

The Cross-Section of Stock Returns and Monetary Policy: The Roles of the Capital Market Imperfection and Interest Rate Channel¹

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Abstract

This study investigates whether monetary policy shocks identified from Bayesian estimation of New-Keynesian dynamic stochastic general equilibrium(DSGE) models are critical for understanding the risk premium in stock markets. As test assets, I use the cross-section of average returns on either the Fama-French 25 size and B/M sorted portfolios alone or with 30 industry portfolios. Empirical results reveal that the implied ICAPMs are at least comparable to or better than the Fama-French three-factor model for the periods of 1980 to 2004. In particular, the permanent monetary policy shocks to inflation target are crucial for capturing the value premium and part of industry risk premium once I account for the capital market imperfection endogenously in New-Keynesian models following the specifications proposed by Graeve (2006). The shocks to investment technology, as a main determinant of the external finance premium, are also important for understanding the value premium.

Keywords: Monetary Policy, New-Keynesian DSGE, ICAPM, Value Premium, Industry Risk Premium, Bayesian Estimation

JEL Classification: E32, E52, G12

1 Introduction

The stock market continuously watches and forms expectations about the Federal Reserve Board(Fed) decisions. It seems that investors in Wall Street take it for granted that the actions of the Fed have a considerable impact on stock market returns while there is controversy on the issue among macro-economists. Two crucial monetary transmission mechanisms have been suggested through which stock prices respond to monetary news. The first is the interest rate channel, which relates to economic activity primarily through consumption and investment since a cut in the borrowing cost should raise the quantity of funds demanded for investment and promotes the current over future consumption, which leads to an increase in economic activity. The second mechanism is the credit channel under the capital market imperfection assumption. When credit markets are tight, unanticipated monetary easing reduces the external finance premium which is a wedge between the external financing by issuing equity or debt and the internal financing by retaining earnings. Bernanke and Gertler (1989) argue that the effect of the capital market imperfection are largest in recessions, when weak balance sheets lead to higher costs of external finance, resulting in lower investment demand and reduced economic activity.

In recent empirical asset pricing studies, several researchers have confirmed that monetary policy shocks affect the future risk premium. Notably, Bernanke and Kuttner (2005) find that monetary policy shocks are important for understanding the risk premium using Campbell and Ammer (1993) type decomposition. Specifically, they find that unanticipated changes in monetary policy affect stock prices not so much by influencing expected dividends or the risk-free real interest rate, but rather by affecting the perceived riskiness of stocks. By employing the long-horizon regression methodology, Patelis (1997) finds that some portion of the observed predictability in excess returns in US stock market can be attributed to shifts in the monetary policy stance. Patelis relates his findings to the credit channel of monetary policy transmission (Bernanke and Gertler (1995)) and to the financial propagation mechanism (Bernanke and Gertler (1989)). By estimating a vector autoregressive(VAR) system that includes monthly equity returns, output growth, inflation, and the federal funds rate, Thorbecke (1997) finds that monetary policy shocks, measured by orthogonalized innovations in the federal funds rate, have a greater impact on smaller capitalization stocks, which is in line with the hypothesis that monetary policy affects firms' access to credit. Jensen, Mercer, and Johnson (1996) find that predictable variation in stock returns depends on monetary as well as business conditions, with expected stock returns being higher in tight money periods than in easy money periods. And business conditions could predict future stock returns only in periods of expansive monetary policy.

While there seems enough time-series evidence of the effect of monetary policy on stock returns, none of the papers investigates directly its implications on the cross-section of stock returns.¹ Fama (1991) conjectures that we should relate the cross-sectional properties of expected returns to the expected returns through time. In fact, since Merton (1973)'s theoretical presentation of the ICAPM, it has been recognized that there exist state variables that capture variations in future investment opportunities, and assets' covariations with such variables should be priced in the cross-section of average returns. Campbell (1996), Brennan, Wang, and Xia (2004), and Petkova (2006) build their models based on Merton (1973) in which only factors that forecast future investment opportunities or stock returns are admitted. From the time-series evidence of return forecastability of monetary policy instruments, it seems natural to investigate the effects of monetary policy on cross-section of stock returns.

In this paper, I examine whether monetary policy shocks extracted from New-Keynesian dynamic stochastic general equilibrium(DSGE) models can explain the cross sectional variability of U.S. stock returns. I employ New-Keynesian models since we must carefully identify monetary policy shocks. In fact, New-Keynesian models utilized in this paper have become benchmarks of much of the recent monetary policy literature since they can explain many stylized facts in monetary economics.² In addition, these models provide many interesting structural shocks. For example, a series of shocks to investment technology can be identified as a major determinant of the external finance premium. Recently, the implication of the capital market imperfection on cross section of stock returns are investigated by Hahn and Lee (2006). While they find that the size and the value premia are compensation for higher exposure to the risks related to changing credit market conditions and interest rates(monetary policy), their results should be cautiously interpreted since other hypotheses might be developed consistent with their measure of risks(yield spreads). In this sense, I can investigate directly whether the identified external finance premium shock is really a determinant for the size or value premium.

I develop the whole estimation procedures in Bayesian methods. After dividing the estimation steps into three blocks based on identifying assumptions frequently used in finance literature, I sequentially estimate each block by Bayesian Markov Chain Monte Carlo method(MCMC) and repeat those steps until every parameter converges. In the first block, I estimate New-Keynesian models using DYNARE-Matlab package. First, I use three different versions of linearized Rational Expectations models consisting of AS, IS and monetary policy rule equations proposed by Cho and Moreno (2006).

¹Some empirical asset pricing studies(e.g.Hahn and Lee (2006)) using cross section of stock returns seem to interpret that significant risk price of the short term interest rate or term spread exists since it is a proxy for monetary policy.

²I summarize the stylized facts in monetary economics and the failure of models before New-Keynesian models in appendix A

Their models are parsimonious yet rich enough to capture the macro dynamics of inflation, real GDP growth and the Federal funds rate.³ Second, I use an extended version of Smets and Wouters (2005) model proposed by Graeve (2006) to precisely uncover the importance of the external finance premium and the permanent monetary policy shock. Finally, as a robustness check for my analysis, I use the structural shocks estimated from factor-augmented vector autoregressive model (FAVAR) of Bernanke, Boivin, and Elias (2005) since results from that model could be robust to model misspecifications and small data set problems. In the second and the third blocks, I estimate the posterior distributions of risks and the risk prices with identified structural shocks. I also calculate the posterior densities of several diagnostic measures for model comparison.

Several empirical findings emerge from this analysis using New-Keynesian models and FAVAR model. First, I find that both the permanent monetary policy shock to inflation target and a proxy of shock to the external finance premium successfully capture major portions of the size and the value premia. While I use more structural methods to identify proxies for the external finance premium and monetary policy shock, these results support the findings of Hahn and Lee (2006) that innovations in the default and term spreads as proxies for capturing revisions in the market's expectation about future credit market conditions and interest rates explain the size and value premium. They argue that small-sized and high-book-to-market firms would be more vulnerable to worsening credit market conditions and higher interest rates. The identified structural shocks for the external finance premium and the monetary policy shock from my models indeed indicate that their conclusions are valid with a structural investigation based on equilibrium models while additional structural shock related to inflation seem also indispensable.

Second, the permanent monetary policy shock to inflation target can explain part of industry risk premium once I appropriately account for the capital market imperfection. In particular, this shock is the only statistically significant variable to determine industry risk premium after controlling for business cycle. This could reflect that while the credit channel under the capital market imperfection is important for determining the value and the size premia, interest rate channel would be more important for explaining industry premium. Peersman and Smets (2005) show that there is considerable cross-industry heterogeneity in the overall monetary policy effects. After exploring which industry characteristics can account for the cross-industry heterogeneity, they find that durability of the output produced by the sector is an important determinant of its sensitivity to monetary policy changes. They

³Cho and Moreno (2006) show that their model with serial correlation is only marginally rejected at the 5 % level against vector autoregressive (VAR) model of inflation, real GDP growth and the federal funds rate using the small-sample likelihood ratio test statistic.

argue this fact as an evidence for interest rate/cost-of-capital channel since the demand for durable products, such as investment goods, is known to be much more affected by a rise in the interest rate through the cost-of-capital channel than the demand for non-durables such as food. Recently, Gomes, Kogan, and Yogo (2007) argue that durability of output is a risk factor since the demand for durable goods is more cyclical than that for nondurable goods and services. Consequently, the cash flow and stock returns of durable-good producers are exposed to higher systematic risk and thus investors request higher risk premium. This study indicates that monetary policy shock is one of the fundamental shocks behind this risk premium.

Third, temporary monetary policy shock extracted from several models is not statistically significant as a determinant for any risk premium. The stock market seems to respond only to fundamental target changes, which by definition have persistent effects on the future economy.

Finally, selected ICAPMs using New-Keynesian models are capable of explaining the cross-section of the Fama-French 25 size and B/M sorted portfolios significantly ($R^2=72\%$) and a part of risk premium for 55 portfolios with their 30 industry portfolios ($R^2=30\%$). Lewellen, Nagel, and Shanken (2006) criticize most of empirical asset pricing models because they only explain the value premium but not any part of the risk premium of industry portfolios. Based on empirical results, I argue that New-Keynesian models with more appropriate firm heterogeneity could be developed to fully account for industry risk premium with fundamental economic shocks.⁴

The rest of the paper is organized as follows. Section 2 presents the structural New-Keynesian models employed in this study. Section 3 outlines the empirical methods used to extract structural shocks from the given models. Section 4 presents the data and discusses the cross-sectional results of my empirical models for 25 size and B/M portfolios alone or with 30 industry portfolios. Section 5 summarizes the main findings and concludes.

2 Models

This section discusses the models to be estimated; the first subsection briefly explains the discrete time asset pricing model implied by new Keynesian equilibrium models and the second subsection presents

⁴Lewellen, Nagel, and Shanken (2006) criticizes most of the cross-sectional asset pricing studies for the choice of the Fama-French 25 portfolios.(Possible Data Snooping problem) Especially, they show that many empirical asset pricing models could price only the Fama-French 25 portfolios(R^2 is above 75 %) but not the 55 portfolios including 30 industry portfolios.(R^2 is typically below 10%) Therefore I check the robustness of the proposed ICAPMs for the value premium and for the capability to explain the industry portfolios. I argue that monetary policy shock is indeed important across different test assets.

three different Keynesian macro models to identify monetary policy shocks implemented in this paper.

2.1 The Pricing Kernel implied by New-Keynesian macro models

Without imposing any theoretical structure, the fundamental existence theorem of Harrison and Kreps (1979) states that, in the absence of arbitrage, there exists a positive stochastic discount factor, or pricing kernel, M_{t+1} , such that, for any traded asset with a gross return at time t of $R_{i,t+1}$, the following equation holds:

$$1 = E_t[M_{t+1}(R_{i,t+1})] \quad (2.1)$$

where E_t denotes the expectation operator conditional on information available at time t .

Standard New-Keynesian macro models employ the following external habit specification in utility function built on Fuhrer (2000).⁵

$$E_t \sum_{s=t}^{\infty} \psi^{s-t} U(C_s; F_s) = E_t \sum_{s=t}^{\infty} \psi^{s-t} \left[\frac{F_s C_s^{1-\sigma} - 1}{1-\sigma} \right]$$

where C_s is the composite index of consumption, F_s represents an aggregate demand shifting factor and usually denotes as $H_s G_s$ where H_s is an external habit level and G_s is a preference shock.; ψ denotes the subject discount factor and σ is the inverse of the intertemporal elasticity of consumption.

Bekaert, Cho, and Moreno (2005) derive the following pricing kernel implied by Fuhrer (2000) assuming standard log-normality:

$$m_{t+1} = \ln \psi - \sigma y_{t+1} + (\sigma + \eta) y_t - (g_{t+1} - g_t) - \pi_{t+1} \quad (2.2)$$

where $m_{t+1} = \ln(M_{t+1})$, y_{t+1} is detrended log output, $g_{t+1} = \ln(G_{t+1})$ and π_{t+1} is the inflation rate.

They express (2.2) in terms of the structural shocks in the economy.

$$m_{t+1} = -i_t - \frac{1}{2} \Lambda' D \Lambda - \Lambda' \varepsilon_{t+1} \quad (2.3)$$

where Λ' is a vector of prices of risks entirely restricted by the structural parameters of New-Keynesian models and D is the covariance matrix of structural shocks.

⁵I closely follow the representation given in Bekaert, Cho, and Moreno (2005)

2.2 A digestion of Risk premium and the New-Keynesian Pricing Kernel

The pricing kernel (2.3) is a linear combination of structural shocks to the overall economy. Following Cochrane (2001), I can interpret (2.3) as an example of the ICAPMs.

One major problem of (2.3) is that this pricing kernel assumes constant risk premium. Bekaert, Cho, and Moreno (2005) articulate that without either heteroscedasticity of structural shocks or time-varying market price of risk, their model essentially imposes that expectation hypothesis holds in bond market. In such a case, ICAPM implication would be seriously challenged since time-varying risk premium implied by ICAPM is inconsistent with this type of New-Keynesian pricing kernel.

One possible remedy is to adapt the external habit specification of Fuhrer (2000) to that of Campbell and Cochrane (1999) and develop a pricing kernel with time-varying risk aversion. Since time-varying risk aversion is emphasized in the finance literature, this extension would be beneficial for explaining asset pricing facts. However, the real challenge behind this scenario is to develop IS model consistent with this new utility function in order to explain the stylized facts in monetary economics before it is implemented in asset market research.⁶

Another suggestion would be introducing heteroscedasticity in the pricing kernel and structural shocks. While this specification naturally allows time-varying risk premium, typical log-linearization of New-Keynesian models is not valid anymore. At least second order approximation of the models should be employed to estimate the models. Unfortunately, an estimation of second-order approximated New-Keynesian models with likelihood-based methods and particle filter have not been ripen in the literature because of computational difficulties. Some steps in this direction have begun to be taken only recently.⁷ The common practice is to estimate the log-linearized economy and plug the estimates into the second-order approximation.

The easiest but ad-hoc solution of the problem is recently implemented by Rudebusch and Wu (2004) and Hordahl, Tristani, and Vestin (2006) when they jointly estimate macro models and term structure of yields. They simply ignore pricing kernel implications of their IS equations and set them exogenously.

Sometimes empirical asset pricing studies in finance seem to have somewhat convenient approximation mechanism similar to the ad-hoc approach presented above. For example, Campbell (1996)'s

⁶I defer the explanation of terminology and implications of New-Keynesian models employed in this paper to the next section.

⁷Refer to An (2006) for bayesian estimation of this type of models

ICAPM is derived under constant risk premium. Strictly speaking, simple pricing kernel form implied by the homoskedastic version of the model combined with the vector autoregression (VAR) pricing model recommended by Campbell (1996) is inconsistent since it does not have any mechanism to generate time-varying risk premium. However, actual implementation of Campbell ICAPM is usually done in the homoskedastic form with the usual VAR. Recently, Petkova (2006) implements this homoskedastic VAR to extract state variables and argue that her five factor "ICAPM" model is better than Fama-French three factor model to explain the value premium.

There seems to be trade-off between developing complex models to estimate tightly restricted models and estimating inconsistent but plausible mechanisms to extract economic state variables. Even though it seems possible to modify the pricing framework in (2.3) using one of the two approaches with time-varying price of risk or heteroscedasticity, I defer these attempts to future work. Instead, I follow a convenient approach, for example, taken by Rudebusch and Wu (2004) in this paper. I argue that this approximation is reasonable in terms of obtaining appropriate monetary policy shocks since current studies in monetary policy literature typically use models of the current study for explaining the stylized facts in monetary economics. While it is convenient to extract state variables in this way, pricing kernels should be interpreted as an approximation or exogenously re-specified to avoid constant risk premium. Specifically, I extract the innovations of state variables from New-Keynesian models and interpret (2.3) as a reasonable approximation of pricing kernel of ICAPM since these New-Keynesian models imply structural VAR of the economy.

Recent research suggests that monetary policy shocks can be identified as a determinant of market risk premium. It seems natural to check the implications of time-series relationship between monetary policy shocks and stock returns for the cross-section of portfolio returns in the spirit of ICAPM but to my knowledge, no one has investigated this issue before. Furthermore, it seems to be critical to investigate this issue closely following recent progress of the monetary policy literature.⁸ In this sense, employing New-Keynesian framework is important since most successful monetary policy analysis is done with log-linearized models considered in this paper.⁹ I explicitly investigate the relationship between monetary policy shocks and the cross-section of portfolio returns. Therefore, my approach seems to capture critical but unexplored areas of empirical asset pricing.

Usual ICAPM intuition suggests that state variables should forecast the changing investment opportunity set in that economy. In this sense, reasonably identified state variables from New-Keynesian

⁸In this sense, it is not clear that modification of (2.3) with heteroscedasticity or time-varying risk aversion would be better as macro models. To my knowledge, this type of research have not yet done much in monetary economics

⁹Refer to first nine chapters in Woodford (2003) for detailed explanations.

models are natural candidates since these models capture the essential feature and satisfy the intuition of various aspects of the data. Specifically, impulse response analysis implied by these models show that each shock explains the future course of the economy consistent with the stylized facts in monetary economics.¹⁰

2.3 New-Keynesian dynamic general stochastic equilibrium models(DSGE)

2.3.1 A summary of three-equation New-Keynesian Macro Models

In this section, I summarize three different versions of three equation New-Keynesian models implemented by Cho and Moreno (2006)¹¹ These models are simple but effective since they find that their three-equation model augmented with autocorrelation is just marginally rejected against a usual vector autoregression(VAR) of observed data using small-sample likelihood ratio test statistics.

These models combine the rigor of the Real Business Cycle (RBC) approach, which is characterized by the derivation of behavioral relationships from the optimizing behavior of agents subject to technological and budget constraints and the specification of a well-defined equilibrium concept, with the tractable introduction of nominal rigidities in order to accommodate nontrivial roles for monetary policy. These models can avoid the Lucas (1976) critique by a consistent treatment of expectations formation and rigorous treatment of micro-foundations.

The first structural model(model1) proposed by Cho and Moreno (2006) contains three equations: The aggregate supply(AS) equation, the IS equation and the monetary policy rule.

First, the AS equation is a generalization of the Calvo (1983) pricing model:

$$\pi_t = \delta E_t \pi_{t+1} + (1 - \delta) \pi_{t-1} + \lambda y_t + \varepsilon_{AS,t} \quad (2.4)$$

where π_t is inflation between $t-1$ and t and y_t stands for the output gap between $t-1$ and t . $\varepsilon_{AS,t}$ can be interpreted as marginal cost push shock, which is assumed to be independently and identically distributed with homoskedastic variance σ_{AS}^2 . E_t is the rational expectations operator conditional on the information set at time t .

To account for the observed persistence in aggregate inflation, this model assumes that price-setting

¹⁰Refer to appendix A for a summary of the stylized facts in monetary economics and theoretical advances before New-Keynesian macro models.

¹¹For detailed review of microfoundation of these models, see Woodford (2003)

intermediate goods producers engage in multi-period, staggered price setting. Since price-setting responds to movements in marginal costs, its persistence arises from shocks to marginal costs if inflation is purely forward looking. In addition to that, Gali and Gertler (1999) generate additional inertia in the Phillips curve by adding rule of thumb price setters with backward-looking behavior. In their model, prices remain fixed in monetary terms during stochastic intervals of time. But unlike the Calvo model, when prices are adjusted, some prices are chosen optimally while others are adjusted according to a backward-looking rule of thumb that introduces dependence upon lagged inflation.

Second, the IS equation is derived with representative agent model with the external habit as in Fuhrer (2000):

$$y_t = \mu E_t y_{t+1} + (1 - \mu) y_{t-1} - \phi(r_t - E_t \pi_{t+1}) + \varepsilon_{IS,t} \quad (2.5)$$

where $\varepsilon_{IS,t}$ is the preference shock, which is assumed to be independently and identically distributed with homoskedastic variance σ_{IS}^2 . The monetary policy channel in the IS equation is captured by the contemporaneous output gap dependence on the ex ante real rate of interest($r_t - E_t \pi_{t+1}$).

In this model, the effects of policy-induced changes on real interest rates directly affect aggregate spending decisions. For example, the central bank with an inflation target increases the short-term nominal interest rate if inflation is above the desired rate. Because of price stickiness, the central bank directly influences the real interest rate through its influence on the short-term nominal interest rate. Then, by influencing the real interest rate, aggregate demand is affected through consumption, via intertemporal substitution effects, and investment, via the cost of capital effects.

Finally, the monetary policy equation is the forward looking rule proposed by Clarida, Gali, and Gertler (2000):

$$r_t = \alpha_{MP} + \rho r_{t-1} + (1 - \rho)[\beta E_t \pi_{t+1} + r y_t] + \varepsilon_{MP,t} \quad (2.6)$$

where α_{MP} is a constant and $\varepsilon_{MP,t}$ is the monetary policy shock, which is assumed to be independently and identically distributed with homoskedastic variance σ_{MP}^2 .

The policy rule exhibits interest rate smoothing with a weight of ρ on the past interest rate. In this specification, the Fed reacts to high expected inflation and to deviations of output from its trend.

Cho and Moreno (2006) extend their model with ad-hoc exogenous autocorrelation(model2) or with

both auto- and cross-correlation of structural shocks(model3) to accommodate the persistence of the macro-dynamics.

$$\varepsilon_{t+1} = F\varepsilon_t + \omega_{t+1} \quad (2.7)$$

where F is a 3x3 stationary matrix, captures the correlation of structural shocks, and is either diagonal(model2) or full matrix(model3), ω_{t+1} is independently and identically distributed with diagonal covariance matrix D .

2.3.2 A summary of an extended New-Keynesian DSGE

Cho and Moreno (2006) find that adding persistence to the baseline New-Keynesian model improves the fit of the model. This might indicate the need for producing more complex models to provide realistic macro-dynamics. Furthermore, their models have one critical shortcoming by maintaining the assumption of frictionless capital markets. The seminal paper by Bernanke and Gertler (1989) and a number of subsequent calibration studies document how relaxing this perfect capital market assumption can generate additional features observed in macroeconomic data. Since then, considerable interest has been placed on the role of credit rather than money in determining business cycle fluctuations.

A series of papers proposed by Smets and Wouters(e.g.Smets and Wouters (2003)) incorporate a number of additional frictions to capture this persistence in the macro-economic data and they also add an exogenous mechanism to impose capital market imperfection. Their New-Keynesian models have become an standard approach in monetary policy literature.¹² This model contains three agents;Households consume, work, set wages, and invest; firms hire labor and capital, produce goods and set the prices of those goods; and the central bank sets the short-term interest rate in response to the deviation of inflation from the inflation target and output gap. The model accommodates both real and nominal frictions such as monopolistic competition in goods and labor markets with sticky nominal prices and wages, partial indexation of prices and wages, costs of adjustment in capital accumulation, external habit formation and variable capital utilization and fixed costs.

In order to endogenize capital market imperfection mechanism into standard New-Keynesian models, Graeae (2006) extends the role of entrepreneurs in Smets and Wouters's economy by explicitly accounting for the external finance premium equation in the sense of Bernanke, Gertler, and Gilchrist (1999).

¹²Refer to Smets and Wouters (2006) in order to fully understand micro-foundations of this model.

He finds that his measure of the external finance premium is closely related to readily available proxies of the premium such as the corporate bond spread(Baa-Aaa) and the high-yield bond spread(Bbb-Aaa).

This explicit capital market imperfection mechanism could be a significant channel for understanding the effects of monetary policy shocks on the cross-section of stock returns. Hahn and Lee (2006) investigate the role of yields spreads as proxies for this mechanism and find that the size and the value premia are compensation for higher exposure to the risks related to changing credit market conditions and interest rates(monetary policy) proxied by changes in yield spreads. However, yield spreads can be interpreted in a number of ways. Probably, other hypotheses could be developed consistent with these results from their reduced form model. For example, risk aversion can be time-varying and is proxied by two variables. In this sense, my paper can be interpreted as more structural investigation of the roles played by the capital market imperfection and monetary policy in explaining the cross-section of stock returns.

In Graeve's model, nine equations are incorporated to capture the macro dynamics of the economy. Most of the equations are just adopted from Smets and Wouters (2003) or Smets and Wouters (2005) except for the role of entrepreneurs.

First, households' maximization provides the aggregate consumption equation and wage equation. In addition to the external habit specification as in Cho and Moreno (2006), households have differentiated labor characteristics and some monopoly power over wages, which introduce sticky nominal wages in the sense of Calvo (1983). Households act as price-setters in the labor market and partial indexation of the wages is allowed. "Hat" means the steady state value.

The aggregate consumption($\hat{C}_t$) in this model is determined by:¹³

$$\begin{aligned}\hat{C}_t = & \frac{h}{1+h}\hat{C}_{t-1} + \frac{h}{1+h}E_t\hat{C}_{t+1} + \frac{\sigma_c - 1}{(1+\lambda_w)(1+h)\sigma_c}(\hat{L}_t - E_t\hat{L}_{t+1}) - \frac{(1-h)}{(1+h)\sigma_c}\hat{R}_t \\ & + \frac{(1-h)}{(1+h)\sigma_c}(\hat{\varepsilon}_t^B - E_t\hat{\varepsilon}_{t+1}^B)\end{aligned}\quad (2.8)$$

where $\hat{\varepsilon}_t^B$ is interpreted as preference shock and follows a first-order autoregressive process with an i.i.d normal error term; $\hat{L}_t$ stands for the labor supply included as the non-separability of the utility function of labor and consumption; $\hat{R}_t(\hat{R}_t^n - E_t\hat{\pi}_{t+1})$ is the ex-ante real interest rate, where $\hat{R}_t^n$ is the nominal interest rate and $\hat{\pi}_{t+1}$ is the inflation rate; Finally, E_t indicates conditional expectation given information up to time t.

¹³This is the equation (1) of Smets and Wouters (2005).

Households set their wages with the following Calvo (1983) type staggered wage-setting scheme proposed by Christopher, Henderson, and Levin (2000). In this model, the real wage $\hat{w}_t$ is a function of expected and past real wages and the expected, current and past inflation rates($\hat{\pi}_t$).¹⁴

$$\begin{aligned} \hat{w}_t = & \frac{\beta}{1+\beta} E_t \hat{w}_{t+1} + \frac{1}{1+\beta} \hat{w}_{t-1} + \frac{\beta}{1+\beta} (E_t \hat{\pi}_{t+1} - \bar{\pi}_t) - \frac{1+\beta\gamma_w}{1+\beta} (\hat{\pi}_t - \bar{\pi}_t) - \frac{\gamma_w}{1+\beta} (\hat{\pi}_{t-1} - \bar{\pi}_t) \\ & - \frac{1}{1+\beta} \frac{(1-\beta\xi_w)(1-\xi_w)}{(1+\frac{(1+\lambda_w)\sigma_l}{\lambda_w})\xi_w} \left[\hat{w}_t - \sigma_l \hat{L}_t - \frac{\sigma_c}{1-h} (\hat{C}_t - h\hat{C}_{t-1}) - \hat{\varepsilon}_t^L \right] + \eta_t^W \end{aligned} \quad (2.9)$$

where η_t^W is interpreted as a wage-markup disturbance. And $\hat{\varepsilon}_t^L$ represents the shock to the labor supply and is assumed to follow a first-order autoregressive process with an i.i.d. normal error term.

New-Keynesian economists emphasize the role of nominal rigidities(price stickiness) based on micro-foundations of imperfect competition. However, for these rigidities to have important implications, it is necessary that wages do not respond much to fluctuations in demand. The fall in output also results in a fall in labor demand which, in turn, would drive down the equilibrium wage in the labor market and the firm's marginal cost curves. This may increase the gain from price adjustment significantly. Thus, for the lack of price adjustment to be a macroeconomic equilibrium, we need real rigidity in the labor market. Staggered wage-setting equation is one of the mechanisms to generate this real rigidity in labor market. In fact, Smets and Wouters (2003) use partial or full indexation of this kind for both wages and prices, and find that this extension of the Calvo pricing model improves the empirical fit of their models.

Intermediate goods firms' optimizations in monopolistic competition markets yield the following equations. First, Cobb-Douglas production function augmented with fixed costs and variable capital utilization is given by:¹⁵

$$\hat{Y}_t = \phi \hat{\varepsilon}_t^A + \phi \alpha \hat{K}_{t-1} + \frac{\phi \alpha}{\psi} \hat{r}_t^k + \phi(1-\alpha) \hat{L}_t \quad (2.10)$$

where output($\hat{Y}_t$) is produced using capital ($\hat{K}_{t-1}$) and labor services ($\hat{L}_t$). Total factor productivity ($\hat{\varepsilon}_t^A$) is assumed to follow a first-order autoregressive process.

The firm's labor demand($\hat{L}_t$) depends negatively on the real wage($\hat{w}_t$) and positively on the rental

¹⁴This is the equation (6) of Smets and Wouters (2005).

¹⁵This is embedded in the equation (8) of Smets and Wouters (2005).

rate of capital($\hat{r}_t^k$) by equalizing marginal cost:¹⁶

$$\hat{L}_t = -\hat{w}_t + (1 + \frac{1}{\psi})\hat{r}_t^k + \hat{K}_{t-1} \quad (2.11)$$

Finally, price is determined following Calvo (1983) scheme.¹⁷

$$\begin{aligned} \hat{\pi}_t - \bar{\pi}_t &= \frac{\beta}{1 + \beta}(E_t \hat{\pi}_{t+1} - \bar{\pi}_t) + \frac{\gamma_p}{1 + \beta\gamma_p}(\hat{\pi}_{t-1} - \bar{\pi}_t) \\ &+ \frac{1}{1 + \beta\gamma_p} \frac{(1 - \beta\xi_p)(1 - \xi_p)}{\xi_p} [\alpha\hat{r}_t^K + (1 - \alpha)\hat{w}_t - \hat{\varepsilon}_t^A] + \eta_t^P \end{aligned} \quad (2.12)$$

where the deviation of inflation($\hat{\pi}_t$) from the target inflation rate ($\bar{\pi}_t$) depends on past and expected future inflation deviations and on the current marginal cost($\alpha\hat{r}_t^K + (1 - \alpha)\hat{w}_t - \hat{\varepsilon}_t^A$). The stochastic component $\hat{\varepsilon}_t^A$ is assumed to follow a first-order autoregressive process and η_t^P is an i.i.d. normal price mark-up shock.

Capital goods producers work in a perfectly competitive environment and their investment decision can be summarized as:¹⁸

$$\hat{I}_t = \frac{1}{1 + \beta}\hat{I}_{t-1} + \frac{\beta}{1 + \beta}E_t \hat{I}_{t-1} + \frac{1/\varphi}{1 + \beta}(\hat{Q}_t + \hat{\varepsilon}_t^I) \quad (2.13)$$

where $\hat{Q}_t$ is the real value of installed capital and φ is the investment adjustment cost parameter. A positive shock to the investment-specific technology, $\hat{\varepsilon}_t^I$ increases investment in the same way as an increase in the value of the existing capital stock $\hat{Q}_t$. This investment shock is also assumed to follow a first-order autoregressive process with an i.i.d normal error term.

And the capital stock evolves as:¹⁹

$$\hat{K}_{t+1} = (1 - \tau)\hat{K}_t + \tau\hat{I}_t + \tau\hat{\varepsilon}_t^I \quad (2.14)$$

where τ is the depreciation rate, $\hat{I}_t$ stands for investment and $\hat{\varepsilon}_t^I$ represents a shock to the investment technology.

Unlike the forward-looking monetary policy used in Cho and Moreno (2006), the monetary policy

¹⁶This is the equation (7) of Smets and Wouters (2005).

¹⁷This is the equation (5) of Smets and Wouters (2005).

¹⁸This is the equation (2) of Smets and Wouters (2005).

¹⁹This is the equation (4) of Smets and Wouters (2005).

rule follows a generalized Taylor rule by gradually responding to deviations of lagged inflation from an inflation objective and the lagged output gap. This reaction mechanism contains two monetary policy shocks: a temporary i.i.d. normal interest rate shock(η_t^R) and a persistent shock for changes in inflation target($\hat{\pi}_t - \bar{\pi}_t$).²⁰

$$\begin{aligned}\hat{R}_t^n = & \rho \hat{R}_{t-1}^n + (1 - \rho) \left\{ \bar{\pi}_t + r_\pi (\hat{\pi}_t - \bar{\pi}_t) + r_Y (\hat{Y}_t - \hat{Y}_t^P) \right\} + r_{\Delta\pi} (\hat{\pi}_t - \bar{\pi}_{t-1}) \\ & + r_{\Delta Y} (\hat{Y}_t - \hat{Y}_t^P - (\hat{Y}_{t-1} - \hat{Y}_{t-1}^P)) + \eta_t^R\end{aligned}\quad (2.15)$$

where $\hat{R}_t^n$ is the federal funds rate, $\bar{\pi}_t$ is the inflation target set by the central bank and potential output($\hat{Y}_t^P$) is defined as the level of output that would prevail under flexible price and wages in the absence of cost-push shocks and in frictionless credit market equilibrium. Finally $\hat{Y}_t$ is the actual real GDP and $\hat{\pi}_t$ is the actual inflation rate.

The goods market equilibrium condition can be written as:²¹

$$\hat{Y}_t = c_y \hat{C}_t + \tau k_y \hat{I}_t + \varepsilon_t^G + \frac{(\bar{R}^K - 1 + \tau)}{\psi k_y} \hat{r}_t^k + k_y (\bar{R}^K - \bar{R}) \left(1 - \frac{\bar{N}}{\bar{K}}\right) (\hat{R}_t^K + \hat{Q}_{t-1} + \hat{K}_t) \quad (2.16)$$

where c_y and k_y denotes the steady-state ratio of consumption and capital to output respectively. And ε_t^G is interpreted as government spending shock, which follows a first-order autoregressive process with an i.i.d. normal error term.

Finally, entrepreneurs buy the capital stock K_{t+1} from capital goods producers at a given price Q_t with internal funds(net worth, N_{t+1}) and bank loans. And they choose capital utilization and rent out capitals to intermediate goods firms at a rate $\hat{r}_t^k$.²²

The aggregate expected real return to capital is given by:

$$E_t \hat{R}_{t+1}^K = \frac{1 - \tau}{\bar{R}^K} E_t \hat{Q}_{t+1}^K + \frac{\bar{r}^k}{\bar{R}^K} E_t \hat{r}_{t+1}^K - \hat{Q}_t \quad (2.17)$$

where $\bar{R}^K$ denotes the steady state return to capital and $\bar{r}^k$ stands for the steady state rental rate. The first term in the equation states the value of remaining capital($\frac{1-\tau}{\bar{R}^K} E_t \hat{Q}_{t+1}^K$), the second term indicates

²⁰This is the equation (9) of Smets and Wouters (2005)

²¹This is the equation (8) of Smets and Wouters (2005)

²²This is modified equation (3) of Smets and Wouters (2005) without exogenous risk premium shock. From now on, I closely follows page 8 and 9 of Graeve (2006)

the return from renting out the capital($\frac{1-\tau}{\bar{R}^K} E_t \hat{Q}_{t+1}^K$) and the last term indicates the paid price for the purchase of capital stock($\hat{Q}_t$).

While Graeve (2006) uses set of equations adopted directly from Smets and Wouters (2005) for the equations described up to now, Graeve (2006) extends the Smets-Wouters model by assuming that entrepreneurs cannot borrow at the risk-less rate because of capital market imperfection. In that case, because of the asymmetric information between the financial intermediary and entrepreneurs, the bank should pay a state verification cost for monitoring entrepreneurs. In equilibrium, entrepreneurs borrow up to the point where the expected return to capital equals the cost of external finance.

At equilibrium, Graeve (2006) argues that the external finance premium is given by:

$$E_t \hat{R}_{t+1}^K = -\varepsilon E_t [\hat{N}_{t+1} - \hat{Q}_t - \hat{K}_{t+1}] + \bar{R}_t \quad (2.18)$$

where ε measures the elasticity of the external finance premium to variations in entrepreneurial financial health($E_t [\hat{N}_{t+1} - \hat{Q}_t - \hat{K}_{t+1}]$), measured by net worth relative to capital expenditures. Following Bernanke, Gertler, and Gilchrist (1999), he assumes that the premium over the risk-free rate required by the financial intermediary is a negative function of the amount of collateralized net worth. When entrepreneurs have sufficient net worth to finance the entire capital stock, Graeve (2006) explains that his model reduces to the Smets and Wouters model.

And Graeve (2006) sets the net worth equation of entrepreneurs by:

$$\hat{N}_{t+1} = \gamma \bar{R}^K \left[\frac{\bar{K}}{\bar{N}} \left(\hat{R}_t^K - E_{t-1} \hat{R}_t^K \right) + E_{t-1} \hat{R}_t^K + \hat{N}_t \right] \quad (2.19)$$

where γ is the entrepreneurial survival rate and $\frac{\bar{K}}{\bar{N}}$ is the steady state ratio of capital to net worth.

Graeve (2006) concludes that his model with the financial accelerator(endogenous external finance premium) performs substantially better in matching the macro-dynamics relative to the Smets-Wouters model without that mechanism from examining the Bayes factor.

2.3.3 Factor-augmented vector autoregressions(FAVAR)

Central banks increasingly pay attention to a much larger number of time-series in their forecasts than is commonly assumed by academic econometricians. For example, the US Fed is thought to keep and evaluate thousands of series. Usual criticisms of the common VAR approach to monetary policy shock

identification center around that a relatively small amount of information is used by usual VARs with at most eight variables. The New-Keynesian models discussed in the last section are also subject to the same criticism since they use at most eight variables. This information set is very small available to the information sets of actual central bankers who constantly watch even hundreds of data series.

Recently, Bernanke, Boivin, and Elias (2005) propose a solution to deal with this critique on limited information problem by combining the usual VAR analysis and principal component analysis to incorporate latent factors extracted with a large panel of economic data. They argue that those latent factors can be interpreted as state variables of the economy such as unobserved potential output or credit conditions.

In this paper, I use a series of monetary policy shock identified from FAVAR model in order to investigate two issues. First, since this model provides monthly estimates of structural shocks, we can examine the relationship between monetary policy shocks and stock returns further at a higher frequency than quarterly horizon. Second, the size of the data set used in estimating New-Keynesian models may be too small to extract monetary policy shocks with 8 variables and 20 years of quarterly data. Since I use almost 40 years of monthly data to check for the effects of monetary policy on the cross-section of stock returns, empirical results using this model would provide another testing ground for the effects of monetary policy.

However, there is a criticism on using this type of models. Even though structural vector autoregressions (VARs) are widely used to show the effect of monetary policy shocks on the economy, these models typically use simple identifying restrictions consistent with various models.²³ Following the standard structural VAR approach, FAVAR proposed by Bernanke, Boivin, and Elias (2005) also focuses on specifications that identify the monetary policy shock while remaining agnostic about the structure of the rest of the model and the number of unobservable factors. Because this is not a true structural model based on microfoundations, it is questionable whether the results are robust and not subject to Lucas (1976) critique problems.

Bernanke, Boivin, and Elias (2005) propose the following state space model:

Transition Equation

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + v_t, v_t \sim (0, Q)$$

²³For example, Sims (1992) assumes that monetary policy only affects output with a lag. (money granger causes output)

where Y_t is an $M \times 1$ vector of observable economic variables assumed to drive the dynamics of the economy and F_t is a $K \times 1$ vector of “unobserved” factors such as unobserved potential output or credit conditions.

Measurement equation

$$X_t = \Lambda^F F_t + \Lambda^Y Y_t + e_t$$

$$(N \times 1) (N \times K) (N \times M) (N \times 1)$$

where $e_t \sim N(0, R)$ and R is a diagonal matrix and e_t and F_t are independent. X_t is $N \times 1$ vector of economic variables useful to extract F_t

In matrix forms, measurement equation can be expressed as the following:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \Lambda^F & \Lambda^Y \\ 0 & I \end{bmatrix} \begin{bmatrix} F_t \\ Y_t \end{bmatrix} + \begin{bmatrix} e_t \\ 0 \end{bmatrix}$$

Following Bernanke, Boivin, and Elias (2005)’s empirical specifications, I extract three latent factors from 120 monthly macro series and use the federal funds rate as the single observed factor. In this case, $Y_t = R_t$ and R_t is monetary policy instrument.

Even though I use several complex models to identify monetary policy shocks, the models presented here should be viewed only as approximations to the actual monetary transmission mechanism. A realistic quantitative model still needs to incorporate additional complexities. Nonetheless, the basic elements of the optimizing model of the monetary transmission mechanism used in this paper are interpreted as being representative of crucial elements of a realistic model; and indeed, Smets and Wouters (2003) argue that the illustrative models discussed here have many elements in common with rational-expectations models of the monetary transmission mechanism that are already being used for quantitative policy evaluation at a number of central banks.

3 Empirical Specification

3.1 Baseline Empirical Models

This section provides a simple Bayesian framework for estimating and evaluating a version of ICAPM based on the state variables estimated from several New-Keynesian models. In order to estimate the

models explained in the previous section, I present a Markov Chain Monte Carlo(MCMC) algorithm to encompass all of the estimation procedures.²⁴

3.1.1 Assumptions and Estimation algorithm

First, I express the joint density of all the parameters by:²⁵

$$f(\lambda, \beta, \sigma_\nu^2, \sigma_e^2, X|R, M)$$

where λ denotes the risk price; β is the risk(betas); σ_ν^2 and σ_e^2 will be defined later; X is a vector of state variables(structural shocks); R is a vector of portfolio returns; M is a vector of macro variables.

I assume that structural shocks(X) are identified only from New-Keynesian models with macro variables but not from stock market returns. However, this assumption might not be innocuous. Modelling and identifying the interaction between monetary policy and the stock market is complicated by endogeneity problem since the Federal Reserve may react to movements in asset price returns while asset price returns are sensitive to the interest rate set by the monetary authorities.(e.g.Rigobon and Sack (2003))

I argue why these assumption can still be valid with the following reasons. First, the reaction of the Fed on stock market behavior might not be too big. For example, Bernanke and Gertler (1999) augment an otherwise conventional Taylor rule with the lag of asset price returns and find that the Fed does not react to the stock market. They argue that the Fed with inflation target objective should respond only to inflation component of stock market volatility. Since inflation rate itself is included in estimation of New-Keynesian models, adding stock market variables would not be that much important for estimation results. Second, none of the standard New-Keynesian models include stock market data to identify structural shocks for macro economy. Probably one notable exception is FAVAR model, which includes stock market returns to extract latent factors from observed variables. Therefore, robustness checks using FAVAR models might be interesting to check whether monetary policy shock is really important for explaining the cross-section of stock returns. Finally, empirical asset pricing studies using macro-variables typically assume that state variables extracted from some macro-models are exogenous to the

²⁴Alternative classical approach can be specified following Brennan, Wang, and Xia (2004).In their approach, they first estimate an essential affine term structure models using maximum likelihood estimation with Kalman filter and do the usual Fama-Macbeth two-step regressions. In this setup, GMM estimation of all parameters is impossible because of Kalman filter, which is true in estimating New-Keynesian DSGEs since it also involves Kalman filter. In fact, since I use diffuse priors for almost all parameters, we might be able to interpret the estimation results similar to bootstrap estimation of all parameters in classical approach.

²⁵I suppress structural parameters in New-Keynesian models since these parameters are not primary concerns.

stock market. For example, Thorbecke (1997) include stock return as most endogenous variables in his structural VAR to investigate the time-series relationship between monetary policy shock and stock returns.

This joint density can now be decomposed as:

$$f(\lambda, \beta, \sigma_v^2, \sigma_e^2 | X, R) f(X | M) \quad (3.1)$$

Furthermore, I assume that prior independence of parameters in $f(X|M)$ and those in $f(\lambda, \beta, \sigma_v^2, \sigma_e^2 | X, R)$. Then I can estimate posterior distributions of all parameters in separate blocks. Based on the given assumptions, I use unified MCMC scheme to estimate all parameters by repeating estimation steps given below.²⁶ I estimate the given models in step 1 for burn-in period.²⁷ And after burn-in period, I start to repeat step 1 through 3 and save series of identified structural shocks and calculate posterior distributions of corresponding risks and risk prices. During the repetition, I calculate and save various statistics for the comparison of different models. However, for the Fama-French three factor model or CAPM, I skip the step 1 since factors are all observed.

Step 1. estimation of $f(X|M)$ I estimate New-Keynesian or FAVAR models and obtain the series of structural errors from given models after burn-in periods. In order to estimate New-Keynesian models and FAVAR model, I utilize a Bayesian method. While maximum likelihood estimation(MLE) is known to produce better results than generalized methods of moments(GMM) in estimating DSGE models, several researchers(e.g. An and Schorfheide (2005)) criticize MLE with "dilemma of absurd parameter estimates" when applying MLE to DSGE models and argue that Bayesian methods often produce more acceptable parameter estimates combining prior information from micro-economic studies.

Specifically, I use the DYNARE package to estimate the Linearized DSGE models.²⁸ The Bayesian estimation methodology in DYNARE package contains the following steps. First, the linearized rational expectations model is solved with the generalized Schur decomposition(QZ) method²⁹, which leads to results in a state equation in the predetermined state variables. Second, the model is written in the state space form by adding a measurement equation that links the observable variables to the vector of state variables. Third, the likelihood function is derived using the Kalman filter. Finally,

²⁶In fact, it becomes a sequential estimation of three blocks of MCMC using assumptions.

²⁷I use Brooks and Gelman (1998)'s convergence diagnostic to make sure actual convergence of algorithm

²⁸To estimate New-Keynesian models I employ DYNARE version 3.5, by S. Adjemian, M. Juillard and O.Kamenik. I appreciate for their kindness to make this phenomenal toolbox available. For FAVAR, I utilize Matlab programs downloaded from Jean Boivin's website. I also thank him for sharing his programs and data

²⁹I refer to Klein (2000) for a reference of the QZ method

after the posterior density is formed by combining the likelihood function with a prior distribution over the parameters, a Random-Walk Metropolis(RWM) algorithm is utilized to generate draws from the posterior distribution of parameters. The RWM algorithm belongs to the more general class of Metropolis-Hastings algorithms which generate Markov chains with stationary distributions that correspond to the posterior distributions of interest.³⁰ In order to get appropriate starting values, DYNARE estimates the posterior mode with Sims' "*cminwel*" function and the inverse of the Hessian is computed at that posterior mode. Since it is well known that the posterior distribution of each parameter is asymptotically normal, a Gaussian approximation around the posterior mode and a scaled asymptotic covariance matrix is used as the proposal distribution. And the scale parameters are chosen to obtain approximately 35 % acceptance rate. The debugging features of DYNARE are used to determine if the optimization routines have found the optimum and if enough draws have been executed for the posterior distributions to be accurate.

Before developing step 2, I state the implied ICAPM in the form of the fundamental asset pricing equation and the corresponding beta-regression.

$$E(M_{t+1}R_{t+1}^e|\psi_t) = 0 \quad (3.2)$$

where R_{t+1}^e is an N-vector of excess returns(test assets) to a short term risk-free from t to t+1; M_{t+1} is the asset pricing kernel(or stochastic discount factor) given in (2.3); ψ_t denotes the information at time t. By plugging (2.3) into (3.2), implied ICAPM model can be intuitively expressed by (expected return = risk price(λ)*risk(β)).

Since I use non-return factors implied from New-Keynesian models, I can not obtain the risk price(λ) and risk(β) simultaneously. Therefore, I assume that we can estimate λ and β in two steps with the Fama-MacBeth analogy. Now, I can express (3.1) by:

$$f(\lambda, \sigma_\nu^2|\beta, \sigma_e^2, X, R)f(\beta, \sigma_e^2|X, R)f(X|M) \quad (3.3)$$

where λ and σ_ν^2 are the parameters in cross-sectional regression; β and σ_e^2 are the parameters in time-series regression.

³⁰I refer to Chib and Greenberg (1995) for an excellent introduction to Metropolis-Hastings algorithms.

Step 2. estimation of risk(β) with $f(\beta, \sigma_e^2 | \mathbf{X}, \mathbf{R})$ If I assume that the econometrician has access to both excess returns and the historical values of the true state variables(structural shocks) given from the first step, then the second step in this estimation scheme is a multivariate time-series regression of excess returns(r^i) on the state variables or structural shocks from the first step(X^i):

$$r^i = X^i \beta^i + e^i, \text{ for } i = 1, 2, \dots, m \quad (3.4)$$

where r^i is a $T \times 1$ vector of the T observations of the dependent variable(portfolio returns), X^i is a $T \times p^i$ matrix of independent variables(state variables or structural shocks), β^i is a $p^i \times 1$ vector of the regression coefficients(betas), and e^i is the vector of errors for the T observations of the i th regression.

In matrix forms,

$$\tilde{r} = \tilde{X} \tilde{\beta} + \tilde{e} \quad (3.5)$$

where

$$\tilde{r} = \begin{pmatrix} r^1 \\ r^2 \\ \dots \\ r^m \end{pmatrix}, \tilde{X} = \begin{pmatrix} X^1 & 0 & . & 0 \\ 0 & X^2 & . & 0 \\ . & . & . & . \\ 0 & 0 & . & X^m \end{pmatrix}, \tilde{\beta} = \begin{pmatrix} \beta^1 \\ \beta^2 \\ \dots \\ \beta^m \end{pmatrix}, \tilde{e} = \begin{pmatrix} e^1 \\ e^2 \\ \dots \\ e^m \end{pmatrix}, \tilde{e} \sim N(0, \sum \otimes I_T)$$

As the above remarks indicate, $\tilde{r}$ are asset returns and the independent variables, $\tilde{X}$ are factors(structural shocks) in asset pricing models, $\tilde{\beta}$ are risks of factors. Since the set of factors is the same across all equations, i.e., ($X \equiv X^1 = X^2 = \dots, X^m$), we can interpret (3.5) as a seemingly unrelated regressions(SUR) model with the same independent variables. Typically, we assume, in linear factor models, that $\sum$ is diagonal, i.e., $e^i \sim N(0, \sigma_e^2)$ and $\text{cov}(e^i, e^j) = 0$ for $i \neq j$. Since generalized least square(GLS) estimation is numerically equal to OLS estimation in this case, we can estimate each equation in the above system with Bayesian estimation of ordinary least squares regression. ($r^i = X^i \beta^i + e^i$ for all i)

Based on the given models, I can utilize simple Bayesian regression method with non-informative priors. If $r^i | \beta^i, \sigma_e^2, X^i \sim N(X^i \beta^i, \sigma_e^2 I)$ and $p(\beta^i, \log \sigma_e^2) \propto \sigma_e^{-2}$ then it follows that the conditional posterior distribution $p(\beta^i | \sigma_e^2; \mathbf{X}, \mathbf{R})$ can be written as:

$$p(\beta^i | \sigma_e^2; \mathbf{X}, \mathbf{R}) \sim N_{\text{MVN}} \left(\left(X^{i'} X^i \right)^{-1} X^{i'} r^i, \sigma_e^2 \left(X^{i'} X^i \right)^{-1} \right) \quad (3.6)$$

The posterior distribution of σ_e^2 can be written as: $p(\sigma_e^2|data) \sim \text{Inv } \chi^2(n-k, s^2)$. Using Gibbs-sampling technique, I can estimate β with previous returns data with state variables(X) from the step 1. However, it is well known that in this case, the following marginal distribution of β holds: $p(\beta|data) \sim \text{MVT}_{n-k}(\beta^{i'}, s^2 X^{i'} X^{i-1})$. Therefore, I just use modes of multivariate t distribution as estimates of β .

Step 3. estimation of risk price(λ) with $f(\lambda, \sigma_\nu^2|\beta, \sigma_e^2, \mathbf{X}, \mathbf{R})$ Finally, I estimate risk prices(λ) using β as independent variables for each time. In classical approach, Fama-MacBeth approach suggests that I should run this cross-sectional regressions each quarter, generating time-series of estimates for risk prices(λ). Means, standard errors, and t-statistics are then computed from these time series and inference proceeds in the usual manner, as if the time series are independently and identically distributed. It is well known that security returns are cross-sectionally correlated, due to common market and industry factors, and also are heteroscedastic. As a result, the usual formulas for standard errors are not appropriate for the OLS cross-sectional regressions(CSR). Fama-Macbeth approach is interpreted as a remedy for this phenomenon. Since the true variance of each quarterly estimator depends on the covariance matrix of returns, cross-sectional correlation and heteroskedasticity are reflected in the time series of quarterly estimates. Following this argument, I run Bayesian cross-sectional regression every time using (3.6). However, its independent variables become (β) instead of X^i , and λ become a vector of coefficients from this regression .

$$p(\lambda^i|\sigma_\nu^2; data) \sim N_{\text{MVN}}\left(\left(\beta^{i'}\beta^i\right)^{-1}\beta^{i'}r^i, \sigma_\nu^2\left(\beta^{i'}\beta^i\right)^{-1}\right) \quad (3.7)$$

where β is obtained from the previous step.

However, estimates given in step 2 provide some information about covariance matrix for error terms in cross-sectional regressions since intercept terms in time-series regressions are related to error terms in cross-sectional regression. In fact, Cochrane (2001) argues, in classical sense, that while GLS is asymptotically more efficient, estimation results may not be trustworthy for large portfolios since GLS meaning OLS on transformed portfolios and it pays attention to uninteresting but low residual variance or near riskless portfolios. Therefore, consistent with previous studies using OLS, I use either Bayesian Gibbs sampling using (3.7) or use modes of multivariate t distribution as before.

$$p(\lambda|\mathbf{X}, \mathbf{R}) \sim \text{multivariatet}_{n-k}\left(\lambda^{i'}, s^2\beta^{i'}\beta^{i-1}\right). \quad (3.8)$$

The whole procedure can be interpreted as usual integrating-out of nuisance parameters. After simulating the posterior distribution of parameters, simulated parameters can then be used to construct the posterior distribution of risk prices by the following form:

$$f[\lambda] = \iiint f(\lambda, \beta, \sigma_e^2, \sigma_\nu^2, X | M, R) d\sigma_\nu^2 d\beta d\sigma_e^2 dX$$

Any function of estimated parameters can also be constructed with same logic. For example, I construct Jagannathan and Wang (1996)'s adjusted R^2 to judge the goodness of fit of the suggested empirical models.

$$R^2 = \frac{\sigma_C^2(\bar{R}) - \sigma_C^2(\bar{e})}{\sigma_C^2(\bar{R})}$$

where σ_C^2 represents the in-sample cross-sectional variance, $\bar{R}$ is a vector of average excess returns, and $\bar{e}$ stands for the vector of average residuals in cross-sectional regression.

4 Data and Empirical Results

4.1 Data

In this study, I use three different macro data sets. First, in order to estimate three versions of Cho and Moreno model, I download their data set from the website of Journal of Money, Credit, and Banking.³¹ They use U.S. quarterly time series for three variables: output gap, inflation rate using GDP deflator and the quarterly average of Federal funds rate from 1980:Q4 to 2004:Q4.³² They choose this sample period after several parameter stability tests and report their results are robust across several output gap measures with the Consumer Price Index(CPI) and the 3 Month T-Bill rate. I estimate their models using linearly-detrended output gap and inflation rate using GDP deflator and the Federal funds rate. Perhaps, this sample period explicitly shows the relationship between monetary policy and stock returns because Fed has responded more vigorously to inflation variations since 1979.

Second, I estimate Graeve (2006)'s model using his data and DYNARE program.³³ His data set

³¹I thank Cho and Moreno for sharing their data set and JMCB for its data policy.

³²They use data from 1980:Q1 to 2000:Q1 in their main estimation but extend their data set for robustness check. Their data is annualized and in percentages. Federal funds rate data was collected from the Board of Governors of the Federal Reserve website. Real GDP and the GDP deflator were obtained from the National Income and Product Accounts (NIPA). I refer to Cho and Moreno (2006) for the details.

³³I greatly appreciate for his sharing of his program and data

consists of real GDP, consumption, investment, real wages, hours worked, price(GDP deflator) and the short-term interest rate of Smets and Wouters (2006) from 1947:Q1 to 2004:Q4.³⁴ Nominal variables are deflated by the GDP-deflator and aggregate real variables are expressed in per capita terms. All variables except for hours, inflation and the interest rate are linearly detrended. Following Smets and Wouters (2006) and Graeve (2006), I estimate Graeve's model using full sample data. But for comparison, I use extracted structural shocks only from 1980:Q4 to 2004:Q4 for explaining the cross-section of stock returns. Even though sample period used in estimation is different, identified structural shocks are similar across different models. For example, any measure of monetary policy shocks from models 1,2 and 3 of Cho and Moreno (2006) has a correlation above 80 % of temporary monetary shocks from Graeve (2006)'s model. This might indicate the robustness of this Smets-Wouters model over simple three equations of New-Keynesian models since parameter instability of simple models would be endogenously incorporated in this complex model.

Finally, I download data from the website of Jean Boivin to estimate FAVAR model.³⁵ They use Federal funds rate and other monthly macro-economic data from January 1959 through August 2001 and extract latent factors from a balanced panel of 120 monthly macroeconomic time series, which is transformed to induce stationarity. Probably, one characteristic of their data is noteworthy to be mentioned. Unlike New-Keynesian models using only macro variables, Bernanke, Boivin, and Elias (2005) include stock prices data(NYSE and S&P stock index, dividend yield, price-earning ratio) to extract their latent factors. I use structural shocks from this model to check the relationship between monetary policy and stock returns for full sample period.

In cross-sectional analysis, I use ,as test assets, the returns on Fama-French 25 portfolios sorted by size and book-to-market and 30 industry portfolios. Even though the 25 portfolios have become the benchmark in testing competing asset pricing models, Lewellen, Nagel, and Shanken (2006) show that the 55 portfolios are the more appropriate to rigorously compare the models. All the portfolio returns and the Fama-French three-factors -the returns of the market portfolio(Rmrf), HML, and SMB are downloaded from French's website.

³⁴For data description, I refer to data appendix of Smets and Wouters (2006).

³⁵I thank him for sharing his data and program. I refer to the data appendix of Bernanke, Boivin, and Elias (2005) for the description of the data set and their detrending methods.

4.2 Priors and estimation results for New-Keynesian models

The Bayesian approach facilitates the incorporation of prior information from other macro as well as micro studies. As is well known from Bayes rule, the posterior distribution of a parameter is proportional to the product of its prior distribution and the likelihood function of the data. This prior distribution describes the available information prior to observing the data used in the estimation. The observed data is then used to update the prior, via Bayes theorem, to the posterior distribution of the parameters. However, Bayesian analysis is often criticized for its subjectivity bias from prior selections. In this study, I employ non-informative priors whenever possible. Especially, for the second and the third blocks of estimation, readily available non-informative Jeffrey priors are used. ($p(\beta^i, \log \sigma_e^2) \propto \sigma_e^{-2}$) In specifying the prior density, I assume that all parameters in each block are independently distributed of other parameters in the other blocks. This assumption simplifies my estimation since all blocks of estimation can be now separately done along with identifying assumptions given in the previous section.

For the first block estimation of New-Keynesian models, however, informative priors seem to be indispensable. While maximum likelihood estimation(MLE) or Bayesian estimation with non-informative priors is known to produce better results than the generalized methods of moments(GMM) in estimating DSGE models, several researchers(e.g.An and Schorfheide (2005)) criticize MLE with "dilemma of absurd parameter estimates" when applying the MLE to DSGE models and argue that Bayesian methods often produce more acceptable parameter estimates. For the estimation of Graeve (2006) and FAVAR, I exactly follow their selections of prior distributions.³⁶ However, I need to select prior distributions of the parameters in Cho and Moreno (2006)'s models since they use MLE in their paper. First, I choose distributional assumptions following Graeve (2006) in the sense that if some parameters have positivity restrictions(e.g.Calvo parameter), I impose beta distribution and I use usual inverted gamma distribution for variance parameters. However, in order to minimize biases caused by the selection of prior distribution and obtain consistent results with Cho and Moreno (2006), I choose almost non-informative priors. For example, with DYNARE, I can check whether posterior modes are uniquely identifiable with given prior density and likelihood function. I set the variance of prior density as large as possible if unique mode is identified.

In Bayesian analysis, monitoring the convergence of parameters is critical since without it, we are not sure whether estimated parameters can be considered as a valid sample from the posterior distribution.³⁷

³⁶I refer to their papers for the details on their prior selection.

³⁷For FAVAR model, I exactly follow the suggestions given in Bernanke, Boivin, and Elias (2005) and obtain similar estimates using their original programs.

Therefore, in order to ensure convergence, I do several checks. First, I simulate samples from each New-Keynesian model at least 200,000 draws from five different chains and after discarding 50 % of them in each chain as burn-in replications, I calculate the convergence diagnostics of Brooks and Gelman (1998) offered in DYNARE package. I find every parameter converged with this statistics. When I also draw one long chain of 1,000,000 draws from each model with 500,000 as burn-in periods, I obtain similar results.

While all of the parameter estimates are similar to those presented in Cho and Moreno (2006) and Graeve (2006),³⁸ I report the estimated structural shocks omitted from the tables of Cho and Moreno (2006) and Graeve (2006). Several points deserve to be mentioned.³⁹ First, in table 1, model 2(M2) and model 3(M3) are extended versions of model 1(M1) with autocorrelation alone or cross-correlation together. We expect that even though estimated shocks are similar across the models, autocorrelations of model 2 and of model 3 will be much lower than that of model 1. These facts are confirmed in the table. Correlations of estimated shocks are above 90% in every case, but autocorrelations of shocks are significantly lower in model 2 and model 3 compared with that of model 1. This pattern is also confirmed in figure 1. Table 2 and figure 2 reports the sample statistics and patterns of estimated structural shocks from Graeve’s model.

Two facts deserve special attention for understanding the risk premium reported in the next section. In Graeve’s model, there are two monetary policy shocks; permanent shock to inflation target(GE_PIE_BAR) and temporary monetary policy shock(GETA_R). Table 3 reports correlation between these two shocks and monetary policy shocks identified from Cho and Moreno’s models. Interestingly, monetary shocks of Cho and Moreno’s models seem to capture mostly temporary monetary shock. Correlation between Cho and Moreno’s monetary policy shocks and Graeve’s temporary monetary policy shocks are around 75% but with permanent shocks, correlation is just 30%. Therefore, I interpret Cho and Moreno’s monetary policy shocks as temporary shocks. Finally, I do not report here but confirm an important result from the table 4 of Graeve (2006). He calculates which structural shock is important for explaining the external finance premium for several different horizons using variance decomposition. In this estimates, the shock to investment technology corresponds to almost 85 % of the external finance premium especially for horizons over two years.

³⁸I omit results of parameter estimation and refer to the tables in each paper for the details since there is no additional information provided from reporting the same estimates.

³⁹I also omit results of FAVAR and just show figure 3 for overall picture since these results are not primary concerns in this paper.

4.2.1 Cross-sectional implications of New-Keynesian models

In this section, I examine the pricing performance of the full set of state variables from New-Keynesian models over the period from 1980:Q1 to 2004:Q4. The full set of shocks of the state variables consists of the price mark-up shock(AS), the preference shock(IS) and the temporary monetary shock for models 1,2 and 3 proposed by Cho and Moreno (2006). For Graeve's model, I choose 4 structural shocks in order to investigate the source of risk premium more precisely. For consistent comparison with Cho and Moreno's models, I choose price mark-up shock(Price-Markup), permanent shock to inflation target(Monetary1) and temporary monetary shock(Monetary2). In addition, I select a shock to investment technology(Investment) as a main determinant for the external finance premium.⁴⁰ These state variables derived from New-Keynesian models are risk factors in the ICAPM model. The objective is to test whether assets' loadings with respect to these risk factors are important determinants of its average returns.

I repeat the following estimation steps for at least 200,000 for each model. After burn-in periods, estimated structural shocks from the first step estimation of New-Keynesian models are saved. In the second block of Bayesian estimation, I regress the portfolio returns on these structural shocks saved from the first block to obtain the risk prices(betas). As in Lettau and Ludvigson (2001), the full-sample loadings, which are the independent variables in the second stage regressions, are computed in this multiple time-series regression using marginal posterior density of parameters. With diffuse priors, I just can use modes of parameters in multivariate t-distribution instead of using Gibbs sampling.⁴¹ The following regression is specifically used.

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{i,1}X_{1,t} + \beta_{i,2}X_{2,t} + \beta_{i,3}X_{3,t} + \varepsilon_{i,t}$$

where $R_{i,t}$ is portfolio returns; $R_{f,t}$ is treasury bill returns; $R_{M,t}$ is market returns; $X_{i,t}$ for $i=1,2$ and 3 are structural shocks extracted from the first block of estimation. For unconditional CAPM and the Fama-French three factor model, usual Rmrf, HML, SMB are used as state variables.

Finally, in the third block of estimation, the posterior means of betas from the previous regressions are subsequently used as independent variables in this cross-sectional regression for all time period. Following Fama-Macbeth analogy, I estimate means and standard deviation of risk prices(λ) for each time using risks(betas) as independent variables from the previous step. The following forms are used

⁴⁰This shock corresponds to 85% of the external finance premium using variance decomposition reported in the table 4 of Graeve (2006)

⁴¹Details of this Bayesian estimation methods are given in the previous section.

in cross sectional regressions.

1. CAPM: $R_{i,t} - R_{f,t} = \alpha_i + \lambda_i \text{Rmrf}$
2. FF3: $R_{i,t} - R_{f,t} = \alpha_i + \lambda_1 \text{Rmrf} + \lambda_2 \text{SMB} + \lambda_3 \text{HML}$
3. Model1,2 and 3: $R_{i,t} - R_{f,t} = \alpha_i + \lambda_1 \text{AS} + \lambda_2 \text{IS} + \lambda_3 \text{Monetary}$
4. GRAEVE: $R_{i,t} - R_{f,t} = \alpha_i + \lambda_1 \text{Investment} + \lambda_2 \text{Monetary1} + \lambda_3 \text{price mark-up} + \lambda_3 \text{Monetary2}$
5. FAVAR: $R_{i,t} - R_{f,t} = \alpha_i + \lambda_1 \text{latent1} + \lambda_2 \text{latent2} + \lambda_3 \text{latent3} + \lambda_4 \text{Monetary2}$

where definition of models and variables are reported in the tables of 4,5 and 6.

After burn-in periods in the first and the second steps of MCMC estimation of models, I save samples of the risk prices and ,using only the last 1,000 samples, I calculate means and standard deviations of them.⁴² To judge the goodness of fit of the suggested empirical models, I use the posterior modes of cross-sectional R^2 measure employed first by Jagannathan and Wang (1996). This R^2 represents the fraction of cross-sectional variation in average returns explained by the model. This measure is calculated as:⁴³

$$R^2 = \frac{\sigma_C^2(\bar{R}) - \sigma_C^2(\bar{e})}{\sigma_C^2(\bar{R})}$$

where σ_C^2 represents the in-sample cross-sectional variance, $\bar{R}$ is a vector of average excess returns, and $\bar{e}$ stands for the vector of average residuals in cross-sectional regression.

I also report the root mean square of pricing errors(α) in cross-sectional regression(RMSE) as another intuitive diagnostic to compare the models. I use $\sqrt{\frac{1}{25} \sum_{i=1}^{25} \alpha_i^2} = \sqrt{\frac{1}{N} \alpha' \alpha}$ for all the models. Cochrane advocates this measure by arguing that even though Hansen-Jagannathan(HJ) distance measure is invariant to portfolio formation, this simple RMSE could be more informative if the original portfolios were primary concerns and the second moment matrix of the test assets is quite close to singular⁴⁴ since the HJ distance places too much weight on pricing near-riskless portfolios rather than pricing the original assets.

Table 4 reports the posterior modes of coefficients, standard errors and the degrees of freedom-adjusted R^2 of Jagannathan and Wang (1996) and the RMSE for the cross-sectional regressions using

⁴²Following Bernanke, Boivin, and Elias (2005), I also use medians of parameters to obtain qualitatively the same results in cross-sectional implication of models.

⁴³Usual model comparison using Bayes factors are not employed for the following reasons. First, I use non-informative or diffuse priors on many parameters in order to minimize possible biases from selections of prior distribution. However, with these diffuse priors, closed form of marginal densities are hard to obtain. Furthermore, New-Keynesian models involve one more step to estimate structural shocks than unconditional CAPM and the Fama-French three factor model. It is unclear whether usual comparison is still valid in this case.

⁴⁴Lewellen, Nagel, and Shanken (2006) suggest that Fama-French 25 size and B/M sorted portfolios have essentially three degree of freedom.

the excess returns on 25 portfolios sorted by book-to-market and size. In this table, structural shocks are identified from New-Keynesian models. First, in most cases, the market factor(Rmrf) receives a negative and statistically insignificant risk premium consistent with the findings of Fama and French (1992).⁴⁵ Even though it appears to be a severe problem for the CAPM, the negative market risk premium has not been understood yet. Since the issue is beyond the scope of this paper, I defer it to the future studies. Second, there is a mixed evidence for the value premium in the data. Even though the HML in the Fama-French three factor itself is not priced in the cross section of average returns, inclusion of the HML tends to increase the cross-section R^2 (R^2 is above 80%). Third, model 1 of Cho and Moreno is even worse than CAPM in terms of R^2 and RMSE. Their models 2 and 3 are comparable to or slightly better than CAPM. Among other things, monetary shock(Monetary) is not statistically significant while aggregate supply shock,i.e., price mark-up shock(AS) and IS shock are statistically significant.

Parameter estimates of Graeve’s model will shed some lights on why Cho and Moreno models fail to fully explain risk premium. This is mainly because Graeve’s model is a significant extension of Cho and Moreno’s models and provides more precise description of the structural shocks. Specifically, Graeve’s model uses two monetary policy shocks. Only the loading with respect to permanent monetary policy shock to inflation target is an important determinant of average returns. Since Cho and Moreno’s monetary shock can mostly be interpreted as temporary monetary shock, we can conclude that investors in the stock market primarily respond to the persistent shock from the Fed decision. This seems natural since target changes, by definition, have persistent effects on the future economy. Second, the loading on a shock to investment as the main proxy of the external finance premium is also an important cross-sectional determinant of average returns. The value premium has been an important yet controversial subject in the asset pricing literature. In fact, Fama and French (1993) argue that HML and SMB represent compensations for risk consistent with Merton (1973)’s ICAPM. While several models have been developed to explain these premiums, Hahn and Lee (2006) find that the size and value premiums are compensation for higher exposure to the risks related to changing credit market conditions and interest rates(monetary policy). They argue that small-sized and high book-to-market firms would be more vulnerable to worsening credit market conditions and higher interest rates since small firms tend to be young, poorly collateralized, and have limited access to external capital markets (Gertler and Gilchrist (1994)) and high book-to-market firms tend to have high financial leverage and cash flow problems. However, there is some controversy over the interpretation of Hahn and Lee (2006)’s

⁴⁵Jagannathan and Wang (1996) and Lettau and Ludvigson (2001) also report negative estimates for the market risk premium, using monthly or quarterly data.

findings since they use term spreads and default spreads as proxies for the external finance premium and monetary policy. Other hypotheses might well be developed to explain their results. My empirical results suggest that their hypotheses are indeed valid for explaining part of the size and value premium since my empirical proxies are obtained from equilibrium models more precisely and the loadings on both components price Fama-French 25 portfolios significantly.

Finally, the loading on price mark-up shock is statistically significant from models of either Cho and Moreno or Graeve. This shock determines the major component of the inflation rate. Even though stocks are claims on real asset, in the short run, they are not good hedges against inflation.⁴⁶ One possible hypothesis is that volatile inflation tends to accompany with volatile levels of real output, which induces inflation risk premium in asset markets. Using reduced form models, Brennan, Wang, and Xia (2004) also find that portion of risk premium is related to the inflation rate.

Figure 4 plots the realized versus predicted returns of the models examined. The closer a portfolio lies on the 45-degree line, the better the model can explain the returns of the portfolio. It can be seen from the graph that the ICAPM implied from Graeve's model explains the value effect comparable to Fama-French three-factor model: In general, the fitted expected returns on value portfolios (larger second digit) are higher than the fitted expected returns on growth portfolios (smaller second digit).

Recently, Lewellen, Nagel, and Shanken (2006) argue that the proposed models for the value premium do not seem to explain premium of industry portfolios. Typically, they find that most of the models are even worse than the Fama-French three factor model in explaining industry premium. Therefore, Lewellen, Nagel, and Shanken (2006) recommend that when three factors explain nearly all of the time-series variation in returns of size-B/M portfolios, we should augment them with 30 industry portfolios which don't correlate with SMB and HML as much for correct comparison of the models. Furthermore, since there are essentially three degrees of freedom in Fama-French 25 portfolios, Cochrane (2006) suggests that asset pricing models with more than three factors, should be carefully investigated even though those models tend to explain Fama-French 25 portfolios.⁴⁷ Following the suggestions of Lewellen, Nagel, and Shanken (2006), I test the robustness of the proposed empirical models by examining the ability of the competing models to price industrial portfolios. I expect that if we have meaningful asset pricing models, my proposed models should describe these asset returns better than the Fama-French model does.

⁴⁶I refer to the chapter 11 of Siegel (2002) for the details

⁴⁷Brennan, Wang, and Xia (2004) also tests their model with this 55 portfolios and finds that their model is statistically rejected. However, they don't report any intuitive statistics.

Table 5 reports the cross-sectional regression results on the 55 portfolios returns. Now ICAPMs implied from New-Keynesian models perform clearly better than unconditional CAPM or the Fama-French three factor model, in explaining the test assets in terms of the intuitive measures (both R^2 and RMSE). Therefore, suggested models clearly satisfy the robustness criteria of Lewellen, Nagel, and Shanken (2006) since they have a higher explanatory power in terms of the 55 portfolios than all the other models. The plots of figure 5 also confirm these facts. However, while permanent monetary policy shock to inflation target prices industry portfolios significantly, all other structural shocks fail to explain industry risk premium. This could reflect that while the credit channel under the capital market imperfection is important for determining the value and the size premia, interest rate channel would be more important for explaining industry premium. Peersman and Smets (2005) show that there is considerable cross-industry heterogeneity in monetary policy effects and find that durability of the output produced by the sector is an important determinant of its sensitivity to monetary policy changes. They argue these facts as evidence for interest rate/cost-of-capital channel since the demand for durable products, such as investment goods, is known to be much more affected by a rise in the interest rate through the cost-of-capital channel than the demand for non-durables such as food. Recently, Gomes, Kogan, and Yogo (2007) argue that durability of output is a risk factor since the demand for durable goods is more cyclical than that for nondurable goods and services. Consequently, the cash flow and stock returns of durable-good producers are exposed to higher systematic risk and investors request higher risk premium for that. This study might indicate that monetary policy shock is one of fundamental shocks behind this risk premium.

New-Keynesian models employed in this paper use at most eight variables in the estimation. However, this information set is very small compared to the information sets which the Fed uses for its conducts monetary policy. Since FAVAR model uses principal components of 120 monthly macro data including stock market variables for extracting state variables of the economy, the result would be robust to possible omitted variable problems in New-Keynesian models. I report the cross-sectional regression results on the 25 and 55 portfolios returns using structural shocks from FAVAR model in table 6 and figure 6.

In summary, identified monetary policy shock is a significant risk factor with same negative sign for 25 and 55 portfolios of monthly returns. This indicate that monetary policy shocks are indeed important for determining risk premium and this result is quite robust to model misspecification. While other structural shocks can be risk factors for explaining part of the value and the size premia, once confronted with industry portfolios, all the factors except for monetary policy shock lose their statistical

significance.

5 Conclusion

This study contributes to the asset pricing literature in several respects. While there seems to be ample time-series evidence of the effects of monetary policy on stock returns, it has not been clear whether monetary policy shocks affect the cross section of stock returns. Even though some research (e.g. Hahn and Lee (2006)) find that connection between the policy shocks and stock returns using indirect measure of the capital market imperfection and monetary policy, many researchers seem to be reluctant to accept the results since they are established from reduced form empirical models.

In this paper, I employ a more direct measure of the capital market imperfection and monetary policy utilizing the recent advance in monetary economics literature. In fact, the present study is the first application of New-Keynesian models to explain the cross-section of stock returns with two monetary transmission mechanisms. I show that empirical models suggested in this study provide more structural interpretation using direct measure of structural shocks.

Two empirical findings emerge from this analysis using quarterly data from 1980 to 2004 and monthly data from 1960 to 2001. First, I find that both the permanent monetary policy shock to inflation target and the shock to the external finance premium successfully capture major portions of the size and the value premia. These results support the findings of Hahn and Lee (2006) that state variables reflecting revisions in the market's expectation about future credit market conditions and interest rates explain the size and the value premia. They argue that small-sized and high-book-to-market firms would be more vulnerable to worsening credit market conditions and higher interest rates.

Second, the permanent monetary policy shock to inflation target explains part of industry risk premium with the capital market imperfection. This may well reflect that while the credit channel with the capital market imperfection is important for determining the value and the size premia, interest rate channel would be more important for explaining industry premium. Peersman and Smets (2005) show that there is a considerable amount of cross-industry heterogeneity in the overall monetary policy effects. Specifically, they find that the durability of the outputs produced by industry sector is an important determinant of its sensitivity to monetary policy changes. Recently, Gomes, Kogan, and Yogo (2007) argue that the demand for durable goods is more cyclical than that for nondurable goods and services. Consequently, the cash flow and stock returns of durable-good producers are exposed to

higher systematic risk and thus investors request higher risk premium. This study shows that monetary policy shock is one of crucial fundamental shocks behind this risk premium.

Finally, selected ICAPMs using New-Keynesian models are capable of explaining the cross-section of the Fama-French 25 size and B/M sorted portfolios significantly ($R^2=72\%$) and part of risk premia for 55 portfolios with their 30 industry portfolios ($R^2=30\%$). This result satisfies the robustness criterion of Lewellen, Nagel, and Shanken (2006) that criticize most of the empirical asset pricing models because they only explain the value premium but not any part of the risk premia of industry portfolios.

While the present study uses a reasonable approximation to the economy, several refinements can be done in the future studies. First, the current study uses exogenous pricing kernel to investigate risk premium since it mainly focuses on obtaining reasonable structural shocks frequently used in monetary economics literature. It would be interesting to see how more consistent pricing kernels using either Campbell and Cochrane (1999) type conditional models or heteroskedasticity based models could explain both the stylized facts in monetary economics and in finance. Second, New-Keynesian models with more extensive form of firm heterogeneity can be developed to explain the industry risk premium since current models seem to capture only part of it. Third, Bekaert, Cho, and Moreno (2005) extend the models of Cho and Moreno (2006) with term structure information. This extension could also be valuable for correct inferences since term structure information links the long-term and short-term interest rates and that link is regarded as a crucial channel for gauging the real effects of monetary policy on aggregate demand equation. Finally, Dedola and Lippi (2005) find sizable and significant cross-industry differences in the effects of monetary policy, using disaggregated data on twenty-one manufacturing sectors, from five industrialized countries. This fact indicates that the international New-Keynesian models could be worthwhile to develop to explain the risk premia in international stock markets.

Appendix

A Alternative approaches in monetary economics

In this section, I briefly summarize stylized facts and alternative models proposed in monetary economics before new Keynesian dynamic general stochastic equilibrium models employed in this paper are developed.

A.1 Stylized facts from time-series analysis

Simple time-series analysis such as vector autoregression(VAR) or structural vector autoregressions(SVAR) have provided the following stylized facts which must be explained with well-suited monetary economic models.⁴⁸

- Monetary policy shocks have a delayed yet persistent effect on real output. Especially positive monetary shocks lead to a hump-shaped positive response of output in USA economy.(Walsh (2001))
- Both anticipated and unanticipated shocks affect real economic activity(Mishkin (1982)).
- An increase in the money supply can reduce the real interest rate(liquidity effect) since more liquidity tends to lower the price of money which is equivalent to lowering the interest rate.

A.2 Various monetary equilibrium models with micro-foundation

From the general equilibrium models built on the joint foundations of individual optimization and flexible prices to the class of general equilibrium models built on optimizing behavior and nominal rigidities are employed in most discussions of monetary policy issues.

Lucas (1976) argue that traditional policy evaluation exercises using macroeconometric models were flawed by a failure to recognize that the relations typically estimated were actually reduced-form rather than truly structural relations. This problem can be addressed by making use of structural relations that explicitly represent the dependence of economic decisions upon expectations regarding future endogenous variables. The inclusion of significant forward-looking terms in key structural relations have substantial consequences for an analysis of the character of optimal policy.

⁴⁸Refer to chapter 1 of Walsh (2001) for a detailed explanation on time series evidence.

1. Flexible price approaches

- Lucas (1973) islands model with rational expectation and imperfect information and competitive markets is the first general equilibrium model based on the microfoundation to explain monetary facts. But in this model, only unanticipated shocks matter and it does not generate any persistence change in output.
 - Cash in advance(CIA) model or monetary real business cycle(RBC) models of Lucas (1982) and Svensson (1985)) generally share same problem with islands model because they essentially keep the same structure of the real economy as RBC models but superimpose a monetary sector. Whilst they are able to generate real-nominal interactions, the effect is not very persistent and output quickly returns to baseline.⁴⁹ Furthermore, the CIA models suffer from the same problems that generate the equity premium puzzle and these basic CIA models are also not very successful in generating plausible asset price and interest rate data.(Giovannini and Labadie (1991))
 - CIA augmented with limited participation mechanism proposed by Fuerst (1992) explains the liquidity effect successfully but it is too complicated by altering the structure of CIA models with limited participation only for explaining the liquidity effect. It is criticized since the appropriate model will have to involve greater complexity than simply assuming certain prices are fixed.
2. RBC with sticky prices alone fails to solve the persistence problem.(V. V. Chari and McGrattan (2000)) They argue that real rigidity in labor market should be added since the wage rate and prices react too strongly in their model to money supply shocks to have persistent output effects.

3. Empirical results and other ideas

- Hodrick, Kocherlakota, and Lucas (1991) find that classical CIA models fail to explain the variability of velocity with reasonable assumptions on the levels of risk aversion.
- Cooley and Hansen (1989) introduce the concept of inflation tax :when inflation is high, the real value of money declines sharply so that agents will hold less money. Since cash is required to finance consumption purchases, this high inflation causes lower consumption and so a nominal variables will affect a real variable. Therefore, inflation acts as a tax on goods which require money to be purchased and as a subsidy on credit goods which do not require

⁴⁹Money in the utility function model has similar problems. Actually, it is well known that under certain conditions there exists an equivalence between putting money in the utility function or specifying cash in advance constraint.

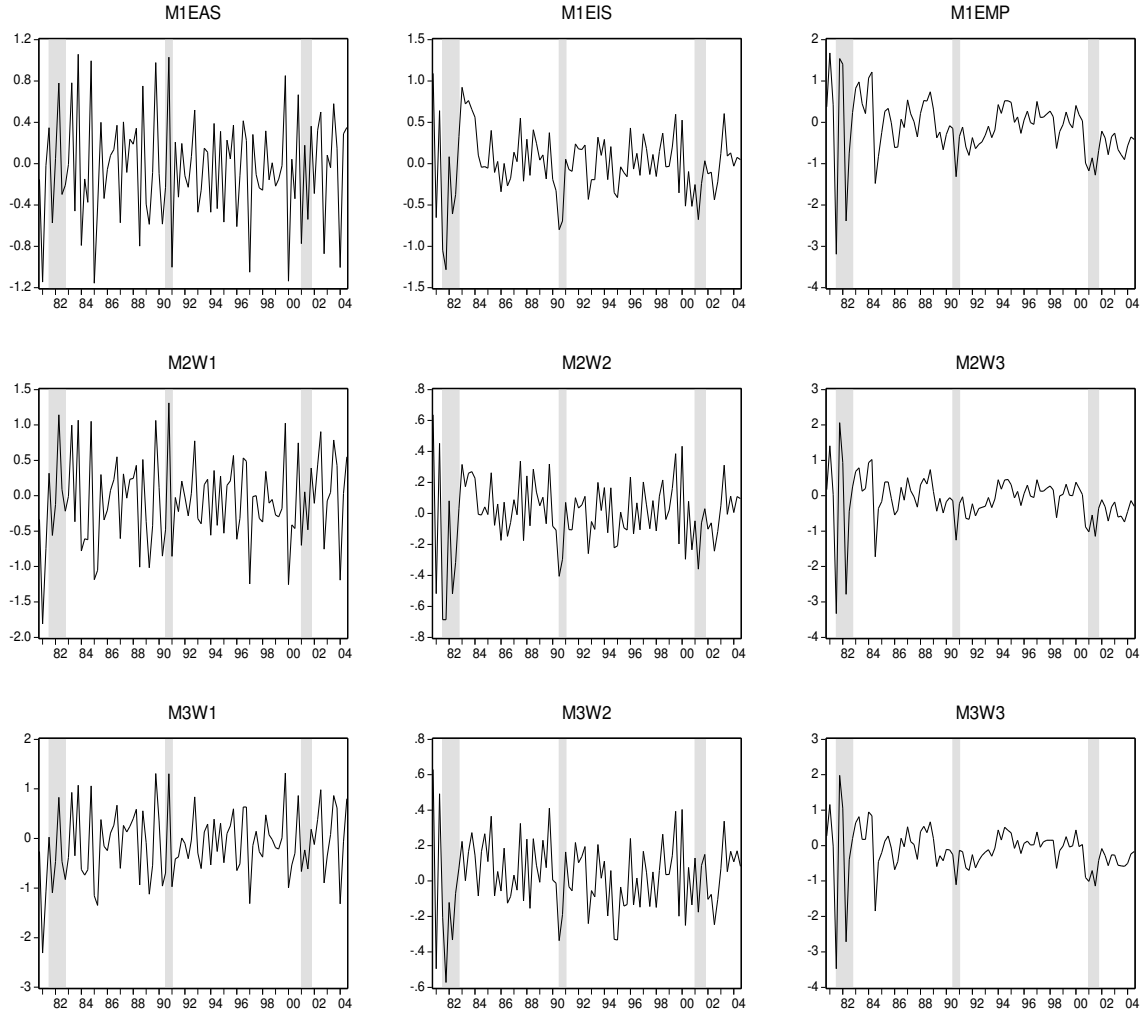
cash. However, this mechanism of non-neutrality is not enough to explain the interaction between real and nominal variables in the data.

- The nominal interest rates is often viewed through the Fisher hypothesis; The nominal interest rate equals the real interest rate plus the expected inflation rate. Therefore, an increase in the money supply can have two effects: it can reduce the real interest rate (liquidity effect) and it forecasts higher future inflation. Therefore to generate a falling nominal interest rate in response to a positive money supply shock, the liquidity effect should outweigh the Fisher effect. However, in neoclassical models money does not influence real variables (the real interest rate), increases in the money supply just forecast higher inflation and so the nominal interest rates rises as there is no liquidity effect but only a Fisher effect.

4. New-Keynesian approaches with microfoundation⁵⁰

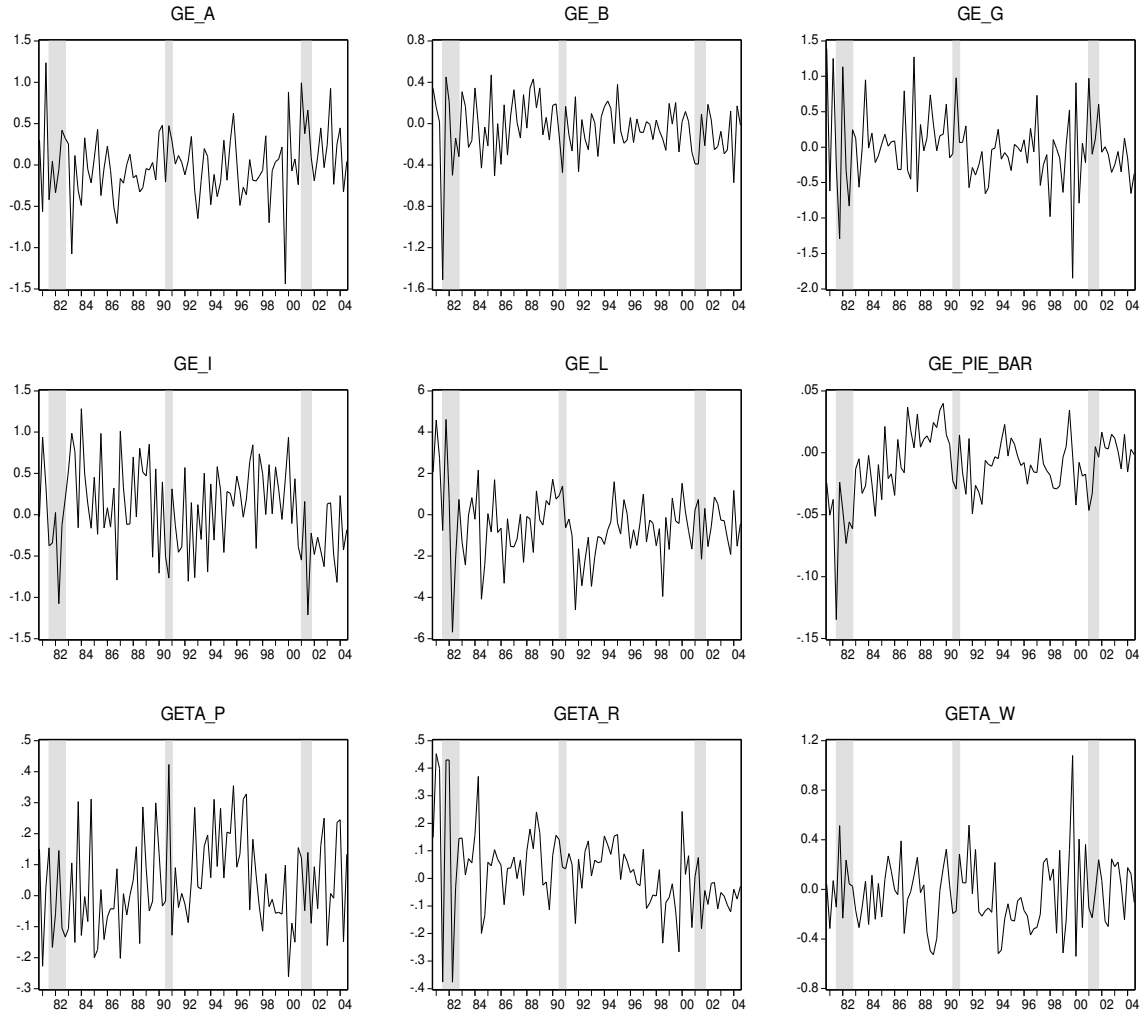
In order to explain a large degree of inflation inertia and persistent impact on output of monetary policy shocks, the New-Keynesian framework assumes that firms operate in monopolistic competitive markets and production is constrained by aggregate demand. Prices are assumed to be sticky and consequently do not move instantaneously to movements in marginal costs. Due to the price stickiness, the central bank affects aggregate demand through its influence on real interest rates. By lowering real interest rates, the central bank induces higher aggregate demand, marginal costs and prices than would otherwise materialize. For example, Rotemberg and Woodford (1999) use a dynamic IS curve based on intertemporal maximization and an aggregate supply curve based on the sticky prices in the New Keynesian Phillips curve. Rather than assuming a cash-in-advance constraint and facing the problems of generating substantial liquidity effects, they jump directly to a formulation in which the instrument of monetary policy is the interest rate itself. (Monetary policy rule) Following this approach, many New-Keynesian models are developed as they are summarized in this paper.

⁵⁰I refer to Woodford (2003) for details



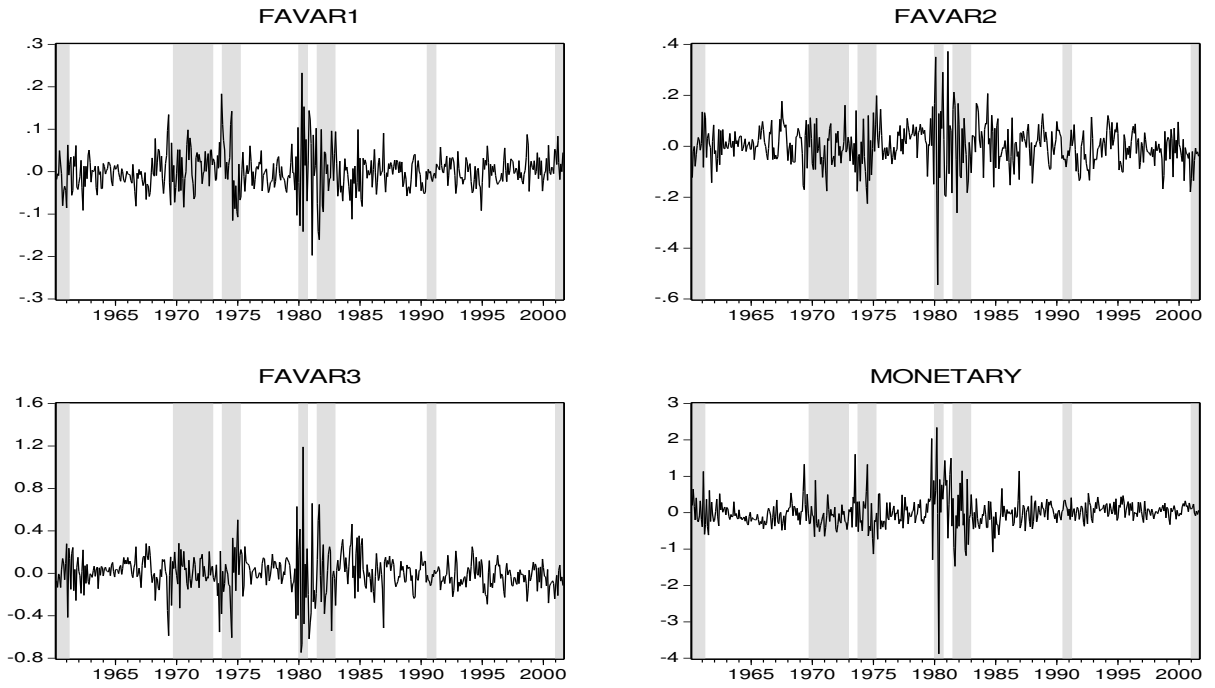
This figure plots the quarterly time series of smoothed structural shocks implied by three-equation New-Keynesian DSGE of Cho and Moreno(2006) Note: EAS or W1 is the estimated aggregate shocks(AS);EIS or W2 is the estimated IS shocks;EMP or W3 is the estimated monetary policy shocks;M1 stands for their baseline New-Keynesian models;M2 stands for M1 augmented with autocorrelation in structural shocks;M3 stands for M2 augmented with cross-correlation in structural shocks. Shared areas indicate NBER business recessions.

Figure 1: Estimated modes of Smoothed Structural Shocks from Cho and Moreno(2006,1980:4-2004:4)



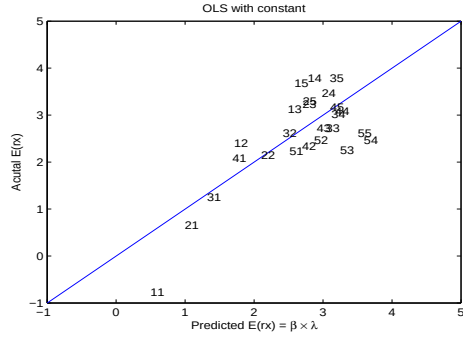
This figure plots the quarterly time series of smoothed structural shocks implied by the extended New-Keynesian DSGE of Graeue(2006) Note: GE_A is the estimated technology shocks;GE_B is the estimated preference shocks;GE_G is the estimated government spending shocks;GE_I is the estimated shocks to investment technology; GE_L is the estimated labor demand shocks;GE_PIE_BAR is the estimated shocks to inflation target set by the Federal reserve(permanent monetary policy shocks);GETA_P is the estimated price mark-up shocks;GETA_R is the estimated temporary monetary policy shocks;GETA_W is the estimated wage mark-up shocks. Shared areas indicate NBER business recessions.

Figure 2: Estimated modes of Smoothed Structural Shocks from Graeue(2006)(1980:4-2004:4)

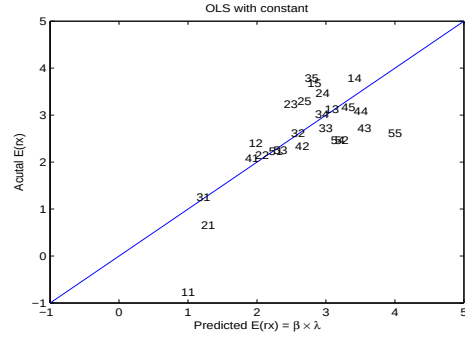


This figure plots the monthly time series of smoothed structural shocks implied by Factor-augmented VAR of Bernanke, Boivin and Elias (2005). Note: FAVAR1 is the estimated shocks from the first latent factors; FAVAR2 is the estimated shocks from the first latent factors; FAVAR3 is the estimated shocks from the first latent factors; MONETARY is the estimated monetary policy shocks. Shaded areas indicate NBER business recessions.

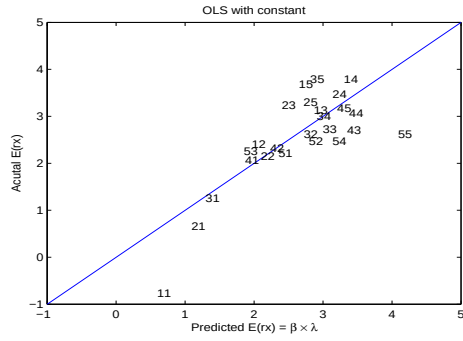
Figure 3: Estimated modes of Smoothed Structural Shocks from FAVAR(1960:3-2001:8)



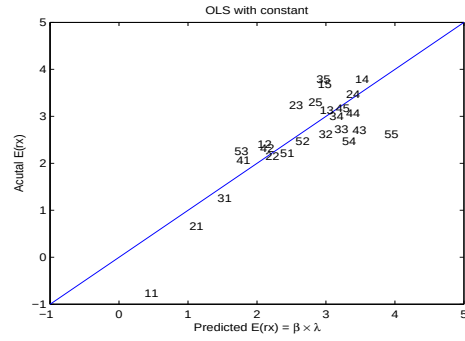
(a) Unconditional CAPM



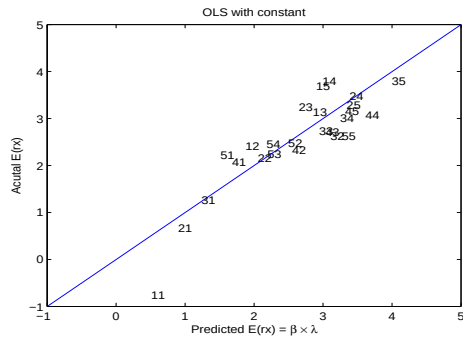
(b) Model1



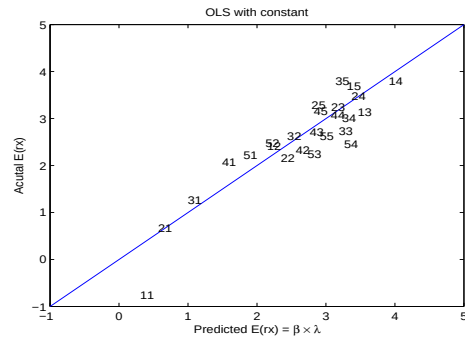
(c) Model2



(d) Model3



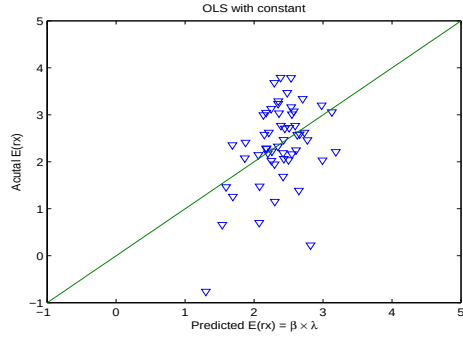
(e) GRAEVE



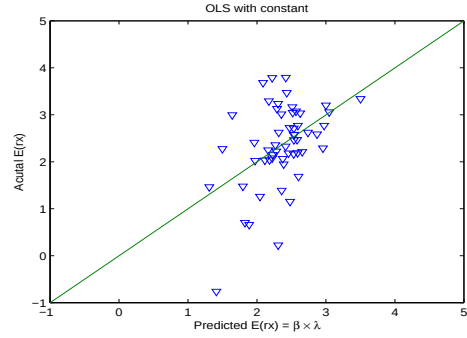
(f) Fama-French Three-factor model

The plot shows realized average returns (in percent) on the vertical axis and fitted expected returns (in percent) on the horizontal axis for 25 size and book-to-market sorted portfolios. The first digit refers to the size quintile (1 being the smallest and 5 the largest), while the second digit refers to the book-to-market quintile (1 being the lowest and 5 the highest). For each portfolio, the realized average return is the time-series average of the portfolio return and the fitted expected return is the fitted value for the expected return from the corresponding model. The straight line is the 45-degree line from the origin. All models are defined in section 4.2.1.

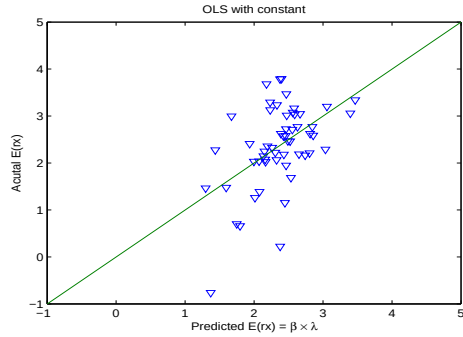
Figure 4: Fitted Expected Returns Versus Average Realized Returns for the Fama French 25 portfolios(1980:4-2004:4)



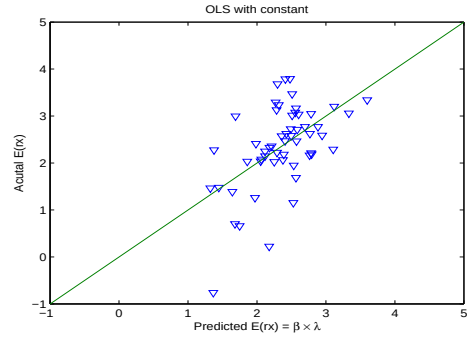
(a) Unconditional CAPM



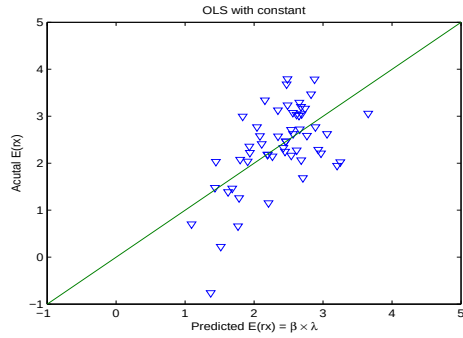
(b) Model1



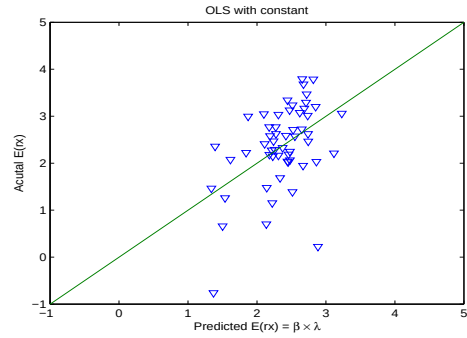
(c) Model2



(d) Model3



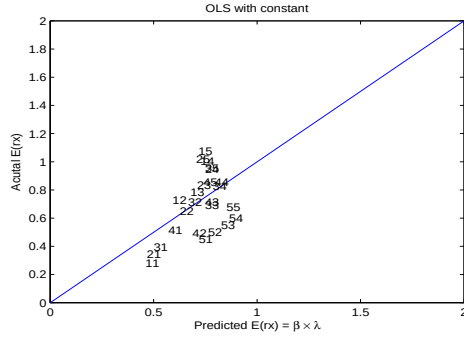
(e) GRAEVE



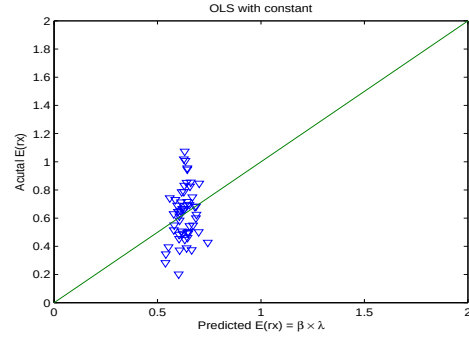
(f) Fama-French Three-factor model

The plot shows realized average returns (in percent) on the vertical axis and fitted expected returns (in percent) on the horizontal axis for 25 size and book-to-market sorted portfolios and 30 industry portfolios. For each portfolio, the realized average return is the time-series average of the portfolio return and the fitted expected return is the fitted value for the expected return from the corresponding model. The straight line is the 45-degree line from the origin. All models are defined in section 4.2.1.

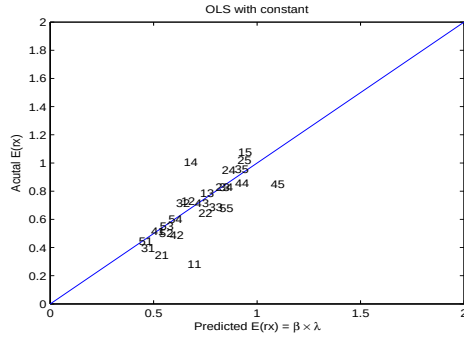
Figure 5: Fitted Expected Returns Versus Average Realized Returns for the Fama French 25 portfolios and 30 Industry portfolios(1980:4-2004:4)



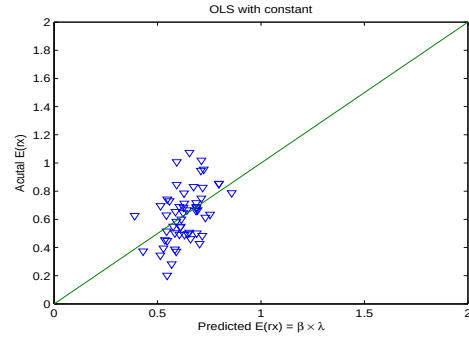
(a) Unconditional CAPM(25)



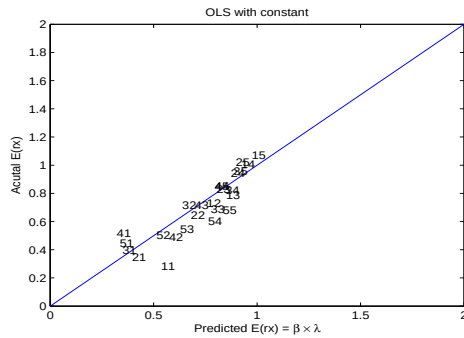
(b) Unconditional CAPM(55)



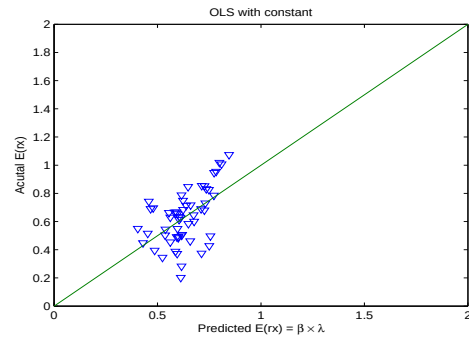
(c) FAVAR(25)



(d) FAVAR(55)



(e) Fama-French Three-factor model(25)



(f) Fama-French Three-factor model(55)

The plot shows realized average returns (in percent) on the vertical axis and fitted expected returns (in percent) on the horizontal axis for 25 size and book-to-market sorted portfolios and 30 industry portfolios. For each portfolio, the realized average return is the time-series average of the portfolio return and the fitted expected return is the fitted value for the expected return from the corresponding model. The straight line is the 45-degree line from the origin. All models are defined in section 4.2.1.

Figure 6: Fitted Expected Returns Versus Average Realized Returns for the Fama French 25 portfolios and the 55 portfolios with 30 Industry portfolios(1960:3-2001:8)

Table 1: Summary Statistics for Cho and Moreno(2006)

Summary statistics for structural shocks from Cho and Moreno(2006) from 1980:4 to 2004:4. The Auto(1) give the first autocorrelation. Note: EAS or W1 is the estimated aggregate shocks(AS);EIS or W2 is the estimated IS shocks;EMP or W3 is the estimated monetary policy shocks;M1 stands for their baseline New-Keynesian models;M2 stands for M1 augmented with autocorrelation in structural shocks;M3 stands for M2 augmented with cross-correlation in structural shocks.

	M1EAS	M1EIS	M1EMP	M2EAS	M2EIS	M2EMP	M3EAS	M3EIS	M3EMP
Panel A: Correlation Matrix									
M1EAS	1.000								
M1EIS	-0.074	1.000							
M1EMP	-0.271	0.322	1.000						
M2EAS	0.945	-0.108	-0.354	1.000					
M2EIS	-0.113	0.954	0.286	-0.153	1.000				
M2EMP	-0.245	0.267	0.975	-0.316	0.251	1.000			
M3EAS	0.889	-0.030	-0.322	0.963	-0.036	-0.288	1.000		
M3EIS	-0.109	0.840	-0.042	-0.156	0.907	-0.046	-0.072	1.000	
M3EMP	-0.232	0.292	0.970	-0.272	0.283	0.991	-0.232	-0.032	1.000
Panel B:Univariate Summary Statistics									
Mean	-0.045	0.004	-0.122	-0.071	0.001	-0.095	-0.103	0.028	-0.118
Skewness	-0.088	-0.181	-0.805	-0.059	-0.409	-1.360	-0.134	-0.032	-1.516
Std. Dev.	0.507	0.396	0.715	0.609	0.226	0.692	0.681	0.208	0.686
Kurtosis	2.798	4.003	6.498	2.947	4.180	9.617	3.132	3.452	10.276
Auto(1)	-0.438	0.179	0.189	-0.192	-0.095	0.028	-0.097	-0.128	0.034

Table 2: Summary Statistics for Graeve(2006)

Summary statistics for structural shocks from Graeve(2006) from 1980:4 to 2004:4. The Auto(1) give the first autocorrelation. Note: GE_A is the estimated technology shocks;GE_B is the estimated preference shocks;GE_G is the estimated government spending shocks;GE_I is the estimated shocks to investment technology; GE_L is the estimated labor demand shocks;GE_PIE_BAR is the estimated shocks to inflation target set by the Federal reserve(permanent monetary policy shocks);GETA_P is the estimated price mark-up shocks;GETA_R is the estimated temporary monetary policy shocks;GETA_W is the estimated wage mark-up shocks.

	GE_A	GE_B	GE_G	GE_I	GE_L	GE_PIE_BAR	GETA_P	GETA_R	GETA_W
Panel A: Correlation Matrix									
GE_A	1.000								
GE_B	-0.019	1.000							
GE_G	0.389	0.000	1.000						
GE_I	-0.209	0.100	-0.055	1.000					
GE_L	0.242	0.006	0.301	0.196	1.000				
GE_PIE_BAR	-0.041	0.644	-0.062	0.082	-0.031	1.000			
GETA_P	-0.067	-0.230	0.148	-0.317	-0.013	0.077	1.000		
GETA_R	0.185	0.409	0.327	0.307	0.658	-0.017	-0.200	1.000	
GETA_W	0.002	-0.109	-0.316	-0.269	0.030	0.063	-0.081	-0.273	1.000
Panel B:Univariate Summary Statistics									
Mean	-0.008	-0.045	-0.022	0.073	-0.529	-0.011	0.041	0.029	-0.038
Std. Dev.	0.405	0.282	0.524	0.522	1.666	0.026	0.152	0.148	0.276
Skewness	-0.033	-1.402	0.168	-0.084	0.025	-1.138	0.364	0.302	0.684
Kurtosis	4.826	8.976	4.653	2.461	4.594	6.768	2.405	4.528	4.444
Auto(1)	-0.127	-0.183	-0.305	-0.020	0.202	0.454	-0.023	0.084	0.018

Table 3: Correlation Matrix of Identified Monetary Policy Shocks

This Table reports correlation matrix of identified monetary policy shocks from Cho and Moreno(2006) and Graeve(2006) from 1980:4 to 2004:4. Note: M1EMP is the estimated monetary policy shocks from model 1; M2EMP is the estimated monetary policy shocks from model 2;M3EMP is the estimated monetary policy shocks from model 3;GE_PIE_BAR is the estimated shocks to inflation target set by the Federal reserve(permanent monetary policy shocks);GETA_R is the estimated temporary monetary policy shocks.

	M1EMP	M2EMP	M3EMP	GE_PIE_BAR	GETA_R
M1EMP	1.000				
M2EMP	0.975	1.000			
M3EMP	0.970	0.991	1.000		
GE_PIE_BAR	0.302	0.357	0.376	1.000	
GETA_R	0.770	0.737	0.740	-0.017	1.000

Table 4: Cross-Sectional Tests of Asset Pricing Models on Fama French 25 size-B/M portfolios(1980:4-2004:4)

The table presents the estimated results of the second step cross-sectional regression using the excess returns on 25 portfolios sorted by book-to-market and size. The full-sample factor loadings, which are the independent variables in the regressions, are computed in one multiple time-series regression following the suggestions of Lettau and Ludvigson (2001). The Adjusted R^2 follows the specification of Jagannathan and Wang (1996). The standard errors are obtained from posterior distribution of estimated parameters. The last column reports the root mean squared pricing errors of the model. Note: Rmrf, SMB, and HML are the Fama and French (1993)'s market and size and B/M factors; Model 1, 2 and 3 are defined in section 2.3.1, which use aggregated supply shock(AS), IS shock and monetary policy shock from Cho and Moreno (2006); GRAEVE use investment shock as a proxy for the external finance premium, price mark-up shock, permanent monetary policy shock or shock to the inflation target(monetary1) and temporary monetary policy shock(monetary2).

Models	Variables	Statistics					
CAPM	constant	Rmrf				Adj.R2	RMSE
	0.058	-3.252				0.574	0.0063
S.E.	0.011	1.405					
Fama-French	constant	Rmrf	SMB	HML		Adj.R2	RMSE
	0.089	-6.845	-0.029	1.233		0.795	0.0042
S.E.	0.015	1.745	0.607	0.838			
Model1	constant	AS	IS	Monetary		Adj.R2	RMSE
	0.035	-0.577	-0.473	-0.382		0.508	0.0065
S.E.	0.008	0.205	0.157	0.357			
Model2	constant	AS	IS	Monetary		Adj.R2	RMSE
	0.038	-0.691	-0.231	-0.246		0.579	0.006
S.E.	0.008	0.255	0.059	0.314			
Model3	constant	AS	IS	Monetary		Adj.R2	RMSE
	0.038	-0.829	-0.201	-0.266		0.644	0.0055
S.E.	0.008	0.293	0.053	0.318			
Graeve	constant	Investment	Monetary1	price-markup	Monetary2	Adj.R2	RMSE
	0.042	-0.619	-0.029	-0.094	-0.035	0.721	0.0048
S.E.	0.008	0.205	0.011	0.048	0.051		

Table 5: Cross-Sectional Tests of Asset Pricing Models on Fama French 25 size-B/M and 30 industry portfolios(1980:4-2004:4)

The table presents the estimated results of the second step cross-sectional regression using the excess returns on 25 portfolios sorted by book-to-market and size together with 30 industry portfolios. The full-sample factor loadings, which are the independent variables in the regressions, are computed in one multiple time-series regression following the suggestions of Lettau and Ludvigson (2001). The Adjusted R^2 follows the specification of Jagannathan and Wang (1996). The standard errors are obtained from posterior distribution of estimated parameters. The last column reports the root mean squared pricing errors of the model. Note: Rmrf, SMB, and HML are the Fama and French (1993)'s market and size and B/M factors; Model 1, 2 and 3 are defined in section 2.3.1, which use aggregated supply shock(AS), IS shock and monetary policy shock from Cho and Moreno (2006); GRAEVE use investment shock as a proxy for the external finance premium, price mark-up shock, permanent monetary policy shock or shock to the inflation target(monetary1) and temporary monetary policy shock(monetary2).

Models	Variables	Statistics					
CAPM	constant	Rmrf				Adj.R2	RMSE
	0.038	-1.546				0.167	0.0079
S.E.	0.009	1.298					
Fama-French	constant	Rmrf	SMB	HML		Adj.R2	RMSE
	0.037	-1.628	-0.105	1.03		0.184	0.0076
S.E.	0.009	1.257	0.595	0.808			
Model1	constant	AS	IS	Monetary		Adj.R2	RMSE
	0.028	-0.119	-0.202	-0.063		0.165	0.0077
S.E.	0.008	0.109	0.121	0.241			
Model2	constant	AS	IS	Monetary		Adj.R2	RMSE
	0.029	-0.118	-0.094	-0.139		0.206	0.0075
S.E.	0.008	0.144	0.063	0.237			
Model3	constant	AS	IS	Monetary		Adj.R2	RMSE
	0.029	-0.198	-0.069	-0.154		0.253	0.0073
S.E.	0.008	0.177	0.057	0.237			
Graeve	constant	Investment	Monetary1	price-markup	Monetary2	Adj.R2	RMSE
	0.031	-0.173	-0.014	0.016	-0.003	0.3	0.007
S.E.	0.008	0.182	0.005	0.037	0.042		

Table 6: Cross-Sectional Tests of Asset Pricing Models on Fama French 25 size-B/M or 55 portfolios with 30 industry portfolios(1960:3-2001:8)

The table presents the estimated results of the second step cross-sectional regression using the excess returns on 25 portfolios sorted by book-to-market(Panel A) or 55 portfolios with 30 industry portfolios.(Panel B) The full-sample factor loadings, which are the independent variables in the regressions, are computed in one multiple time-series regression following the suggestions of Lettau and Ludvigson (2001). The Adjusted R^2 follows the specification of Jagannathan and Wang (1996). The standard errors are obtained from posterior distribution of estimated parameters. The last column reports the root mean squared pricing errors of the model. Note: Rmrf, SMB, and HML are the Fama and French (1993)'s market and size and B/M factors; Latent 1,2 and 3 are extracted structural shocks from FAVAR model. Monetary stands for identified monetary shock from FAVAR.

Panel A. 25 portfolios							
CAPM	constant	Rmrf				Adj.R2	RMSE
	0.014	-0.624				0.214	0.0019
S.E.	0.004	0.432					
Fama-French	constant	Rmrf	SMB	HML		Adj.R2	RMSE
	0.013	-0.756	0.129	0.439		0.752	0.001
S.E.	0.003	0.394	0.134	0.146			
FAVAR	constant	latent1	latent2	latent3	Monetary	Adj.R2	RMSE
	-0.001	-0.035	0.057	0.21	-0.539	0.508	0.0014
S.E.	0.003	0.022	0.029	0.093	0.192		
Panel B. 55portfolios							
CAPM	constant	Rmrf				Adj.R2	RMSE
	0.009	-0.228				0.03	0.0018
S.E.	0.003	0.349					
Fama-French	constant	Rmrf	SMB	HML		Adj.R2	RMSE
	0.009	-0.347	0.113	0.249		0.244	0.0016
S.E.	0.003	0.335	0.147	0.137			
FAVAR	constant	latent1	latent2	latent3	Monetary	Adj.R2	RMSE
	0.003	-0.007	0.004	0.051	-0.194	0.146	0.0017
S.E.	0.003	0.01	0.016	0.043	0.099		

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