities between one regime at time t and the contiguous regime at time t+1 are fixed and contained in a 2×2 transition matrix P:

$$\Pr[S_{t+1} = j \mid S_t = i] \equiv p_{ij}, \quad \sum_{j=0}^{1} p_{ij} = 1, \quad i, j \in \{0,1\}, \quad P \equiv \begin{bmatrix} p_{00} & p_{10} \\ p_{01} & p_{11} \end{bmatrix} \tag{3.21}$$

$$S_{t+1} = \lambda_0 + \lambda_1 S_t + \nu_{t+1}, \qquad S_{t+1} - \pi = \lambda_1 (S_t - \pi) + \nu_{t+1} \tag{3.22}$$

, where $\lambda_0 = 1 - p_{00}$, $\lambda_1 = p_{11} + p_{00} - 1$, and $\pi \equiv E(S_{t+1}) = \dfrac{1 - p_{00}}{2 - p_{11} - p_{00}}$.

We specify the regime-dependent consumption volatility in a two-state case as follows:

$$\sigma^2_{S_{t+j+1}} = \sigma_0^2 + (\sigma_1^2 - \sigma_0^2) S_{t+j+1} \tag{3.23}$$

, where σ_0^2 denotes variance of consumption growth at the low volatility state and σ_1^2 does at the high volatility state. (We provide the analytical solution for a three-state case in Appendix C.1.) Solving the recursive dynamics for the latent regime indicator in equation (3.22) *j*-period forward, we can obtain the effect of a shock to the expectation on the current state on the expectation on *j*-period forward consumption volatility:

$$(E_{t+1} - E_t)\sigma^2_{S_{t+j+1}} = (\sigma_1^2 - \sigma_0^2)\lambda_1^j \eta_{t+1} \tag{3.24}$$

, where $\eta_{t+1} \equiv (E_{t+1} - E_t) S_{t+1} = Pr(S_{t+1} = 1 \mid \Psi_{t+1}) - Pr(S_{t+1} = 1 \mid \Psi_t)$ indicates the revision of the probability of being in the high volatility state.

We also assume that the economic agent cannot observe the consumption volatility states and instead infers them from other observable data by calculating the posterior probability of being in each state of the economy as a learning process. Therefore, η_{t+1} is obtained from the prediction and updating process of filtered probabilities in the Hamilton (1989) filter, rather than from the generated states in the Bayesian estimation process.

Third, we approximate the dynamics of the de-meaned state variables given by equation (3.19) as the stationary VAR(1) process and can represent its dynamics in the following form:

$$Z_{t+1} = A_0 + E_t(\sigma^2_{t+1}) A_1 + Z^*_{t+1}, \qquad Z^*_{t+1} = B Z^*_t + u_{t+1} \tag{3.25}$$

, where $A_0 \equiv \begin{pmatrix} a_{c,0} & a_{y,0} & a_{rs,0} & a_{pp,0} \end{pmatrix}'$ and $A_1 \equiv \begin{pmatrix} a_{c,1} & a_{y,1} & a_{rs,1} & a_{pp,1} \end{pmatrix}'$. Therefore, the revision of expectation on *j*-period forward values of the state variables takes a different form from equation (3.13) in the BKSY model:

$$(E_{t+1} - E_t)Z_{t+j+1} = (E_{t+1} - E_t)\{A_0 + E_{t+j}(\sigma^2_{t+j+1})A_1 + Z^*_{t+j+1}\} = B^j u_{t+1} + \lambda_1^j(\sigma_1^2 - \sigma_0^2)A_1\eta_{t+1} \qquad (3.26)$$

, where, in the right-hand side, the first term takes the same form as in the BKSY model, which delivers the innovation to current de-meaned state variables (u_{t+1}) to *j*-period forward de-meaned state variables, while the second term that does not appear in the BKSY model plays the role of transmitting the current shock to regime probabilities (η_{t+1}) to *j*-period forward means of state variables. It is worth noting that since the shock to regime probabilities affects the means of state variables through the agent's revision of the expectation on consumption volatility, they should be identified as another channel of consumption volatility risk in our model, regardless of whether they are included in cash flow risk or discount rate risk in the BKSY model.

Equation (3.26) indicates that all of risk channels in the BKSY model measured from the first moment of state variables include a part of the consumption volatility risk by the structure of our model. The only exception is the macroeconomic volatility risk $N_{V,t+1}$:

$$N_{V,t+1} \equiv (E_{t+1} - E_t)\sum_{j=1}^{\infty}\rho^j V_{t+j} = \frac{1}{2}(1-\gamma)^2\chi(E_{t+1} - E_t)\sum_{j=1}^{\infty}\rho^j\sigma^2_{t+j+1} = \frac{1}{2}(1-\gamma)^2\chi\kappa(\sigma_1^2 - \sigma_0^2)\eta_{t+1} \quad (3.27)$$

, where $\kappa \equiv \dfrac{\rho\lambda_1}{1-\rho\lambda_1}$ is the constant of the long-run responses from the shock to regime probabilities. Compared to equation (3.14) in the BKSY model, the macroeconomic volatility risk in our model does not contain the error term in the VAR(1) setting (u_{t+1}), because the innovation to the conditional consumption volatility does not stem from the shock to the realized variance, but from an unexpected change in regime probabilities (η_{t+1}), which accounts for a much weaker role of the consumption volatility risk in the determination of the equity premium as shown in Section 3.5.

For the identification of unobservable human capital return, we make an assumption about the relationship between expected human capital return, de-meaned state variables, and conditional consumption volatility:

$$E_t r_{H,t+1} = \alpha_0 + \alpha_1 E_t(\sigma_{t+1}^2) + \beta' Z_t^* \tag{3.28}$$

Using equations (3.26) and (3.28), we can derive the analytical solution for all other types of news as follows:

$$N_{C,t+1} \equiv (E_{t+1} - E_t) i_1' Z_{t+1} = i_1' u_{t+1} + (\sigma_1^2 - \sigma_0^2) i_1' A_1 \eta_{t+1} \tag{3.29}$$

$$N_{R,t+1}^S \equiv (E_{t+1} - E_t) i_3' Z_{t+1} = i_3' u_{t+1} + (\sigma_1^2 - \sigma_0^2) i_3' A_1 \eta_{t+1} \tag{3.30}$$

$$N_{DR,t+1}^S \equiv (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j i_3' Z_{t+j+1} = i_3' Q u_{t+1} + \kappa(\sigma_1^2 - \sigma_0^2) i_3' A_1 \eta_{t+1} \tag{3.31}$$

$$N_{DR,t+1}^H = (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j (\alpha_1 \sigma_{t+j+1}^2 + \beta' Z_{t+j}) = \beta' B^{-1} Q u_{t+1} + \alpha_1 \kappa(\sigma_1^2 - \sigma_0^2) \eta_{t+1} \tag{3.32}$$

$$N_{R,t+1}^H = N_{CF,t+1}^H - N_{DR,t+1}^H = \{i_2'(I_4 + Q) - \beta' B^{-1} Q\} u_{t+1} + (\sigma_1^2 - \sigma_0^2)\{(1+\kappa) i_2' A_1 - \alpha_1 \kappa\} \eta_{t+1} \tag{3.33}$$

$$N_{DR,t+1} = \{(1-\omega) i_3' + \omega \beta' B^{-1}\} Q u_{t+1} + \kappa(\sigma_1^2 - \sigma_0^2)\{(1-\omega) i_3' A_1 + \omega \alpha_1\} \eta_{t+1} \tag{3.34}$$

$$N_{CF,t+1} = \{(1-\omega) i_3' + \omega i_2'\}(I_4 + Q) u_{t+1} + (1+\kappa)(\sigma_1^2 - \sigma_0^2)\{(1-\omega) i_3' + \omega i_2'\} A_1 \eta_{t+1} \tag{3.35}$$

(See Appendix C.2 for details of the identification of α_1 and β.)

We can rewrite equations (3.34) and (3.35), considering that terms with the shock to regime probabilities (η_{t+1}) should be identified as the consumption volatility risk:

$$\mathbf{N_{DR,t+1}} = N_{DR,t+1} - N_{DR,t+1}^{\eta} \tag{3.36}$$

$$\mathbf{N_{CF,t+1}} = N_{CF,t+1} - N_{CF,t+1}^{\eta} \tag{3.37}$$

, where the notations in bold represent discount rate and cash flow news in our model, while $N^{\eta}_{DR,t+1}$ and $N^{\eta}_{CF,t+1}$ indicate terms with the shock to regime probabilities (η_{t+1}) in equations (3.34) and (35). Combining equations (7), (36) and (37), we can identify the consumption volatility risk $\mathbf{N_{V,t+1}}$ in our model as:

$$\mathbf{N_{V,t+1}} = -\gamma N^{\eta}_{CF,t+1} + N^{\eta}_{DR,t+1} + N_{V,t+1} \tag{3.38}$$

Therefore, the consumption volatility risk in our model is measured through three different channels (cash flow channel, discount rate channel, and macroeconomic volatility channel).

3.4 DATA AND ESTIMATION

3.4.1 *Data*

We use annual data from 1930 to 2015 to compare empirical results from our model and the BKSY model. Real consumption c_{t+1} is constructed from real per capita expenditures on nondurable goods and services and real labor income y_{t+1} from real per capita disposable personal income. They are extracted from U.S. Bureau of Economic Analysis interactive data system. We construct real aggregate stock return $r_{S,t+1}$ and price-dividend ratio pd_{t+1} from monthly returns with dividend and without dividend on the value-weighted portfolio of all NYSE, AMEX, NASDAQ, and ARCA stocks in the CRSP data, which are aggregated over each year for the construction of annual data. To construct price-total payout (dividends plus repurchases) ratio, we follow the methodology of Bansal, Dittmar, and Lundblad (2005). Appendix A.1 provides technical details of the construction of stock repurchase data. For the calculation of stock returns in excess of risk-free rate, monthly yields on 30-day U.S. Treasury bill are used. For the cross section analysis of stock returns, we extract monthly with-dividend and without-dividend returns on size- and book-to-market-sorted portfolios from Ken French's data library, which are also aggregated over each year for the construction of each portfolio's annual return, price-dividend ratio, price-total payout ratio, dividend growth rate, and total payout growth rate.

3.4.2 *Estimation Algorithm*

We generate both the parameters of our model and the unobserved Markov-switching variables from appropriate conditional distributions using Gibbs-sampling. The priors are identical across the different regimes. This implies that the features of the regimes are not restricted and that differences arise due to the data and the identification condition that the variance of (1,1)'th element in the error variance-covariance matrices $\Sigma_{S_{t+1}}$ is greater in higher volatility states ($\Sigma_0^{[1,1]} < \Sigma_1^{[1,1]}$). Appendix B.1 provides the description of the priors in detail.

The posterior distribution is obtained combining the likelihood function with the priors. Following Kim and Nelson (1998, 1999b), we employ a multi-move Gibbs sampling algorithm to draw from the posterior distribution. The Gibbs sampling proceeds with the following steps:

Step 1) Initialize A_0, A_1, B, Σ_0, Σ_1, p_{00}, and p_{11}.

Step 2) Generate $\tilde{S}_T$, using the multi-move Gibbs sampling proposed by Carter and Kohn (1994), conditional on $\tilde{Z}_T$, A_0, A_1, B, Σ_0, Σ_1, p_{00}, and p_{11}, where $\tilde{S}_T \equiv \{S_1, S_2, \cdots, S_t, \cdots, S_{T-1}, S_T\}$, $\tilde{Z}_T \equiv \{Z_1, Z_2, \cdots, Z_t, \cdots, Z_{T-1}, Z_T\}$, and T is the end of the sample period. $Pr(S_{t+1} = 1 | \Psi_{t+1})$ and $Pr(S_{t+1} = 1 | \Psi_t)$, which are used to calculate $E_t(\sigma_{t+1}^2)$ and η_{t+1}, are generated in Hamilton (1989) filter as a byproduct of generating $\tilde{S}_T$ in Carter and Kohn's (1994) multi-move Gibbs sampling.

Step 3) Generate A_0, A_1, and B, from the multivariate normal distribution, conditional on $\tilde{Z}_T$, $\tilde{S}_T$, Σ_0, and Σ_1. While generating B, discard the draws that violate the stationarity condition and redraw until the stationarity condition is satisfied.

Step 4) Generate Σ_0 and Σ_1 from the inverted Wishart distribution, conditional on $\tilde{Z}_T$, $\tilde{S}_T$, A_0, A_1, B. Discard the draws that violate the identification condition that $\Omega_0^{[1,1]} < \Omega_1^{[1,1]}$ and redraw until the identification condition is satisfied.

Step 5) Generate p_{00} and p_{11} from the beta distribution, conditional on $\tilde{S}_T$.

Step 6) Go to step 2 and repeat until we reach a total of 30,000 iterations.

After discarding the first 10,000 draws in the Gibbs simulation, the next 20,000 draws are used to derive the posterior distribution statistics such as means, medians, and standard errors. We employ medians of the next 20,000 draws to extract the values of news components which are presented in the form of tables and graphs in this chapter.

3.5 Empirical Results

3.5.1 *Preliminary Results*

We set the share of human wealth in the total wealth ω to 0.8, the average value used in Lustig and and van Nieuwerburgh (2008), while the elasticity of intertemporal substitution ψ is set to 2, following Gourio (2012), BKSY (2014), Collin-Dufresne, Johannes, and Lochstoer (2016). We use the degree of risk aversion γ which enables the model-implied equity premium for the aggregate stock index to fit the data (the average annual equity premium of 8.2% from 1930 to 2015).

We plot the model-implied equity premium for aggregate stock index against different degrees of risk aversion within a reasonable range for three different cases in Figure 3.1.[1] We find from Figure 3.1 that risk aversion of five and six can match the BKSY model-implied equity premium with the observed excess return for aggregate stock index when we use price-dividend ratio and price-total payout ratio in the BKSY model, respectively. However, a higher risk aversion of nine is required in our proposed model with price-total payout ratio. Unless otherwise stated, risk aversion is set to the level that allows each model-implied equity premium for the aggregate stock index to fit the data.

Before we document empirical results in our proposed model in comparison with those of the BKSY model, we check whether replacing price-dividend ratio with price-total payout ratio in the BKSY model can produce some significant changes in the level of risk premium and roles of each of risk channels in determining the equity premium as a preliminary step.

As shown in Table 3.1, the use of price-total payout ratio instead of price-dividend ratio weakens the role of the macroeconomic volatility channel in the equity premium in a non-negligible manner. At a risk aversion of five, the BKSY model derives 7.7% excess return for the aggregate stock index, using price-dividend ratio as one of state variables, while the model-implied equity premium decreases to 5.9%, using price-total payout ratio instead. The share of the macroeconomic volatility risk channel in the total equity premium also declines from 57% to 41% with the use of the adjusted price-dividend ratio. Out of five book-to-market- and five size-sorted portfolios, only two portfolios (growth portfolio and large cap portfolio) show a bigger contribution of the macroeconomic volatility risk to the excess return than the cash flow risk.

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[1] Mehra and Prescott (1985) and Bansal and Yaron (2004) argue that a reasonable upper bound for risk aversion is around 10.

Table 3.2 shows that a reduction in model-implied risk premium and a weaker role of the volatility risk channel are not restricted to the equity return. Risk premium from the macroeconomic volatility channel declines from 2.0% to 1.2% in the return to total wealth and from 1.4% to 0.9% in the return to human capital, while risk premium from the cash flow channel decreases in neither of two returns.

BKSY (2014) claim that the introduction of time-varying macroeconomic volatility can reverse a negative correlation between equity and human capital returns documented by Lustig and van Nieuwerburgh (2008) and Chen, Favilukis, and Ludvigson (2013). The use of price-total payout ratio in the BKSY model makes their claim somewhat questionable as shown in Table 3.3. Table 3.3 shows that, when price-total payout ratio is included in the set of state variables, the correlation between stock and labor returns is made ambiguous even in the BKSY setting. In the long-run, equity and labor returns show a negative correlation, while they exhibit no correlation in the shorter-run.

Therefore, we can conclude that a sizable risk premium carried by the macroeconomic volatility channel and a positive correlation between equity and labor returns from the BKSY model are partly attributable to the choice of price-dividend ratio as a predictor of stock return, which shows a non-stationary dynamics partly due to the measurement error. To avoid the measurement error from the use of price-dividend ratio, we employ price-total payout ratio as a predictor of stock return hereafter.

In Figure 3.2, we depict the estimated probabilities of each regime ($Pr(S_{t+1}=0\,|\,\psi_{t+1})$, $Pr(S_{t+1}=1\,|\,\psi_{t+1})$) against the NBER dating of recessions. Our inference on consumption volatility states are broadly consistent with Lettau, Ludvigson, and Wachter (2008), who report a sustained rise in asset prices in 1990s as a result of persistent decline in consumption volatility during the period.

Table 3.4 provides the marginal posterior distributions of the parameters in our proposed model. Parameters whose 95% posterior bands do not contain zero are regarded as being statistically different from zero at the 5% significance level. It is worth noting that all of coefficients relating expected level of consumption volatility and means of the state variables are less than zero and statistically different from zero at the 5% significance level. Therefore, when the economic agent assigns a higher probability of being in the high volatility state, means of consumption, labor income, stock return, and price-total payout ratio decline. At the low volatility state, the standard deviation of consumption growth is 0.6%, while that of consumption growth at the high volatility state is 2.3%. At the high volatility state, other state variables as well as consumption growth show higher volatilities.

3.5.2 *News Components*

From this subsection, we compare the empirical results between the BKSY model and our proposed model, both of which use price-total payout ratio instead of price-dividend ratio as one of state variables in the VAR(1) setting. Since, from equations (3.7) and (3.8), the risk premium for an asset i is determined by the covariance between the asset i's return $r_{i,t+1}$ and stochastic discount factor m_{t+1}, which is decomposed into three types of news components ($N_{CF,t+1}$, $N_{DR,t+1}$, $N_{V,t+1}$), we look into the dynamic features of these three news components by plotting each of them over the whole sample period of 1930 to 2015 in Figure 3.3. A caveat with these news components is that we calculate them in our proposed model based on equations (3.36), (3.37), and (3.38), while using equations (3.15), (3.16), and (3.14) in the BKSY model.

In the top panel of Figure 3.3, we graphically represent observed value and expected value of the realized variance measured from the industrial output. The gap between these two values acts as the source of the macroeconomic volatility news in the BKSY model. The middle panel of Figure 3.3 shows the expected values of endogenously generated consumption volatility conditional upon the information available up to the current period and up to the previous period. The gap between these two values acts as the source of the consumption volatility news in our proposed model. We compare these two sources of the volatility news in the bottom panel of Figure 3.3, which clearly shows that the source of the consumption volatility news in our proposed model is much smoother than the source of the macroeconomic volatility news in the BKSY model.

The top panel of Figure 3.4 shows similar dynamic pattern of the cash flow news between the BKSY model and ours although we can notice a slightly higher variation of cash flow news in the proposed model. From the second panel of Figure 3.4, the discount rate news in our model move somewhat in the opposite direction to the discount rate news in the BKSY model, which accounts for a small negative risk premium from the discount rate risk channel in our model. The third panel shows a smoother movement in the consumption volatility news from the proposed model than the macroeconomic volatility news from the BKSY model. The lower variation of the consumption volatility news in our model is more evident after 1990's, which is characterized as the dominance of the low consumption volatility state as shown in Figure 3.2. We graphically represent the composition of the consumption volatility news from our model in the bottom panel of Figure 3.4. From equation (3.38), the consumption volatility news is measured from cash flow, discount rate, and macroeconomic volatility channels and the bottom panel of Figure 3.4 shows that the cash flow channel adds a bit of risk premium to the consumption volatility risk, although not enough to compensate for a sizable loss of risk premium from the macroeconomic volatility channel.

3.5.3 *Risk Premium and Roles of Risk Factors*

The use of price-total payout ratio instead of price-dividend ratio as one of state variables affects the determination of risk premium and the joint dynamics of returns to human capital and equity in the BKSY model in a non-negligible manner as shown in subsection 3.5.1. We reveal that the incorporation of endogenously generated consumption volatility with regime shifts into the BKSY model more significantly changes the implications for the risk premium and the joint dynamics of equity and labor returns.

We provide model-implied equity premium for the aggregate market index and five book-to-market- and five size-sorted portfolios from the BKSY model and our proposed model in Table 3.5, setting the risk aversion to the level that enables each of two models to fit the realized average excess return for the market index from 1930 to 2015 ($\gamma = 6$ in the BKSY model and $\gamma = 9$ in the proposed model). In the BKSY model, the model-implied equity premium for the market index from the volatility risk is 3.8%, which still accounts for a sizeable share (46.9%) of the total equity premium, while the counterpart equity premium in our proposed model is 0.6%, only 7.5% of the total equity premium. On the other hand, the equity premium from the cash flow risk increases from 4.2% in the BKSY model to 7.6% in the proposed model, although most of this increase is attributable to a higher risk aversion in our model. The equity premium from the discount rate risk is still small in absolute value, but takes a negative sign in our model. The two models capture the cross-sectional dispersion in expected returns in a decent manner although each of them delivers different implications for the roles of cash flow and volatility risks in the cross-sectional equity premium. In the BKSY model, four out of ten portfolios exhibit a higher contribution of the volatility risk to the cross-sectional equity premium than the cash flow risk, while none of ten portfolios belongs to this category in our model (More specifically, the cash flow risk accounts for more than 70% of the cross-sectional equity premium for all of ten portfolios in the proposed model).

The increase in the risk premium from the cash flow and the decrease in the risk premium from the consumption volatility are not as evident in total wealth and labor returns as in equity return. In labor return in particular, the risk premium from the cash flow decreases from 1.2% in the BKSY model to 0.6% in the proposed model, although the share of the cash flow risk in the total risk premium for human capital rises from 37% to 41%. It is also worth noting that our model derives a lower risk premium for total wealth and human capital. The risk premium for total wealth and human capital are 4.3% and 3.4% in the BKSY model respectively, while the counterparts in our model are 2.8% and 1.5%, respectively.

3.5.4 *Equity and Human Capital Returns*

We find that, from the previous subsections, the size of the consumption volatility risk gets much smaller in our model than in the BKSY model due to a drastic decrease in the variation of the macroeconomic volatility news $N_{V,t+1}$. As a corollary, we reveal that the consumption volatility risk is not large enough to reverse a negative correlation between equity and human capital returns documented by Lustig and van Nieuwerburgh (2008) and Chen, Favilukis, and Ludvigson (2013), both of whom assume that consumption volatility is not time-varying. We show that the introduction of time-varying consumption volatility does not change their conclusion, which contradicts the claim of BKSY (2014).

The effect of the magnitude of the variation in the macroeconomic volatility news on the correlation between equity and labor returns is shown by BKSY (2014) as follows:

$$(E_{t+1}-E_t)\sum_{j=1}^{\infty}\rho^j \Delta c_{t+j+1} = \psi N_{DR,t+1} - \frac{\psi-1}{\gamma-1}N_{V,t+1} = \psi\{(1-\omega)N_{DR,t+1}^{S} + \omega N_{DR,t+1}^{H}\} - \frac{\psi-1}{\gamma-1}N_{V,t+1} \quad (3.39)$$

, which is obtained from combining equations (3.4), (3.6), and (3.15). We can infer from equation (3.39) that, given a much lower variation of consumption growth than stock return and a positive correlation between the macroeconomic volatility news $N_{V,t+1}$ and the market discount rate news $N_{DR,t+1}^{S}$, a high variation in the macroeconomic volatility news enables a correlation between $N_{DR,t+1}^{S}$ and $N_{DR,t+1}^{H}$ to take a positive value, one of typical examples for which is a positive correlation between equity and labor returns in the BKSY model using price-dividend ratio as shown in Table 3.3.

We provide the comparison of correlations among equity, total wealth, and labor returns between the BKSY model and the proposed model in Table 3.7. In our model, equity return and labor return show negative correlations, regardless of the length of the horizon of interest when we use price-total payout ratio as one of state variables. Therefore, we can conclude that whether equity and human capital returns are positively correlated does not depend on the introduction of time-varying consumption volatility, but on its magnitude of the variation, which is revealed to be too small to produce a positive correlation between equity and labor returns by our model.

3.6 CONCLUSION

We reveal that the main claim of BKSY (2014) that the macroeconomic volatility risk carries a sizable risk premium and equity and human capital returns are positively correlated when time-varying consumption volatility is incorporated is not strongly justified since their results are attributable to the use of price-dividend ratio with measurement error and excessively volatile measure of consumption volatility. Our use of price-total payout ratio with less measurement error instead of price-dividend ratio weakens the results of BKSY (2014) even within their framework in a non-negligible manner. We attempt to extend their model in a more fundamental way so that the consumption volatility, as a source of the volatility risk, is generated endogenously within the model. In our proposed model, the consumption volatility risk is measured through three different channels since the economic agent's revision of expectation on consumption volatility states affect directly macroeconomic volatility channel and indirectly both cash flow and discount rate channels. Although the diversified channels add a bit of risk premium to the consumption volatility risk, the risk premium carried by the consumption volatility risk significantly decreases since the variation of endogenously generated consumption volatility is much smaller than that of exogenously realized variance measure employed by BKSY (2014). In our model, most of the equity premium for aggregate market index and book-to-market- and size-sorted portfolios is explained by the cash flow risk, while the role of the consumption volatility risk in the total equity premium gets much weaker. We also show that equity and human capital returns are negatively correlated even when the time-varying consumption volatility is incorporated.

So far, we have implicitly assumed that the economy has a representative economic agent and her consumption can be well represented by the aggregate consumption data we employ. Mankiw and Zeldes (1991) and Vissing-Jorgensen (2002) emphasize that not everyone owns stocks and that stock prices are determined by stockholders, not all households. They explore the role of limited stock market participation in explaining stock return data. Because the estimation and testing of limited participation models requires disaggregated, household-level data that often has a short time-series dimension and is subject to significant measurement error, the literature has progressed slowly in evaluating these models empirically relative to the representative economic agent formulations. Given further progress in this strand of study, we leave these subjects for our future research.

3.7 TABLES AND FIGURES

Table 3.1: Model-Implied Equity Premium for Aggregate Index and Portfolios (BKSY Model)

Equity Premium Level (%)

	Data	Price-Dividend Ratio				Price-Total Payout Ratio			
		Total	CF	DR	VOL	Total	CF	DR	VOL
Market	8.20	7.74	2.94	0.28	4.40	5.88	3.49	-0.01	2.40
BM1	7.63	8.25	2.48	0.45	5.26	6.40	2.41	0.25	3.75
BM2	8.11	8.75	3.14	0.36	5.17	6.42	3.21	0.08	3.14
BM3	9.65	9.17	4.42	0.18	4.52	7.18	4.43	-0.05	2.82
BM4	10.74	10.83	6.62	-0.03	4.21	8.98	6.64	-0.26	2.65
BM5	13.87	12.90	10.31	-0.43	3.25	12.13	10.20	-0.54	2.67
Size1	14.89	12.16	8.50	-0.16	4.01	10.77	8.36	-0.31	2.94
Size2	13.05	12.39	6.23	0.20	5.91	9.64	6.12	-0.11	3.65
Size3	11.86	11.40	5.36	0.25	5.74	8.86	5.21	-0.02	3.67
Size4	10.67	9.48	3.97	0.28	5.11	7.00	3.91	0.01	3.09
Size5	7.75	7.51	2.95	0.26	4.23	5.81	2.86	0.08	2.90

Shares of Risk Factors in Total Equity Premium

	Data	Price-Dividend Ratio				Price-Total Payout Ratio			
		Total	CF	DR	VOL	Total	CF	DR	VOL
Market	8.20	100.0%	38.0%	3.6%	56.9%	100.0%	59.3%	-0.2%	40.9%
BM1	7.63	100.0%	30.0%	5.5%	63.7%	100.0%	37.7%	3.8%	58.6%
BM2	8.11	100.0%	35.9%	4.1%	59.1%	100.0%	49.9%	1.3%	48.9%
BM3	9.65	100.0%	48.2%	2.0%	49.3%	100.0%	61.8%	-0.7%	39.4%
BM4	10.74	100.0%	61.1%	-0.3%	38.9%	100.0%	73.9%	-2.9%	29.5%
BM5	13.87	100.0%	79.9%	-3.3%	25.2%	100.0%	84.1%	-4.4%	22.0%
Size1	14.89	100.0%	69.9%	-1.3%	33.0%	100.0%	77.7%	-2.9%	27.3%
Size2	13.05	100.0%	50.2%	1.7%	47.7%	100.0%	63.6%	-1.1%	37.9%
Size3	11.86	100.0%	47.1%	2.2%	50.3%	100.0%	58.8%	-0.2%	41.5%
Size4	10.67	100.0%	41.9%	3.0%	53.9%	100.0%	55.9%	0.1%	44.2%
Size5	7.75	100.0%	39.2%	3.5%	56.4%	100.0%	49.2%	1.4%	49.8%

Note: All the values above are derived from the medians for the 20,000 draws in the Gibbs simulation after the coefficient of risk aversion is set to $\gamma=5$ regardless of whether we use price-dividend ratio or price-total payout ratio in the BKSY model, and the elasticity of intertemporal substitution parameter is set to $\psi=2$. The "Data" column reports average excess returns for the corresponding portfolios during 1931-2015. "BM1" indicates a book-to-market sorted portfolio with the lowest book-to-market ratio (growth portfolio), while "BM5" indicates a book-to-market sorted portfolio with the highest book-to-market ratio (value portfolio). "Size 1" indicates a size sorted portfolio with the smallest market capitalization (small cap portfolio), while "Size 5" indicates a size sorted portfolio with the largest market capitalization (large cap portfolio).

Table 3.2: Model-Implied Risk Premium for Equity, Wealth and Labor Returns (BKSY Model)

	Risk Premium Level (%)		Shares of Risk Factors	
	Price-Dividend Ratio	Price-Total Payout Ratio	Price-Dividend Ratio	Price-Total Payout Ratio
Equity Return:	7.74	5.88	100.0%	100.0%
- Cash Flow Risk	2.94	3.49	38.0%	59.3%
- Discount Rate Risk	0.28	-0.01	3.6%	-0.2%
- Volatility Risk	4.40	2.40	56.9%	40.9%
Wealth Return:	3.65	2.77	100.0%	100.0%
- Cash Flow Risk	1.29	1.42	35.5%	51.4%
- Discount Rate Risk	0.10	0.02	2.7%	0.6%
- Volatility Risk	1.97	1.22	54.0%	44.0%
Labor Return:	2.60	1.98	100.0%	100.0%
- Cash Flow Risk	0.92	0.92	35.4%	46.6%
- Discount Rate Risk	0.06	0.03	2.2%	1.3%
- Volatility Risk	1.35	0.92	51.7%	46.6%

Note: All the values above are derived from the medians for the 20,000 draws in the Gibbs simulation after the coefficient of risk aversion is set to $\gamma=5$ regardless of whether we use price-dividend ratio or price-total payout ratio in the BKSY model, and the elasticity of intertemporal substitution parameter is set to $\psi=2$.

Table 3.3: Equity, Wealth, and Labor Return Correlations (BKSY Model)

	Price-Dividend Ratio	Price-Total Payout Ratio
Equity and Labor Return:		
- Immediate Shocks	0.23	0.00
- Discount Shocks	0.12	-0.33
- Five-Year Expectations	0.25	0.02
Equity and Wealth Return:		
- Immediate Shocks	0.74	0.66
- Discount Shocks	0.70	0.59
- Five-Year Expectations	0.70	0.69
Wealth and Labor Return:		
- Immediate Shocks	0.84	0.77
- Discount Shocks	0.89	0.69
- Five-Year Expectations	0.91	0.79

Note: All the values above are derived from the medians for the 20,000 draws in the Gibbs simulation after the coefficient of risk aversion is set to $\gamma=5$ and the elasticity of intertemporal substitution parameter is set to $\psi=2$. The "Immediate Shocks" row reports the correlations between unexpected returns. The "Discount Shocks" row reports the correlations between the revisions of expectations on future returns. The "Five-Year Expectations" row reports the correlations between the five-year expected returns.

Table 3.4: Posterior Distribution of Parameters (Proposed Model)

	Mean	Median	St. Dev.	95% Bands	
p_{00}	0.841	0.849	0.063	(0.718,	0.964)
p_{11}	0.830	0.835	0.064	(0.705,	0.955)
$a_{c,0}$	0.024	0.024	0.006	(0.011,	0.036)
$a_{y,0}$	0.026	0.026	0.009	(0.008,	0.043)
$a_{rs,0}$	0.095	0.095	0.030	(0.035,	0.154)
$a_{pp,0}$	3.733	3.728	0.318	(3.110,	4.356)
$a_{c,1}$	-19.959	-19.965	9.357	(-38.299,	-1.619)
$a_{y,1}$	-19.283	-19.245	9.097	(-37.113,	-1.453)
$a_{rs,1}$	-122.300	-122.217	55.337	(-230.760,	-13.839)
$a_{pp,1}$	-2,504.171	-2,508.368	694.230	(-3,864.861,	-1,143.481)
$b_{c,c}$	0.320	0.325	0.140	(0.045,	0.594)
$b_{c,y}$	0.061	0.059	0.083	(-0.102,	0.223)
$b_{c,rs}$	0.039	0.038	0.008	(0.023,	0.054)
$b_{c,pp}$	0.011	0.011	0.005	(0.001,	0.022)
$b_{y,c}$	0.022	0.030	0.345	(-0.654,	0.698)
$b_{y,y}$	0.301	0.296	0.206	(-0.102,	0.704)
$b_{y,rs}$	0.046	0.046	0.021	(0.006,	0.087)
$b_{y,pp}$	0.012	0.012	0.013	(-0.012,	0.037)
$b_{rs,c}$	-2.328	-2.329	2.035	(-6.317,	1.660)
$b_{rs,y}$	0.878	0.889	1.082	(-1.244,	3.000)
$b_{rs,rs}$	0.017	0.015	0.145	(-0.266,	0.301)
$b_{rs,pp}$	-0.044	-0.037	0.107	(-0.253,	0.165)
$b_{pp,c}$	-1.970	-1.973	3.177	(-8.197,	4.257)
$b_{pp,y}$	0.774	0.785	1.572	(-2.307,	3.855)
$b_{pp,rs}$	-0.227	-0.222	0.221	(-0.659,	0.205)
$b_{pp,pp}$	0.671	0.674	0.199	(0.280,	1.061)
$\Sigma_0^{[c,c]}$	0.00004	0.00004	0.00001	(0.00002,	0.00006)
$\Sigma_1^{[c,c]}$	0.00052	0.00050	0.00011	(0.00031,	0.00073)
$\Sigma_0^{[c,y]}$	0.00005	0.00005	0.00002	(0.00001,	0.00008)
$\Sigma_1^{[c,y]}$	0.00083	0.00081	0.00020	(0.00044,	0.00122)
$\Sigma_0^{[c,rs]}$	0.00031	0.00031	0.00017	(-0.00003,	0.00065)
$\Sigma_1^{[c,rs]}$	0.00155	0.00148	0.00073	(0.00012,	0.00298)
$\Sigma_0^{[c,pp]}$	0.00037	0.00036	0.00024	(-0.00009,	0.00083)
$\Sigma_1^{[c,pp]}$	0.00082	0.00078	0.00098	(-0.00110,	0.00275)
$\Sigma_0^{[y,c]}$	0.00005	0.00005	0.00002	(0.00001,	0.00008)

	Mean	Median	St. Dev.	95% Bands	
$\Sigma_1^{[y,c]}$	0.00083	0.00081	0.00020	(0.00044,	0.00122)
$\Sigma_0^{[y,y]}$	0.00051	0.00049	0.00011	(0.00030,	0.00072)
$\Sigma_1^{[y,y]}$	0.00252	0.00246	0.00054	(0.00145,	0.00359)
$\Sigma_0^{[y,rs]}$	-0.00005	-0.00005	0.00059	(-0.00121,	0.00111)
$\Sigma_1^{[y,rs]}$	0.00057	0.00052	0.00152	(-0.00240,	0.00354)
$\Sigma_0^{[y,pp]}$	0.00000	-0.00001	0.00076	(-0.00149,	0.00149)
$\Sigma_1^{[y,pp]}$	-0.00164	-0.00159	0.00213	(-0.00581,	0.00252)
$\Sigma_0^{[rs,c]}$	0.00031	0.00031	0.00017	(-0.00003,	0.00065)
$\Sigma_1^{[rs,c]}$	0.00155	0.00148	0.00073	(0.00012,	0.00298)
$\Sigma_0^{[rs,y]}$	-0.00005	-0.00005	0.00059	(-0.00121,	0.00111)
$\Sigma_1^{[rs,y]}$	0.00057	0.00052	0.00152	(-0.00240,	0.00354)
$\Sigma_0^{[rs,rs]}$	0.04700	0.04582	0.00922	(0.02893,	0.06507)
$\Sigma_1^{[rs,rs]}$	0.06065	0.05887	0.01220	(0.03673,	0.08457)
$\Sigma_0^{[rs,pp]}$	0.04441	0.04299	0.01039	(0.02403,	0.06478)
$\Sigma_1^{[rs,pp]}$	0.05505	0.05334	0.01423	(0.02716,	0.08294)
$\Sigma_0^{[pp,c]}$	0.00037	0.00036	0.00024	(-0.00009,	0.00083)
$\Sigma_1^{[pp,c]}$	0.00082	0.00078	0.00098	(-0.00110,	0.00275)
$\Sigma_0^{[pp,y]}$	0.00000	-0.00001	0.00076	(-0.00149,	0.00149)
$\Sigma_1^{[pp,y]}$	-0.00164	-0.00159	0.00213	(-0.00581,	0.00252)
$\Sigma_0^{[pp,rs]}$	0.04441	0.04299	0.01039	(0.02403,	0.06478)
$\Sigma_1^{[pp,rs]}$	0.05505	0.05334	0.01423	(0.02716,	0.08294)
$\Sigma_0^{[pp,pp]}$	0.07254	0.07035	0.01542	(0.04232,	0.10277)
$\Sigma_1^{[pp,pp]}$	0.11113	0.10676	0.02926	(0.05378,	0.16849)

Note: The first 10,000 draws in the Gibbs simulation are discarded, and then the next 20,000 draws are used to derive the posterior distribution statistics above.

Table 3.5: Model-Implied Equity Premium for Aggregate Index and Portfolios

Equity Premium Level (%)

	Data	BKSY Model				Proposed Model			
		Total	CF	DR	VOL	Total	CF	DR	VOL
Market	8.20	8.00	4.18	0.06	3.75	7.96	7.60	-0.39	0.60
BM1	7.63	9.09	2.90	0.36	5.86	6.74	4.86	-0.27	2.15
BM2	8.11	8.92	3.85	0.18	4.90	8.27	6.15	-0.33	2.40
BM3	9.65	9.74	5.32	0.04	4.41	10.63	8.62	-0.43	2.29
BM4	10.74	11.86	7.96	-0.17	4.14	14.51	13.17	-0.62	1.77
BM5	13.87	15.69	12.24	-0.45	4.17	18.01	21.12	-0.92	-1.98
Size1	14.89	14.10	10.03	-0.22	4.59	13.37	16.00	-0.71	-1.78
Size2	13.05	13.02	7.35	0.00	5.71	13.53	12.30	-0.62	1.87
Size3	11.86	12.08	6.25	0.09	5.74	11.82	10.23	-0.52	2.11
Size4	10.67	9.64	4.69	0.11	4.83	9.47	7.64	-0.41	2.26
Size5	7.75	8.11	3.43	0.17	4.52	7.52	5.59	-0.30	2.23

Shares of Risk Factors in Total Equity Premium

	Data	BKSY Model				Proposed Model			
		Total	CF	DR	VOL	Total	CF	DR	VOL
Market	8.20	100.0%	52.3%	0.7%	46.9%	100.0%	95.5%	-4.9%	7.5%
BM1	7.63	100.0%	31.9%	4.0%	64.5%	100.0%	72.1%	-4.0%	31.9%
BM2	8.11	100.0%	43.1%	2.0%	54.9%	100.0%	74.4%	-4.0%	29.0%
BM3	9.65	100.0%	54.6%	0.4%	45.3%	100.0%	81.1%	-4.0%	21.5%
BM4	10.74	100.0%	67.2%	-1.5%	34.9%	100.0%	90.8%	-4.3%	12.2%
BM5	13.87	100.0%	78.0%	-2.9%	26.6%	100.0%	117.2%	-5.1%	-11.0%
Size1	14.89	100.0%	71.2%	-1.6%	32.6%	100.0%	119.7%	-5.3%	-13.3%
Size2	13.05	100.0%	56.5%	0.0%	43.8%	100.0%	90.9%	-4.6%	13.8%
Size3	11.86	100.0%	51.8%	0.8%	47.5%	100.0%	86.6%	-4.4%	17.8%
Size4	10.67	100.0%	48.7%	1.1%	50.1%	100.0%	80.7%	-4.3%	23.9%
Size5	7.75	100.0%	42.3%	2.2%	55.8%	100.0%	74.4%	-4.0%	29.7%

Note: All the values above are derived from the medians for the 20,000 draws in the Gibbs simulation after the coefficient of risk aversion is set to γ =6 (BKSY model with price-total payout raio) and 9 (our model with price-total payout ratio), respectively and the elasticity of intertemporal substitution parameter is set to ψ =2. The “Data” column reports average excess returns for the corresponding portfolios during 1931-2015. “BM1” indicates a book-to-market sorted portfolio with the lowest book-to-market ratio (growth portfolio), while “BM5” indicates a book-to-market sorted portfolio with the highest book-to-market ratio (value portfolio). “Size 1” indicates a size sorted portfolio with the smallest market capitalization (small cap portfolio), while “Size 5” indicates a size sorted portfolio with the largest market capitalization (large cap portfolio).

Table 3.6: Model-Implied Risk Premium for Equity, Wealth and Labor Returns

	Risk Premium Level (%)		Shares of Risk Factors	
	BKSY Model	Proposed Model	BKSY Model	Proposed Model
Equity Return:	8.00	7.96	100.0%	100.0%
- Cash Flow Risk	4.18	7.60	52.3%	95.5%
- Discount Rate Risk	0.06	-0.39	0.7%	-4.9%
- Volatility Risk	3.75	0.60	46.9%	7.5%
Wealth Return:	4.30	2.76	100.0%	100.0%
- Cash Flow Risk	1.82	1.99	42.2%	72.1%
- Discount Rate Risk	0.08	-0.10	1.8%	-3.5%
- Volatility Risk	2.24	0.76	52.1%	27.4%
Labor Return:	3.35	1.47	100.0%	100.0%
- Cash Flow Risk	1.24	0.60	37.1%	40.9%
- Discount Rate Risk	0.08	-0.02	2.4%	-1.5%
- Volatility Risk	1.85	0.78	55.3%	52.8%

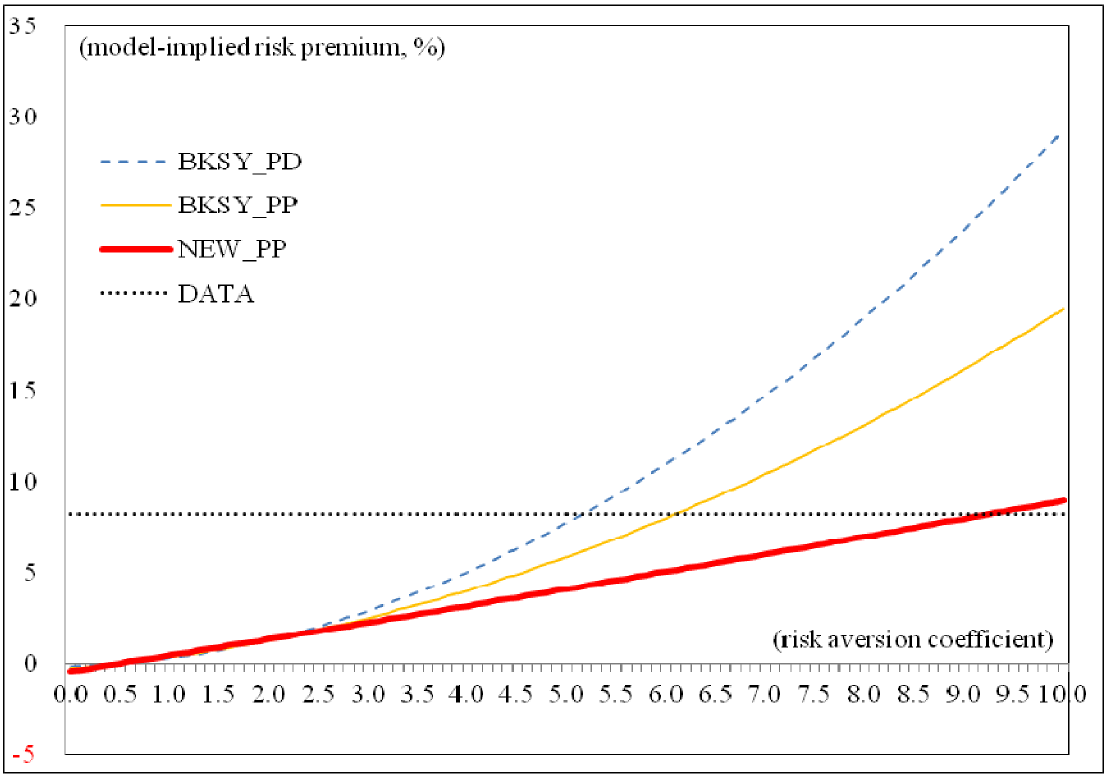
Note: All the values above are derived from the medians for the 20,000 draws in the Gibbs simulation after the coefficient of risk aversion is set to γ =6 (BKSY model with price-total payout raio) and 9 (our model with price-total payout ratio), respectively and the elasticity of intertemporal substitution parameter is set to ψ =2.

Table 3.7: Equity, Wealth, and Labor Return Correlations

	BKSY Model	Proposed Model
Equity and Labor Return:		
- Immediate Shocks	0.09	-0.33
- Discount Shocks	-0.15	-0.59
- Five-Year Expectations	0.16	-0.62
Equity and Wealth Return:		
- Immediate Shocks	0.66	0.62
- Discount Shocks	0.63	-0.06
- Five-Year Expectations	0.71	0.00
Wealth and Labor Return:		
- Immediate Shocks	0.82	0.54
- Discount Shocks	0.77	0.89
- Five-Year Expectations	0.85	0.85

Note: All the values above are derived from the medians for the 20,000 draws in the Gibbs simulation after the coefficient of risk aversion is set to γ =6 (BKSY model with price-total payout raio) and 9 (our model with price-total payout ratio), respectively and the elasticity of intertemporal substitution parameter is set to ψ =2. The "Immediate Shocks" row reports the correlations between unexpected returns. The "Discount Shocks" row reports the correlations between the revisions of expectations on future returns. The "Five-Year Expectations" row reports the correlations between the five-year expected returns.

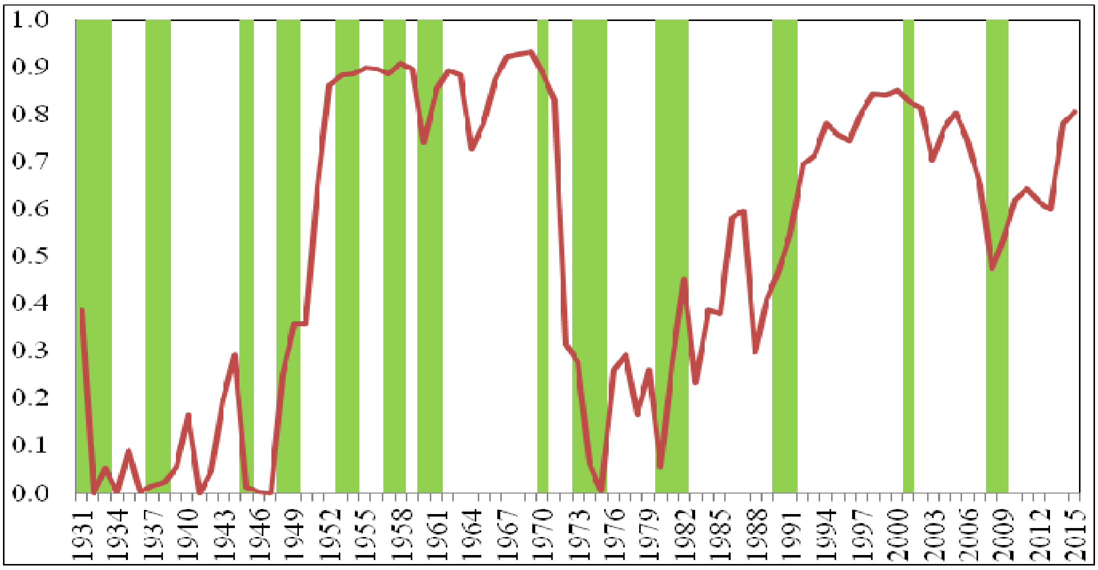
Figure 3.1: Model-Implied Equity Premium for Aggregate Index and Risk Aversion



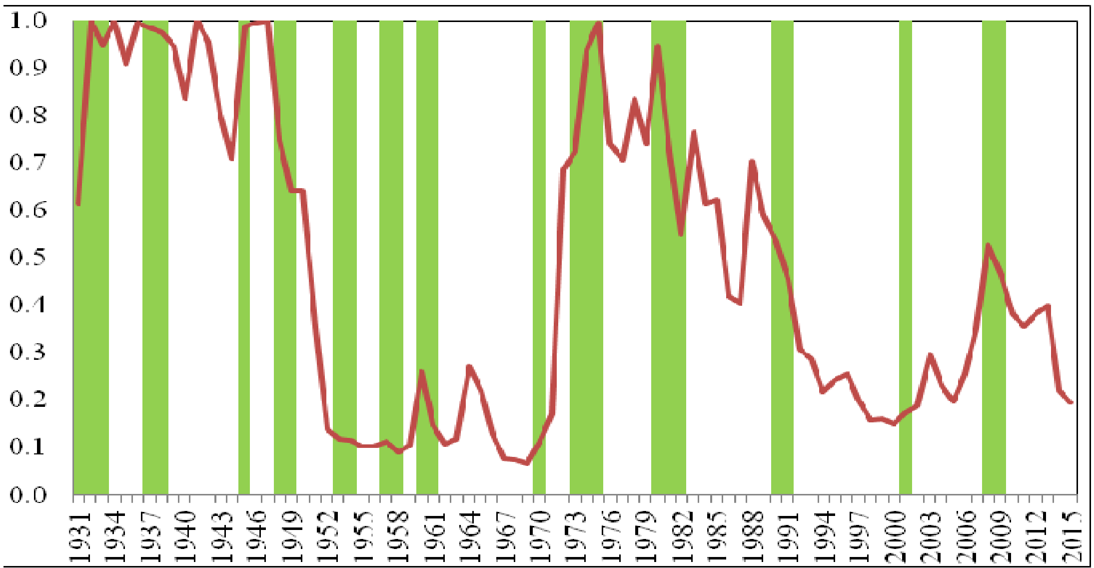
Note: All the graphs above are plotted from the medians for the 20,000 draws in the Gibbs simulation. "DATA" (8.2%) represents an average annual excess return for the value-weighted CRSP index during 1930-2015. "BKSY_PD", "BKSY_PP", and "NEW_PP" refer to model-implied equity premium from the BKSY model using price-dividend ratio, from the BKSY model using price-total payout ratio, and from our proposed model using price-total payout ratio, respectively.

Figure 3.2: Estimated Regime Probabilities (Gibbs-Sampling)

Low Consumption Volatility State: $Pr(S_{t+1}=0|\psi_{t+1})$



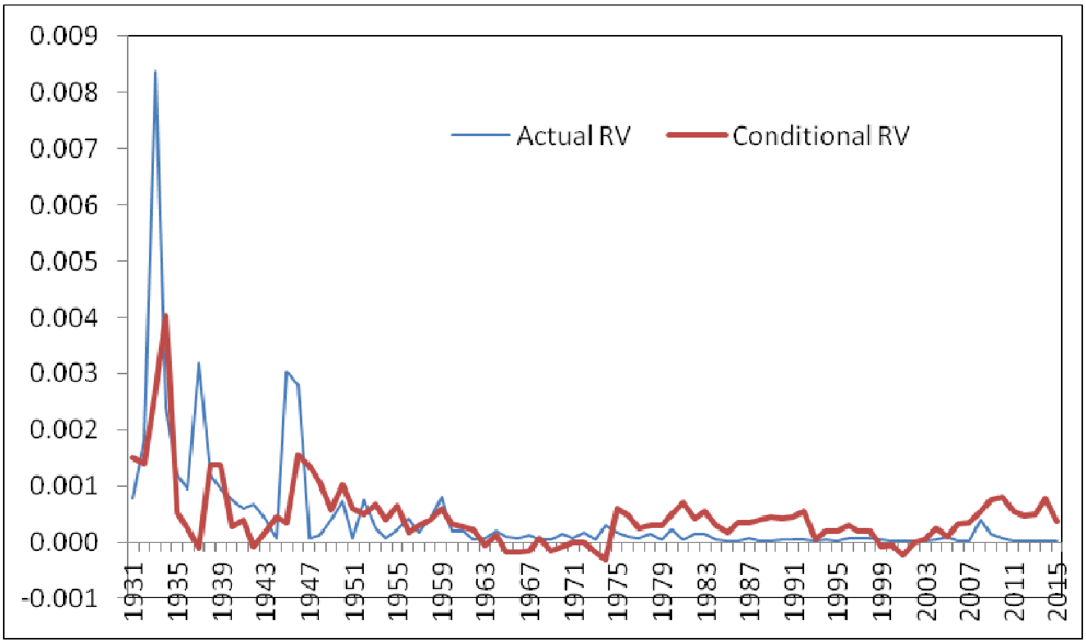
High Consumption Volatility State: $Pr(S_{t+1}=1|\psi_{t+1})$



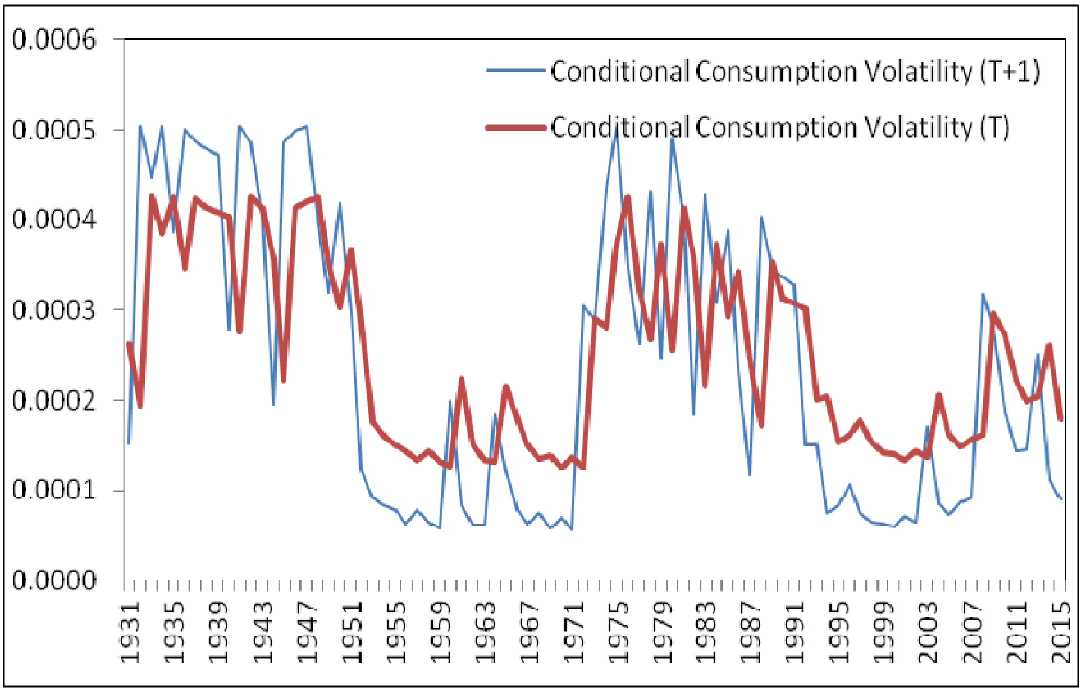
Note: The shaded areas represent the NBER dating of recessions.

Figure 3.3: Realized Variance vs. Conditional Consumption Volatility

Actual Realized Variance vs. Conditional Realized Variance



Conditional Consumption Volatility



Shock from Volatility Channel

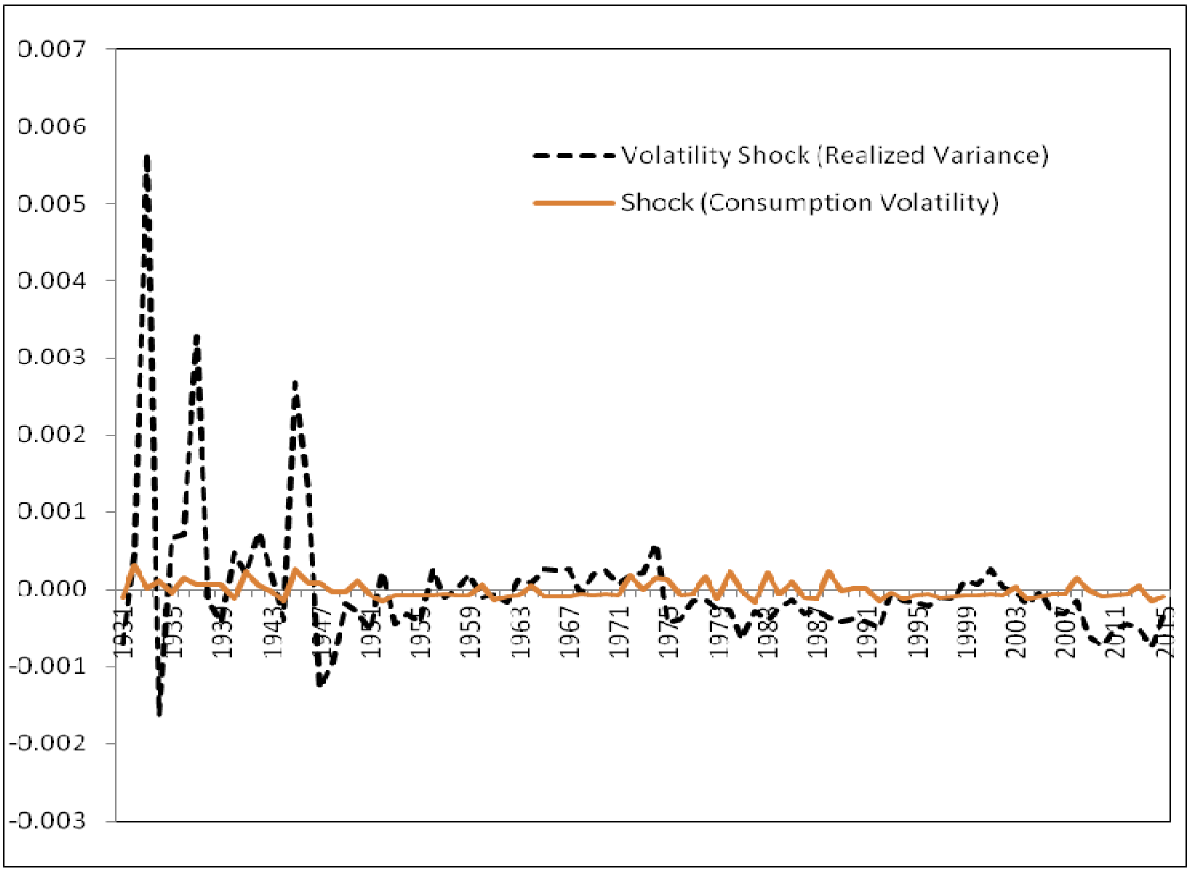
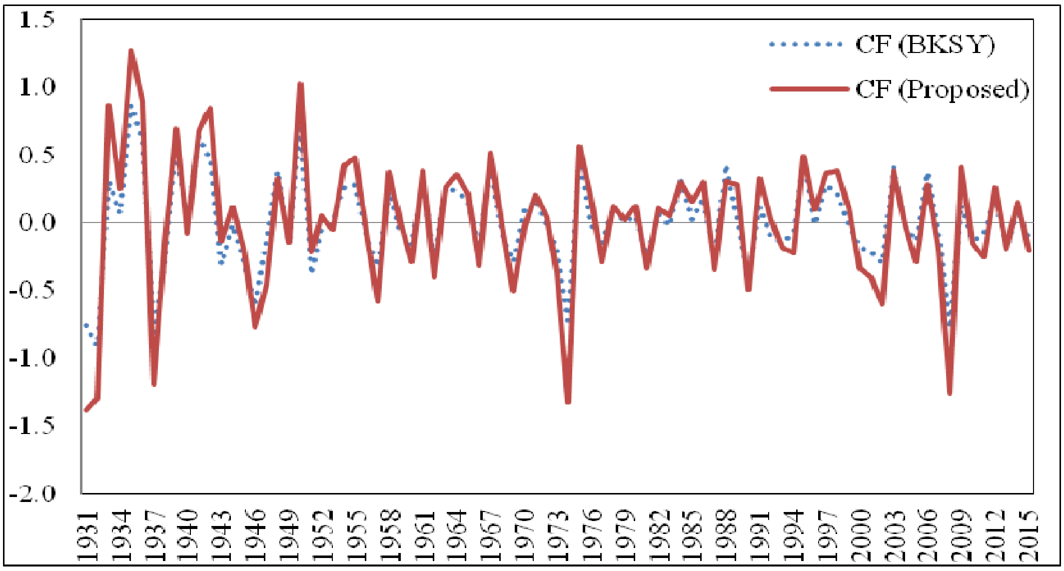
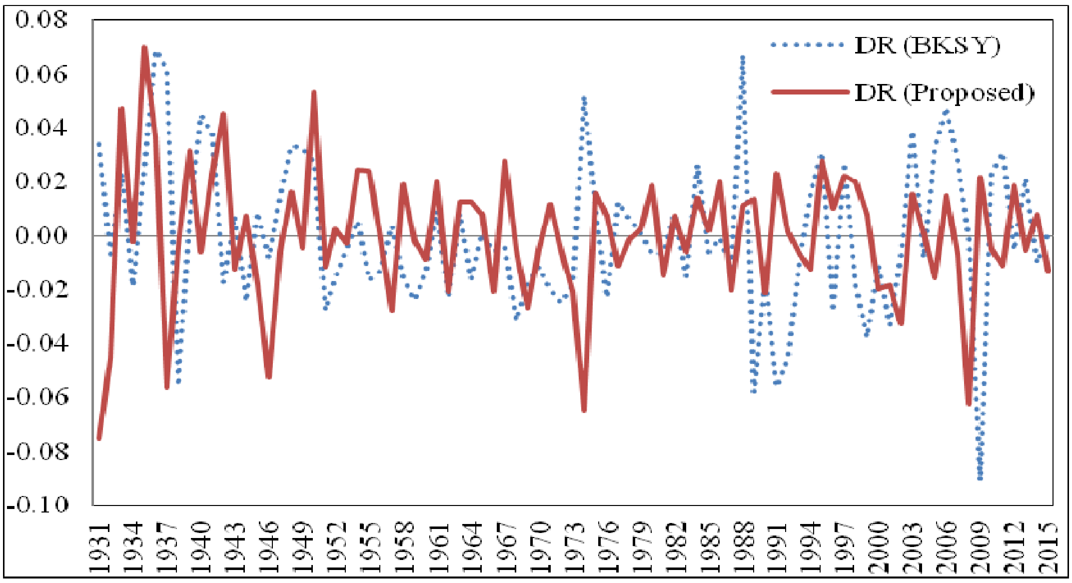


Figure 3.4: Cash Flow, Discount Rate, and Volatility News

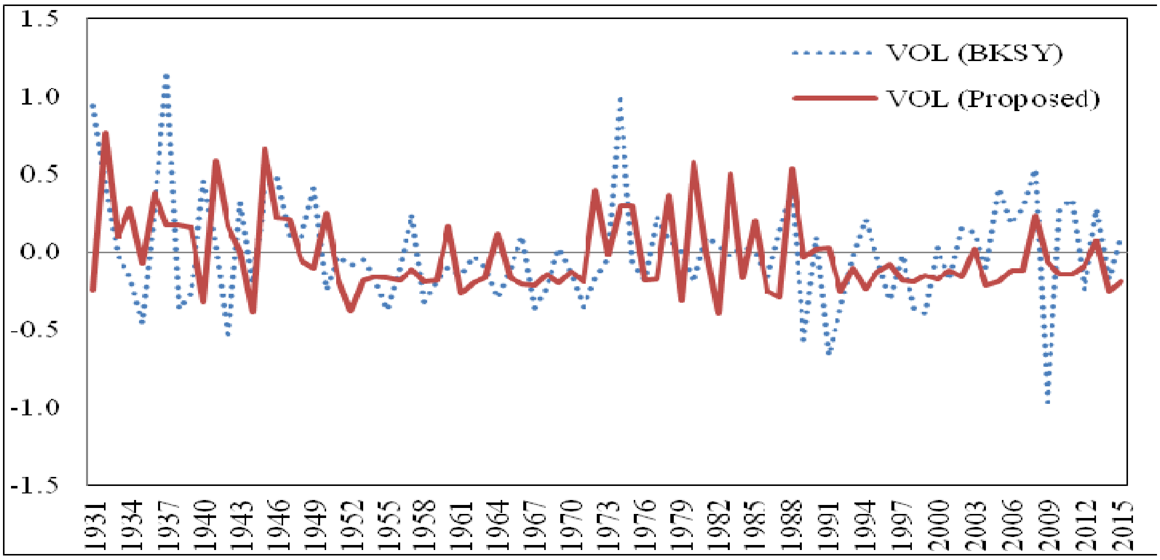
Cash Flow News (BKSY Model vs. Proposed Model)



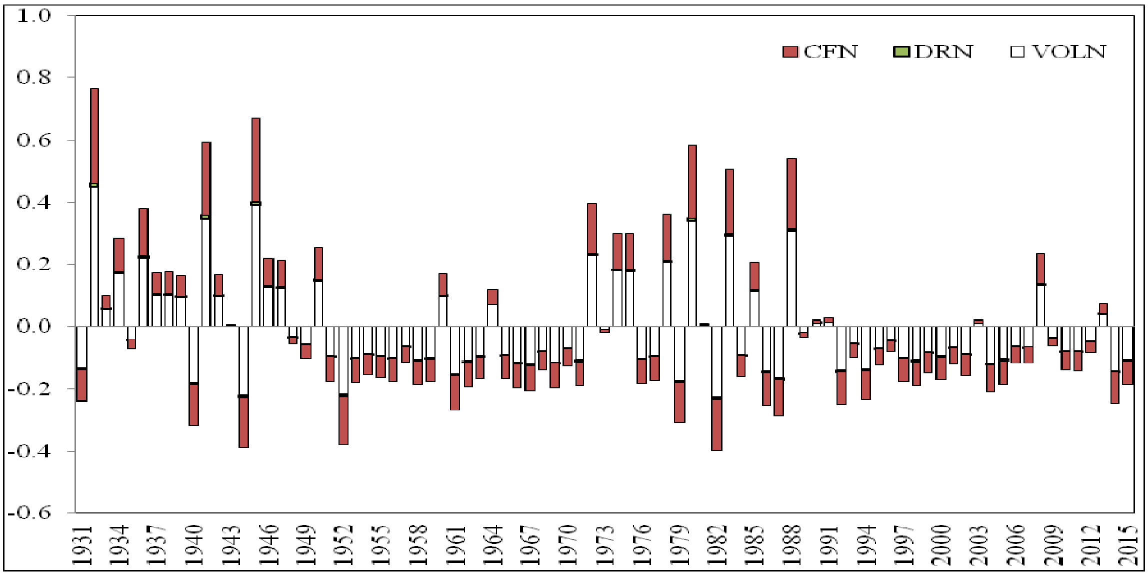
Discount Rate News (BKSY Model vs. Proposed Model)



Volatility News (BKSY Model vs. Proposed Model)



Composition of Consumption Volatility News (Proposed Model)



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APPENDIX A. APPENDIX TO CHAPTER 1

A.1 CONSTRUCTION OF DIVIDENDS AND REPURCHASES SERIES

We follow the methodology of Bansal, Dittmar, and Lundblad (2005) to construct dividend and repurchase series. We collect cum-dividend return (RET) and ex-dividend return (RETX) of each firm for every month and construct aggregate monthly series by calculating monthly weighted averages after assigning each weight by market capitalization for the previous month.

Let RET_t, $RETX_t$, P_t, D_t denote cum-dividend return, ex-dividend return, price and dividend, respectively. Then, subtracting ex-dividend return from cum-dividend return and normalizing initial price $P_0 = 1$ makes it possible to construct dividend and price series:

$$RET_{t+1} \equiv \frac{P_{t+1} + D_{t+1}}{P_t} \tag{A.1}$$

$$RETX_{t+1} \equiv \frac{P_{t+1}}{P_t} \tag{A.2}$$

$$RET_{t+1} - RETX_{t+1} \equiv \frac{D_{t+1}}{P_t} \tag{A.3}$$

When firms repurchase stocks, shareholders receive cash by the amount of repurchases, but their capital gain should decrease as much since some of them sold their stocks. We can construct the adjusted capital gain series for a given firm ($RETX_{t+1}^A$) as follows:

$$RETX_{t+1}^A = \left[\frac{P_{t+1}}{P_t}\right] \min\left[\frac{n_{t+1}}{n_t}, 1\right] \tag{A.4}$$

, where n_t is the number of shares after adjusting for splits and stock dividends, using the CRSP share adjustment factor (CFACSHR). Repurchase and total payout (dividends plus repurchases) is calculated by subtracting the adjusted capital gain from the cum-dividend return:

$$RET_{t+1} - RETX^{A}_{t+1} \equiv \frac{D_{t+1} + REP_{t+1}}{P_t} \tag{A.5}$$

, where we denote stock repurchase series as REP_{t+1}.

APPENDIX B. APPENDIX TO CHAPTER 2

B.1 PRIORS FOR THE BAYESIAN ESTIMATION

The priors for the VAR coefficients and the variance-covariance matrices are symmetric across regimes and are obtained from running the OLS regression for the first-order VAR equation without a regime change:

$$Z_{t+1} = A + BZ_t + u_{t+1}, \quad u_{t+1} \sim N(0,\Sigma) \tag{B.1}$$

, where we denote the standard deviation of *i*'th element of u_{t+1} by σ_i for $i \in \{1,\cdots,4\}$.

The priors for the VAR coefficients are:

$$\mathbf{B} \equiv vec\left(\begin{bmatrix} A_0 & B \end{bmatrix}'\right) \sim N(\mathbf{B}_0, S_0 \otimes N_0^{-1}) \tag{B.2}$$

, where $\mathbf{B}_0$ is the OLS estimates for $\mathbf{B}$ and $S_0 \equiv diag\left(\left\{\sigma_i^2\right\}_{i=1,\cdots,4}\right)$. As in Sims and Zha (1998), the variance of the prior distribution is specified by a number of hyperparameters that pin down N_0. Let λ be a 5×1 vector containing the hyperparameters. The diagonal elements of N_0^{-1} corresponding to autoregressive coefficients are given as $\left(\frac{\lambda_0 \lambda_1}{\sigma_j l^{\lambda_3}}\right)^2$ where $l \in \{1,2,\cdots,L\}$ denotes the lags in the VAR ($L=1$ or $L=4$ in this paper). The constant terms in N_0^{-1} are controlled by the term $(\lambda_0 \lambda_4)^2$. The choice for the hyperparameters are $\lambda_0 = 1$, $\lambda_1 = 1$, $\lambda_2 = 1$, $\lambda_3 = 1$, and $\lambda_4 = 1$.

The priors for the variance-covariance matrices and transition probabilities are described by the inverted Wishart distribution and the beta distribution with non-informative parameters, respectively:

$$\Sigma \sim IW(5, 5S_0) \tag{B.3}$$

$$p_{00} \sim beta(8,2), \quad p_{11} \sim beta(8,2) \tag{B.4}$$

APPENDIX C. APPENDIX TO CHAPTER 3

C.1 AN EXTENSION OF THE BKSY MODEL IN A THREE-STATE REGIME SHIFT

Choi, Kim, and Park (2017) consider the following three-state, first-order Markov switching process, S_{t+1}, with the transition probabilities:

$$\Pr[S_{t+1} = j \mid S_t = i] \equiv p_{ij}, \quad \sum_{j=0}^{2} p_{ij} = 1, \quad i, j \in \{0,1,2\} \tag{C.1}$$

Then, by defining

$$S_{j,t+1} = \begin{cases} 1, & S_{t+1} = j, \quad j = 0,1,2 \\ 0 & otehrwise \end{cases} \tag{C.2}$$

, they derive the following result:

$$\begin{bmatrix} S_{0,t+1} \\ S_{1,t+1} \\ S_{2,t+1} \end{bmatrix} = \begin{bmatrix} p_{00} & p_{10} & p_{20} \\ p_{01} & p_{11} & p_{21} \\ p_{02} & p_{12} & p_{22} \end{bmatrix} \begin{bmatrix} S_{0,t} \\ S_{1,t} \\ S_{2,t} \end{bmatrix} + \begin{bmatrix} v_{0,t+1} \\ v_{1,t+1} \\ v_{2,t+1} \end{bmatrix} \tag{C.3}$$

$$(S_{t+1}^{*} = P^{*} S_t^{*} + v_{t+1}^{*})$$

, where v_{t+1}^{*} is a vector of martingale difference sequences. Because $\sum_{j=0}^{2} S_{j,t} = 1$, they rewrite equation (C.3) as:

$$\begin{bmatrix} S_{1,t+1} \\ S_{2,t+1} \end{bmatrix} = \begin{bmatrix} p_{01} \\ p_{02} \end{bmatrix} + \begin{bmatrix} (p_{11} - p_{01}) & (p_{21} - p_{01}) \\ (p_{12} - p_{02}) & (p_{22} - p_{02}) \end{bmatrix} \begin{bmatrix} S_{1,t} \\ S_{2,t} \end{bmatrix} + \begin{bmatrix} v_{1,t+1} \\ v_{2,t+1} \end{bmatrix} \tag{C.4}$$

$$(\tilde{S}_{t+1} = \tilde{p}_0 + \tilde{\lambda} \tilde{S}_t + \tilde{v}_{t+1})$$

By taking expectations on both sides of equation (A.4), they obtain:

$$\tilde{\pi} = \tilde{p}_0 + \tilde{\lambda} \tilde{\pi} \tag{C.5}$$

, where $\tilde{\pi} = (I_2 - \tilde{\lambda})^{-1} \tilde{p}_0$ is a vector of unconditional probabilities. Then, by subtracting (C.5) from (C.4), they obtain the following VAR(1) representation for $\tilde{S}_{t+1}$:

$$\tilde{S}_{t+1} = \tilde{\pi} + \tilde{\lambda}(\tilde{S}_t - \tilde{\pi}) + \tilde{\nu}_{t+1} \tag{C.6}$$

Using the VAR(1) dynamics for the de-meaned $\tilde{S}_{t+1}$, we can express the revision of the expectation on *j*-period forward states $\tilde{S}_{t+j+1}$ in terms of the revision of the expectation on the current states $\tilde{S}_{t+1}$ as follows:

$$(E_{t+1} - E_t)\tilde{S}_{t+j+1} = \tilde{\lambda}^j (E_{t+1} - E_t)\tilde{\eta}_{t+1} \tag{C.7}$$

, where $\tilde{\eta}_{t+1} \equiv (E_{t+1} - E_t)\tilde{S}_{t+1}$ is the revision of the expectation on the current states. We specify the regime-dependent consumption volatility as follows:

$$\sigma^2_{S_{t+1}} = \sigma_0^2 + (\sigma_1^2 - \sigma_0^2)S_{1,t+1} + (\sigma_2^2 - \sigma_0^2)S_{2,t+1} \equiv \sigma_0^2 + \widetilde{\sigma^2}' \tilde{S}_{t+1} \tag{C.8}$$

, where σ_j^2 is consumption volatility at state $j \in \{0,1,2\}$ and $\widetilde{\sigma^2} \equiv \left[(\sigma_1^2 - \sigma_0^2) \quad (\sigma_2^2 - \sigma_0^2) \right]'$.

Combining equation (C.7) and equation (C.8), we can obtain the effect of a shock to the expectation on the current state on the revision of the expectation on *j*-period forward consumption volatility:

$$(E_{t+1} - E_t)\sigma^2_{t+j+1} = \widetilde{\sigma^2}' \tilde{\lambda}^j \tilde{\eta}_{t+1} \tag{C.9}$$

Equation (3.26), which provides the analytical solution for the revision of expectation on *j*-period forward value of the state variables in a two-state regime shift, is extended to a three-state regime shift as follows:

$$(E_{t+1} - E_t)Z_{t+j+1} = (E_{t+1} - E_t)\{A_0 + E_{t+j}(\sigma^2_{t+j+1})A_1 + Z^*_{t+j+1}\} = B^j u_{t+1} + A_1 \widetilde{\sigma^2}' \tilde{\lambda}^j \tilde{\eta}_{t+1} \tag{C.10}$$

Using equation (C.9) and (C.10), we can derive the analytical solution for all types of news as follows:

$$N_{V,t+1} \equiv (E_{t+1} - E_t)\sum_{j=1}^{\infty}\rho^j V_{t+j} = \frac{1}{2}(1-\gamma)^2 \chi (E_{t+1} - E_t)\sum_{j=1}^{\infty}\rho^j \sigma^2_{t+j+1} = \frac{1}{2}(1-\gamma)^2 \chi \widetilde{\sigma^2}' \tilde{\kappa}\tilde{\eta}_{t+1} \quad \text{(C.11)}$$

, where $\tilde{\kappa} \equiv (I_2 - \rho\tilde{\lambda})^{-1}\rho\tilde{\lambda}$ is the matrix of the long-run responses from the shock to regime probabilities.

$$N_{C,t+1} \equiv (E_{t+1} - E_t) i_1' Z_{t+1} = i_1' u_{t+1} + i_1' A_1 \widetilde{\sigma^2}' \tilde{\eta}_{t+1} \quad \text{(C.12)}$$

$$N^S_{R,t+1} \equiv (E_{t+1} - E_t) i_3' Z_{t+1} = i_3' u_{t+1} + i_3' A_1 \widetilde{\sigma^2}' \tilde{\eta}_{t+1} \quad \text{(C.13)}$$

$$N^S_{DR,t+1} \equiv (E_{t+1} - E_t)\sum_{j=1}^{\infty}\rho^j i_3' Z_{t+j+1} = i_3' Q u_{t+1} + i_3' A_1 \widetilde{\sigma^2}' \tilde{\kappa}\tilde{\eta}_{t+1} \quad \text{(C.14)}$$

$$N^H_{DR,t+1} = (E_{t+1} - E_t)\sum_{j=1}^{\infty}\rho^j (\alpha_1 \sigma^2_{t+j+1} + \beta' Z_{t+j}) = \beta' B^{-1} Q u_{t+1} + \alpha_1 \widetilde{\sigma^2}' \tilde{\kappa}\tilde{\eta}_{t+1} \quad \text{(C.15)}$$

$$N^H_{R,t+1} = N^H_{CF,t+1} - N^H_{DR,t+1} = \{i_2'(I_4 + Q) - \beta' B^{-1} Q\} u_{t+1} + \{i_2' A_1 \widetilde{\sigma^2}' (I_2 + \tilde{\kappa}) - \alpha_1 \widetilde{\sigma^2}' \tilde{\kappa}\}\tilde{\eta}_{t+1} \quad \text{(C.16)}$$

$$N_{DR,t+1} = \{(1-\omega) i_3' + \omega\beta' B^{-1}\} Q u_{t+1} + \{(1-\omega) i_3' A_1 + \omega\alpha_1\}\widetilde{\sigma^2}' \tilde{\kappa}\tilde{\eta}_{t+1} \quad \text{(C.17)}$$

$$N_{CF,t+1} = \{(1-\omega) i_3' + \omega i_2'\}(I_4 + Q) u_{t+1} + \{(1-\omega) i_3' + \omega i_2'\} A_1 \widetilde{\sigma^2}' (I_2 + \tilde{\kappa})\tilde{\eta}_{t+1} \quad \text{(C.18)}$$

C.2 IDENTIFICATION OF THE VALUES OF α_1 AND β

Substituting equations (3.27), (3.29), (3.30), (3.33), and (3.34) into equation (3.4) and rearranging in terms of u_{t+1} and η_{t+1} gives us:

$$u_L u_{t+1} + \eta_L \eta_{t+1} = u_R u_{t+1} + \eta_R \eta_{t+1} \quad \text{(C.19)}$$

, where u_L is a coefficient for u_{t+1} on the left-hand side of equation (3.4), u_R for u_{t+1} on the right-hand side of equation (3.4), η_L for η_{t+1} on the left-hand side of equation (3.4), and η_R for

η_{t+1} on the right-hand side of equation (3.4). Assuming that the model-implied shocks to de-meaned consumption and to mean of consumption match the corresponding VAR consumption shocks, we can obtain:

$$u_L = u_R, \qquad \eta_L = \eta_R \tag{C.20}$$

From $u_L = u_R$, we can derive:

$$i_1^{'} = \{(1-\omega)i_3^{'} + \omega i_2^{'}(I_4 + Q) - \omega\beta^{'}B^{-1}Q\} + (1-\psi)(1-\omega)i_3^{'}Q + (1-\psi)\omega\beta^{'}B^{-1}Q \tag{C.21}$$

Solving equation (C.21) for β:

$$\beta^{'} = [(1-\omega)i_3^{'} - i_1^{'} + \omega i_2^{'}(I_4 + Q) + (1-\psi)(1-\omega)i_3^{'}Q](\psi\omega B^{-1}Q)^{-1} \tag{C.22}$$

From $\eta_L = \eta_R$, we can obtain:

$$i_1^{'}A_1 = (1-\omega)i_3^{'}A_1 + \omega i_2^{'}A_1(1+\kappa) - \omega\alpha_1\kappa + (1-\psi)(1-\omega)i_3^{'}A_1\kappa + (1-\psi)\omega\alpha_1\kappa + \frac{1}{2}(\psi-1)(\gamma-1)\chi\kappa \tag{C.23}$$

Solving equation (C.21) for α_1:

$$\alpha_1 = \{(1-\omega)i_3^{'}A_1 - i_1^{'}A_1 + \omega i_2^{'}A_1(1+\kappa) + (1-\psi)(1-\omega)i_3^{'}A_1\kappa + \frac{1}{2}(\psi-1)(\gamma-1)\chi\kappa\} / (\psi\omega\kappa) \tag{C.24}$$

VITA

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