Pontifícia Universidade Católica
do Rio de Janeiro

Max Cramer

Macroeconomic factors in asset pricing: an analysis of out-of-sample robustness

Dissertação de Mestrado

Dissertation presented to the Programa de Pós–graduação em Economia da PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Economia.

Advisor: Prof. Ruy Monteiro Ribeiro

Rio de Janeiro
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Abstract

Cramer, Max; Ribeiro, Ruy Monteiro (Advisor). **Macroeconomic factors in asset pricing: an analysis of out-of-sample robustness**. Rio de Janeiro, 2018. 41p. Dissertação de Mestrado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

This study aims to identify the macroeconomic factors constituting the systematic risk for US asset prices and mutual fund returns using the Arbitrage Pricing Theory in the spirit of Chen, Roll and Ross (1986). We find that the model does not explain the cross-section of stock returns well in the most recent sample and that risk premia estimates are not stable.

Keywords

Asset Pricing; Macroeconomic Factors; Mutual Funds; Arbitrage Pricing Theory.

Resumo

Cramer, Max; Ribeiro, Ruy Monteiro (Advisor). **Macroeconomic factors in asset pricing: an analysis of out-of-sample robustness.** Rio de Janeiro, 2018. 41p. Dissertação de Mestrado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Este estudo tem como objetivo identificar os fatores macroeconômicos que constituem o risco sistemático para preços de ativos dos EUA e retornos de fundos mútuos usando a Teoria do Preço de Arbitragem, inspirado metodologicamente pelo Chen, Roll e Ross (1986). Concluímos que o modelo não explica bem o cross-section dos retornos nas ações na amostra mais recente e que as estimativas dos prêmios de risco não são estáveis.

Palavras-chave

Apreçamento de Ativos; Fatores Macroeconômicos; Fundos de Investimento; Arbitrage Pricing Theory.

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1.
Introduction

Much has been written about the forces that drives asset prices. The academic groundbreaker of modern asset pricing models, namely the Capital Asset Pricing Model (CAPM), has been developed by the pioneers Sharpe (1964), Lintner (1965) and Black (1972). This one factor approach to capture the systematic risk were later extended by Merton (1973), Long (1974), Rubinstein (1976), Breeden (1979), and Cox et al. (1985) to intertemporal models. They build on the breakthrough research of Harry M. Markowitz (1952), who ultimately linked and quantified the risk and return of an asset or a portfolio of assets. The fundamental insight that more return can only be archived by assuming more risk is one of the few uncontested paradigms of financial economics. An equally important understanding is the differentiation between systematic/pervasive and idiosyncratic risk. While latter is only relevant for some assets or group of assets and can therefore be diversified away in portfolios, the former can`t. This implies that a rational investor should only be compensated for assuming systematic risk, and the challenge asset pricing models must master is defining the systematic risk. Although Ross (1976) did not challenge these principles, he enriched the debate by stating that only if the true market portfolio were used in the tests we could rely on the results. As the true market is not observable, his Arbitrage Pricing Theory (APT) successfully laid the foundation for using multi-factor models. In this framework, which is free of theoretical limitations to which kind of factor qualifies as component of the pricing set, systematic risk can be captured by more than one factor. The most acknowledged multi-factor model might be the Fama and French (1992) model and its extensions. In stark contrast to the CAPM the model has neither a widely accepted theoretical foundation for the choice of its factors nor about the economic implications of its significance. The justification for the pricing set composition is purely empirical instead, resulting of various observed patterns which first were treated as anomalies contradicting the predictions of the CAPM. The lack of comprehensive theory is compensated by the statistical explanatory power of the models in explaining the cross section of asset returns.

This study tries a different path. In the spirit of Chan, Chen and Hsieh (1985, hereafter CCH) and Chen, Roll and Ross (1986, hereafter CRR), different methods of innovation creation in macro series will be tested in cross sectional test procedures to see whether they constitute a pervasive set of factors, therefore, the systematic risk. The motivation for the use of macroeconomic series in APT models is the theoretic ease to interpret these models. We focus on US-American equity prices.

We will first give a short overview of the literature of multi-factor models with macroeconomic series in chapter 2. The next chapter first explains the technical aspects of innovation generation and then reports the testing procedure. Chapter 4 summarizes and interprets my results. Chapter 5 shows two case studies which aim to link the CRR factors to mutual fund returns.

Additionally, I show what aspects might be crucial for linking asset prices with fundamental economic risk.

2.
Literature Overview

Standard asset pricing models (APM) often use the discounted cash flow framework to describe one possibility how prices should be set. According to it, price fluctuations are caused by changes in expected cash flows or the rate at which investors discount these future pay offs. As aforementioned, possible diversification implies that investors will only be compensated for bearing systematic risk, as firm specific risks can be diversified away by compiling a portfolio of assets with countervailing risk exposures. In the long run, the return on assets must reflect the deterministic force of systematic economic variables. CRR described the state of defining the systematic risk factors as following: “A rather embarrassing gap exists between the theoretically exclusive importance of systematic "state variables" and our complete ignorance of their identity”. Although an endogeneity problem emerges when linking asset returns with macroeconomic series, economic theory, especially equilibrium models, offer good arguments for using economic state variables in APMs. There is a huge variety of APM types to choose from.

2.1.
CRR categorization and replications

The relationship between macroeconomic variables can be investigated in long term models, as in Humpe, A., and Macmillan, P., (2007) using a Vector Autoregession (VAR) model. This framework allows for flexibility regarding the speed of transition from macroeconomic shocks to a respond in asset prices. Furthermore, these models also allow for an indirect relationship via all variables included in the VAR. By including lags of the dependent variables, the responses don’t have to be immediate.

For finding an immediate response to exogenous shocks the Fama and Macbeth (1973) approach, constituting of two different linear regression types, is the most common model. The practical procedure for implementing the APT is conducted by first running time series regressions, then using the time series coefficients (=loadings) in cross sectional regressions to get the risk premia per independent variable. This approach follows the reasoning of the Efficient Market

Theory statement, that financial markets are informationally efficient when all available information is priced fairly quick. The task one must master therefore is first to identify the economic factors constituting the non-diversifiable risk. Then we must manipulate the data in a way that fulfill the technical requirements of the used model and match the characteristics of the explanatory data as investors perceive it. Only macroeconomic surprises will be allowed to enter the APT model. As CRR elaborates, it is a problem that available macroeconomic series normally are altered (smoothed, averaged etc). This creates the challenge to extract the relevant new information. A guide to the technical objectives is Burmeister et al (1988), where the requirements for factors entering an APT model are listed:

1. *At the beginning of every period, the factor must be completely unpredictable to the market.*

2. *Each APT factor must have a pervasive influence on stock returns.*

3. *Relevant factors must influence expected return; i.e., they must have non-zero prices.*

If there is a pervasive influence can by verified by subsampling over longer periods of time. Regarding the search for a model and the economic factor examined in it, CCH and CRR are the primary reference points of this study. The risk factors here are predefined, observable macroeconomic factors which are selected based on economic intuition, derived by equilibrium models. Shanken and Weinstein (2006) point out that the selection of the factors is justified by intertemporal models and Shanken (1987) further explain that these macroeconomic factors can be depicted as a “multivariate proxy for the unobservable equilibrium benchmark”. The risk premium per factor is estimated by the Fama and Macbeth (1973) approach. The identified factors are: the growth rate of industrial production, expected inflation, unexpected inflation, a bond default risk premium, and a term structure spread. The innovation in these series are simply first differences of the macroeconomic variables of interest. The test assets (TAs), therefore the independents, are value weighted and equally weighted portfolios of NYSE-listed stocks. Latter is being dropped due to the usefulness of value weighted indices in correcting for error in variables problems.

The default and term premium are found to be priced risk factors and industrial production remains a strong candidate for being one. The economic reasoning for these significances is that the discount rate changes with the yield curve spreads across different maturities and with changes in the level of rates, both captured by the two spread factors. Changes in industrial production should influence the current value of future cash flows, therefore also cause changes in today's equity prices. Besides these theoretical points, M.A. Berry, E. Burmeister, and M.B. McElroy (1988) show that we can at least take it for granted that economic factors add explanatory power to the CAPM.

There are various authors who tried to replicate the findings of CRR, with varying degree of success. The five-factor model is tested intensively for robustness, also to counter sceptics, as Fama (1991) noted:

> Since multifactor models offer at best vague predictions about the variables that are important in returns and expected returns, there is the danger that measured relations between returns and economic factors are spurious, the result of special features of a particular sample (factor dredging). Thus, the Chen, Roll and Ross tests, and future extensions, warrant extended robustness checks.

Cutler, Poterba, and Summers (1989) for example state that industrial production growth is significantly positively correlated with real stock returns over the period 1926-1986, but not in the 1946-1985 subperiod, overlapping CRR's 1958-1984 sample period. Investigations of non-US markets also are mostly based on the Chen et al. (1986) approach. Hamao (1988) tested the Japanese market and found strong pricing evidence, except for the case of Japanese monthly production. Martinez and Rubio (1989) used Spanish data and found no significant pricing relationship between stock returns and macroeconomic variables.

Poon and Taylor (1991) are also unable to explain stock returns in the UK by the factors used by Chen et al. (1986) Antoniou, Garrett and Priestley (1998) test the pricing set on stocks listed on the London Stock Exchange, explicitly addressing the Fama (1991) hurdle. By testing the pricing set allowing for idiosyncratic risk among stocks to be correlated, they find significant risk premia for unexpected inflation, the money supply and excess returns on the market portfolio, latter two not included in the CRR pricing set. Shanken and Weinstein (2006) report significantly diverging results relative to CRR and CCH by changing the beta estimation process in the first regression step. They also conclude that only industrial production is significantly priced between 1958 and 1983 in 20 size portfolios. Panetta (2001) discusses the reasons for these mixed results. The hypothesis, that the estimated instability in the relationship is due to estimation errors, is rejected. Using Italian equity prices across different risk classes and subsampling these over different time periods the author find that the factor rotation observed by the huge majority of researches is rooted in structural problems. The reason for this "true instability" could be that investors' reaction to innovation in economic series differ along business cycle stages or that the relationship is non-linear. As the APT model only tests for a multivariate, linear and pervasive relationship, this is its major blind spot.

Furthermore, there are various studies which tried to test for an indirect link between a macroeconomic pricing set and equity prices via the statistically highly significant Fama and French (1992) and extensions factors. Vassalou (2003) argues that the ability of the Fama-French model to explain the crosssection of mean returns can be attributed to the fact that Fama-French factors provide good proxies for macroeconomic factors. In Fama and French (1995) a possible link to firm's fundamentals is scratched. Kelly (2003) presents evidence for 18 countries where HML and SMB portfolios are correlated with future innovations in inflation and real economic growth. Hahn and Lee (2006) find that changes in term and default yield spreads capture most of the systematic risks proxied by size and B/M effects.

2.2.
Innovation extraction as optimization factor: a possible extension

Market participant's perceptiveness of macroeconomic factors is a point which is additionally addressed in this work, and which is directly linked to the technical and theoretical requirements for APT models. The basic assumptions Ross (1976) impose on financial markets is that there cannot be arbitrage opportunities over time. In aggregate, there should be enough market participants able to take advantage of risk free profit opportunities, eliminating these. This is the reasoning behind the requirement that factors must be unpredictable, only new information should cause price fluctuations. Technically spoken, the unanticipated components should be mean-zero, serially uncorrelated white-noise processes.

As argued by Priestley (1996) and Antoniou, Garrett and Priestley (1998), the process of extracting new information out of macroeconomic series demands some prior assumptions about investor's expectation generation process. Priestley (1996) discuss three methods: First of all, rate of change methods, where factors are simply the first differences of series, as used in CRR. In Autoregressive (AR) and Kalman Filter (KF) modelling the residuals from the models are used as factors. He concludes "that the rate of change methodology fails to provide the basic criteria that the unexpected components are serially uncorrelated and the autoregressive methodology fails to provide an expectations generating process that avoids the possibility of agents making systematic forecast errors." The latter point to Lucas (1976) critique, that parameters of models could change. The Kalman Filter modelling of time series is therefore the only methodology that does not exhibit any of the problems. This study applies all three methods to check their explanatory power after ascertaining if the rate of change factors possesses unit roots. If testing show that autoregressive residuals have a significant and pervasive effect on asset prices the implication for our assumptions about agents' learning capability should be discussed.

The next chapters first provide information about the origins of the used series and show how the unexpected components were derived. Next, the tests are described mathematically and the results are presented. There are several questions addressed, each aiming to classify the relevance of macroeconomic innovation for asset prices: Can we find significant and non-zero prices for macro factors in the cross section of US market returns?

There are also two different case studies discussed in the appendix. There we check if the risk premia estimates differ for returns of professionally managed portfolios. And lastly, we ask if a link from economic fundamentals to traditional performance measurement can be drawn. The framework here is Jensen's Alpha, gained by running time series regressions with Fama and French (1992) factors.

Then tests are conducted to see if the unexplained part of that model covariate with macroeconomic innovation over time.

3.
Data description and manipulation

3.1.
Data origin and description

All used data is in monthly frequency, ranging from 01/1964 to 12/2016. The original series aren't seasonally adjusted to avoid the use of future data not available in t. The data were obtained from Center for Research in Security Prices (CRSP), Federal Reserve Economic Data (FRED), Kenneth R. French´s website and Moody`s database for corporate bond returns.

Origins of economic series and transformation:

	Original Series	Alterations
Industrial production (MP)	Industrial Production Index, FRED	Growth rate $\frac{x_t}{x_{t-1}}$ -1 of log of index, first difference taken
Contemporaneous unanticipated inflation (UI)	Consumer Price Index, Bureau of Labor Statistics for inflation and CRSP Database: "US Treasury and Inflation Indexes" for 30 days T Bills returns	Growth rate $\frac{x_t}{x_{t-1}}$ -1 of log of index is inflation, subtracted $E[\pi_t]$ = Tbill_t-$\sum_{j=1}^{12}\text{Tbill}_{t-j}$ so that UI=π_t- $E[\pi_t]$
Change in expected inflation (DEI)	30 days T Bills returns from CRSP Database	First difference taken from $E[\pi_t]$, so that DEI= E_t $[\pi_t]$- $E_{t-1}[\pi_t]$
Term structure, being the excess return of long-term government bonds (20Y) over 30 days T Bills (UTS)	CRSP Database: "US Treasury and Inflation Indexes"	20Y bonds – 30 days T Bills
Excess return of low grade corporate bonds over long term government bonds (20 Y) (UPR)	BAA Returns: Moody's BAA Return Index, Government Bonds from CRSP Database	Baa returns - 20Y bonds

Our two alternative procedures for innovation extraction where conducted by (1) running automated AR(p) models on inflation and industrial production, then using its error terms as innovation and (2) running an automated Kalman Filter over both series and using its error terms as innovation. For both procedures, inflation entered the model only one time, reducing the multivariate model to a four factor model.

UTS and UPR entered all models without further alterations as both are return series.

Kenneth R. French's website provide returns for the Fama and French (1992) factors, namely SMB, HML, Market, risk free rate and all used aggregate market portfolios. These where ordered by different categories to assure robustness among different aggregate asset types. We used the returns from 10 capitalization size ordered portfolios, 10 investment rate ordered portfolios, 10 operating profit ordered portfolios, 10 book to market ordered portfolios and from 10 different industries portfolios. If tested significantly, the pricing set would be highly robust among different TAs over two fairly long intervals.

The returns from mutual funds which invest in the US are attained from two different sources: Morningstar Direct and CRSP Mutual Fund Database. In total we have returns from 50 different aggregate markets, and 1717 different mutual funds serving as dependents.

3.2.
Data Manipulation

The macro variables entering the models must be decomposed in expected and unexpected components. This follows from no arbitrage and informational rationality arguments: As available information should already be processed and therefore priced, only new, unexpected information should move prices. The unanticipated component should be a mean zero, serially uncorrelated innovation that is orthogonal to the information set. We test first differences, estimation of AR(p) models and KF process for innovation extraction, varying the degree of what agents know of the true structure of the time series generation mechanism.

3.2.1. First differences

By taking first differences, that is

$$X_t^i = X_t - X_{t-1} \qquad (1)$$

Innovation in t, X_t^i, is simply the difference between past and present values. This implies that the expectation equals the current value X_t, so it is assumed that the recent observation reflects all information. That implies that investors do not use past information, what is an essential implication of modelling asset prices as if they follow random walks. Using Augmented Dickey-Fuller Tests to see if the series are serially correlated, we can't confirm the finding of Priestley (1996) that the produced innovation series doesn`t fulfill the basic criteria of being serially uncorrelated. Hereafter the results (alternative hypothesis: stationarity).

Augmented Dickey-Fuller Test data: MP Dickey-Fuller = -13.732, Lag order = 8, p-value = 0.01	Augmented Dickey-Fuller Test data: UI Dickey-Fuller = -6.284, Lag order = 8, p-value = 0.01
Augmented Dickey-Fuller Test data: DEI Dickey-Fuller = -10.344, Lag order = 8, p-value = 0.01	

3.2.2. Autoregressive models

Assuming that AR(p) models reflect the way investors decompose time series means also assuming that investors use past information for estimating how much present and future values are determined by past realizations and that agents do not change these parameters according to new information. Clare and Thomas (1994) do, after rigorously comparing CHH and CRR surprise modelling, advocate the use of AR(p) models. We first estimate how many lags of a series must be included as explanatories so that the current values are not serially correlated anymore, meaning that its current realizations are not determined by past realizations, therefore creating white noise error terms. The residuals enter the APT model as surprise component, mathematically:

AR(p):

$$X_t = \text{c} + \sum_{i=1}^{p} X_{t-1} + \varepsilon_t \tag{2}$$

Where p is the smallest number of lags needed to create white noise error terms. Innovation in t, X_t^i is equal to ε_t . Unit root test results:

Augmented Dickey-Fuller Test data: IP-AR Dickey-Fuller = -8.0948, Lag order = 8, p-value = 0.01	Augmented Dickey-Fuller Test data: Infl-AR Dickey-Fuller = -8.7553, Lag order = 8, p-value = 0.01

3.3.
Kalman Filter processes

The aforementioned methods of surprise creation suppose in the case of first differences that agent's expectation of future values match actually materialized realization, $E_{t-1}(X_t)= X_t$, and AR(p) modelling assumes that they try to decompose time series by creating white noise error terms, sticking to the AR(p) specification once conducted (parameter stability). Friedman (1979) draft a different view of expectation generation, which was later generalized by Cuthbertson (1988). Instead of assuming that investors know the true data generating process, the theory goes that agents use a simple linear model with time-varying parameters, trying to approximate the possibly more complex true model. The crucial point here is the allowance of learning by letting the parameters vary over time. As more information becomes available each period, agents try to extract the signals that contain information of the parameters recursively. This type of generating process equals a simple unobserved components model from the category of state space model. The model can be written as

$$X_t = E_{t-1}(X_t) + \varepsilon_t \tag{3}$$

$$E_{t-1}(X_t) = E_{t-2}(X_{t-1}) + \gamma_{t-1} + \xi_t \tag{4}$$

$$\gamma_t = \gamma_{t-1} + \omega_t \tag{5}$$

Where ε_t, ξ_t and ω_t are white noise error terms. As Priestley (1996) elaborates, this satisfy the assumption of Ross (1989) that information regarding X emerges as a random walk. Equations (5) and (6) capture the recursive nature of the model, showing the transition of signal reception and processing over time. The first equation enables the measurement of the deviation from the expected value. As before, innovation in t, X_t^i, is equal to ε_t.

The Kalman Filter process produces two different kind of innovation in inflation, as in Antoniou, Garrett and Priestley (1998). We differ between unexpected and expected inflation. The unexpected inflation is the current inflation minus the expected, π_t-$E_{t-1}(\pi_t)$. Expected inflation is $E_t(\pi_{t+1})$-$E_{t-1}(\pi_t)$.

Augmented Dickey-Fuller Test	Augmented Dickey-Fuller Test
data: IP-KF Dickey-Fuller = -6.8401, Lag order = 8, p-value = 0.01	data: Infl-KF Dickey-Fuller = -11.616, Lag order = 8, p-value = 0.01

As all three methods of surprise components generation produce series that are not serially autocorrelated, the selection process for the factors entering the APM tests must rely on a different approach. We therefore conduct our cross-sectional procedure for all three methods to infer their pricing relevance. One interesting point here is: Do we expect professional asset managers to show more advanced skills regarding expectation generation than measured in aggregate markets? As the Kalman Filter process is the only one allowing for parameter changes, we would expect professionals' risk premia to be greater and more significant here. This expectation stem from Priestley (1996), where it is argued that the use of rate of change and AR(p) models rule the possibility out that agents use past information efficiently, reacting to changing parameters over time.

4.
Model testing and Results

The following tests were conducted over the period of 01/1964 to 12/2016 in sequent two-year subsamples. The first ranges from 01/1964 to 12/1989 and the second from 01/1990 to 12/2016. The regressand returns entered the models as excess returns over Kenneth R. French monthly risk-free rates. All estimations were conducted by the Ordinary Least Square estimator.

4.1.
Cross sectional tests procedure

To test if one of the three methods of innovation creation show significant non-zero prices one must undertake two different tests. The first one is to estimate betas, that is time series sensitivities (or exposure) to macro factors.

First step regressions, time series part, conducted as linear panel regression:

$$R_{1,t} = \alpha_1 + \beta_{1,F1} F_{1,t} + \ldots + \beta_{1,Fm} F_{m,t} + \varepsilon_{1,t} \quad (6)$$

.

$$R_{n,T} = \alpha_n + \beta_{n,F1} F_{1,t} + \ldots + \beta_{n,Fm} F_{m,t} + \varepsilon_{n,T} \quad (7)$$

Where n is the number of independents, m is the number of F different explanatory factors. We conduct this test with Tas ($R_{n,T}$) being the 5 attributed sorted Kenneth factors, resulting in 50 different test portfolios.

Then one must conduct cross sectional tests, aiming to check if the sensitivities over time amount to significant pricing across assets. In the end, we want to know if the systematic risk set is composed of the tested macroeconomic series, leading to risk premia. So, the variation of exposure to factors must cause a significant share of variations in returns.

Second step regression, cross sectional part:

$$\mathrm{E}(R\quad) = \lambda_0 + \lambda_{1,F1} \hat{\beta}_{1,F1} + \ldots + \lambda_{m,F1} \hat{\beta}_{i,Fm} + \varepsilon_1 \quad (8)$$

Where E(R) is the 5 year average return for each independent and $\hat{\beta}_{i,Fm}$ are the estimated betas from step one. This test produces the statistics we need for inference. For each factor we get a coefficient λ, being an average price of risk among the test assets. The coefficient should be different from zero and have a statistically significant influence on prices (non-flat slopes).

4.2. Results

50 French deciles on CRR Factors risk premia estimates 01/1964-12/1989		**50 French deciles on CRR Factors risk premia estimates 01/1990-12/2016**	
	Dependent variable:		*Dependent variable:*
	01/1964-12/1989		01/1990-12/2016
MP	0.009^{***}	MP	-0.0003
	(0.001)		(0.001)
UI	-0.0001	UI	0.0002^{**}
	(0.0002)		(0.0001)
DEI	-0.0001	DEI	-0.00005
	(0.0002)		(0.00005)
UTS	-0.004	UTS	-0.003
	(0.003)		(0.002)
UPR	0.083	UPR	0.827^{***}
	(0.493)		(0.262)
Constant	1.155^{***}	Constant	1.040^{***}
	(0.203)		(0.082)
Observations	50	Observations	50
R^2	0.501	R^2	0.295
Adjusted R^2	0.445	Adjusted R^2	0.215
Residual Std. Error	0.125 (df = 44)	Residual Std. Error	0.109 (df = 44)
F Statistic	8.852^{***} (df = 5; 44)	F Statistic	3.677^{***} (df = 5; 44)
Note:	*p<0.1; **p<0.05; ***p<0.01	*Note:*	*p<0.1; **p<0.05; ***p<0.01

Interestingly, R^2 is bigger for the 1964-1989 period with only one of the factors being significantly priced contrasted to two significant ones in the second sub sample, where the R^2 is much smaller. Only industrial production has a significant risk premium in the first sub period, the second one shows contemporaneous unanticipated inflation and the spread of low grade corporate bonds over long term government bonds being priced risk factors.

4.3.

Result discussion

If any persistent finding among the subsamples could be reported, subsampling over the long period from 1964 to 2016 should guarantee robustness. So, it must be evaluated if any of the three procedures of macroeconomic surprise generation processes do produce significant and persistent risk premia in our subsamples. The question how the size of the risk premia must be evaluated respectively the requirement that risk premia shouldn’t be mean zero seems to be answered by the impressively small standard errors of the significant part of findings.

So, we compare our findings with expected outcomes.

For industrial production we expect a positive risk premium as Cutler, Poterba and Summers (1989) find for the period 1926-1986 and CRR for 1985 to 1984. As changes in industrial production affect the opportunities facing investors and the real values of cash flows, the risk premium should reflect the value of insuring against real production risks. In our samples, this finding can only be confirmed for the first subperiod.

A negative risk premium is expected for innovation in inflation, inflation impacts both the level of the discount rate and the size of the future cash flows, that is true for expected as for unexpected inflation. If people prefer stocks whose returns are positively correlated with inflation, then the risk premium for the inflation risk variables would be negative. These negative signs on the premium mean that stocks can be perceived as hedges against the adverse influence of inflation on other assets which are more fixed in nominal terms. Contemporaneous unanticipated inflation (UI) is significantly priced in the second sample only, indicating that the 2 measures tested for inflation surprises aren’t a part of the pervasive systematic risk set.

Differences between the rate on bonds with a long maturities and short maturities, the term structure of interest rates, affect the value of payments far in the future relative to near-term payments. CRR see it as measurement of the unexpected return on long term bonds. A positive premium would state that stocks or portfolios provides hedge against stochastic shifts in the interest (after controlling for the effect of inflation) contrasting the believe that long term government bonds should be the hedges against this unanticipated change in interest rates. In all test settings, the yield curve coefficient (UTS) is not consistently priced.

Differences between the return on risky bonds (BAA) and long term government bonds are used to measure the market's reaction to risk, therefore the risk premia. CRR interpret it as measurement variable for market's degree of risk aversion and argue that a positive sign means investors wish to hold a hedge against unanticipated increases in the risk premium, triggered for example from a surge of uncertainty. We find a significant UPR coefficient in the second sample, but as with UI, it isn't part of the unique set of variables defining the systematic risk over time due to the insignificant result in the first subperiod.

5.
Conclusions

The aim of this study is to identify the macroeconomic variables as perceived by investors constituting the systematic risk for asset US asset prices. We allow for different kinds of possible expectation generation processes, the robustness is guaranteed by subsampling. Furthermore, by testing different theories how investors may formulate their expectation, we check if the unsatisfying results former studies present result from inadequate assumptions about innovation generation. A second particularly important methodological extension to earlier works is the contrast of aggregate return data to professional asset manager portfolio returns. The question raised here is if there is a difference between professional and ordinary expectation generation. Find the test results in the appendix. As commented before, we only not find convincing evidence that the CRR five factor model is replicable in our sample of 50 Kenneth French portfolio returns. We do find highly significant risk premia of the CRR five factor model in two mutual fund return samples. The tests conducted to check if professionals should, in a sense of traditional alpha generation, be sensible to macroeconomic innovation did not produce relevant results.

There are different lines of investigations one can follow from here. Continuing to assume that macroeconomic factors are priced risk factors, we can try to find other factors, assume a different speed of shock propagation, find a more a complex, non-linear or even indirect relationship, search for better data and investigate if macroeconomic series should enter the model being structurally modelled. These approaches are partly entangled.

The search for another set of macroeconomic factors might be the most appealing path. One could argue that the only task is to find the right combination of economic variables. But there is an important issue here: data mining is opposed to theory driven pre-specification. In the first place, we argued that the choice for our ex-ante chosen set of factors is based on reliable equilibrium models. We can depart from that approach by taking every economic variable that is somehow related to asset prices and develop a sophisticated model specification algorithm. The objective of this machine could be to maximize the significance of persistent risk premia estimates among subsamples by testing all kind of original and manipulated variables. The faster this procedure could process cross sectional risk premia estimates, the more highly significant risk premia we would get. The point here is that the results would be exposed to the exact same problems we explained to exclude the use of accounting data models: The lack of theoretically inferred reasons why the factors should be priced. The following approaches are more nuanced by naming the theoretical issues they address.

A search for better data would be motivated by the assumption that we are exposed to a measurement error. The quarterly released data for inflation for example could not be the relevant proxy for inflation risk. This could force investors to focus more on release dates as on trajectories over time. But as asset prices are continuously exposed to macroeconomic risks, it is not possible take that thinking till an equilibrium framework.

There are two additional, closely related approaches. The use of structural models for our economic variables or try to explain the empirical highly successful models by linking accounting data to macroeconomic forces. The basic idea behind these approaches is that the chosen factors are in fact priced, systematic risk factors, but investors do perceive them in a more complex, indirect way. The conducted tests in this study already are a search for the transmission mechanism. The difference to structural modelling is the use of other explanatories than past realizations. Simply using only series' lags denies a dependence of perception on other variables. The effort Fama and Gibbons (1984) show for examining inflation forecasts could be done for every macroeconomic series, producing factors that depend on own, past realizations and other forces as well. The attempts trying to link Fama and French (1992) factors to macroeconomic fundamentals follow the same line of thinking.

The change of assumed speed of propagation and modelling non-linear relationships are aspects directly addressed to the choice of the correct model. The aforementioned VAR models allow for lags and nearly all models can be modificated in a non-linear way. But one has to offer a theory why agents need time to realize shocks or why these shocks do not propagate linearly. The Efficient Market Theory, arguing for immediate shock propagation and the APT, establishing a linear relationship do in contrast have strong formal and theoretic underpinnings.

A more profound problem could be tackled attacking the very core of our result evaluation method, therefore allowing for a different inference. As the ultimate objective of our analysis is finding a pervasive influence on asset prices, factor rotation is explicitly forbidden, the Fama (1991) paradigm prohibit shifts among macroeconomic regimes. But one could ask why investors should react to macroeconomic series without considering the state of the economy and therefore the importance of individual factors for the future opportunity set. Should, for example, an investor reacts equally to changes in the yield curve in times of quantitative easing and periods of more orthodox monetary policies? It could also be the case that we do not have to consider the whole economic environment to define an expected importance and especially the direction of influence on asset prices of the innovation of a specific variable. It could already improve risk premia estimates if we take the level of the variable into account, not just the recent trajectory (as in AR(p) and Kalman Filter processes). Does it, for example, make sense to assume that innovation in variables like inflation and yield curve during the 70ties and 80ties should carry the same information as more recently? Should investors worry about double digit inflation and double digit short term interest rates the same way they do today?

6.
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Appendix

Appendix A – CRR model with alternative innovation creation

50 French deciles on AR(p) Factors Risk premia estimates 01/1964-12/1989		**50 French deciles on AR(p) Factors Risk premia estimates 01/1990-12/2016**	
	Dependent variable:		*Dependent variable:*
	01/1964-12/1989		01/1990-12/2016
IP-AR	0.0002	IP-AR	-0.0001
	(0.001)		(0.0002)
Infl-AR	0.0003***	Infl-AR	-0.00001
	(0.0001)		(0.00003)
UTS	0.0001	UTS	-0.005**
	(0.004)		(0.002)
UPR	0.361	UPR	0.878***
	(0.458)		(0.249)
Constant	0.902***	Constant	1.079***
	(0.178)		(0.067)
Observations	50	Observations	50
R^2	0.334	R^2	0.256
Adjusted R^2	0.275	Adjusted R^2	0.190
Residual Std. Error	0.143 (df = 45)	Residual Std. Error	0.110 (df = 45)
F Statistic	5.650*** (df = 4; 45)	F Statistic	3.870*** (df = 4; 45)
Note:	*p<0.1; **p<0.05; ***p<0.01	*Note:*	*p<0.1; **p<0.05; ***p<0.01

50 French deciles on KF Factors Risk premia estimates 01/1990-12/2016	
	Dependent variable:
	01/1990-12/2016
IP-KF	-0.088
	(0.127)
Infl-KF	-0.028
	(0.084)
UTS	-0.004**
	(0.002)
UPR	0.904***
	(0.245)
Constant	1.076***
	(0.066)
Observations	50
R^2	0.256
Adjusted R^2	0.189
Residual Std. Error	0.110 (df = 45)
F Statistic	3.862*** (df = 4; 45)
Note:	*p<0.1; **p<0.05; ***p<0.01

50 French deciles on KF Factors Risk premia estimates 01/1964-12/1989	
	Dependent variable:
	01/1964-12/1989
IP-KF	0.372***
	(0.116)
Infl-KF	0.329**
	(0.138)
UTS	0.002
	(0.004)
UPR	0.487
	(0.427)
Constant	0.744***
	(0.178)
Observations	50
R^2	0.415
Adjusted R^2	0.364
Residual Std. Error	0.134 (df = 45)
F Statistic	7.996*** (df = 4; 45)
Note:	*p<0.1; **p<0.05; ***p<0.01

As the signs and significances aren’t stable among the two subperiods, inference is difficult to make. Both alternatives to first differences aren’t dominant in a sense that the expectations generated are priced over both samples.

Appendix B – CRR model with alternative innovation creation and mutual fund returns as independents

A further inference we can make is that portfolios formed by professional fund manager are more sensitive to macroeconomic innovations than aggregate asset prices.

CRSP Fund return on CRR Factor Risk premia estimates 01/1995-12/2000	
	Dependent variable:
	01/1995-12/2000
MP	-0.007***
	(0.001)
UI	0.0001***
	(0.00001)
DEI	-0.00001
	(0.00002)
UTS	0.002***
	(0.001)
UPR	-0.021
	(0.022)
Constant	0.669***
	(0.021)
Observations	1,289
R^2	0.279
Adjusted R^2	0.276
Residual Std. Error	0.498 (df = 1283)
F Statistic	99.284*** (df = 5; 1283)
Note:	*p<0.1; **p<0.05; ***p<0.01

CRSP Fund return on CRR Factors Risk premia estimates 01/2001-12/2006	
	Dependent variable:
	01/2001-12/2006
MP	-0.005***
	(0.0005)
UI	0.0002***
	(0.00004)
DEI	-0.0002***
	(0.00002)
UTS	0.004***
	(0.001)
UPR	-0.176***
	(0.020)
Constant	0.341***
	(0.016)
Observations	1,289
R^2	0.347
Adjusted R^2	0.344
Residual Std. Error	0.376 (df = 1283)
F Statistic	136.286*** (df = 5; 1283)
Note:	*p<0.1; **p<0.05; ***p<0.01

Morningstar Fund return on CRR Factors Risk premia estimates 01/1995-12/2000	
	Dependent variable:
	01/1995-12/2000
MP	-0.0002
	(0.001)
UI	0.0001***
	(0.00002)
DEI	0.0001***
	(0.00003)
UTS	0.002*
	(0.001)
UPR	-0.038*
	(0.020)

Morningstar Fund return on CRR Factors Risk premia estimates 01/2001-12/2006	
	Dependent variable:
	01/2001-12/2006
MP	-0.007***
	(0.001)
UI	-0.0002***
	(0.00004)
DEI	-0.0002***
	(0.00002)
UTS	0.008***
	(0.001)
UPR	0.154***
	(0.036)

Constant	1.846*** (0.042)	Constant	0.474*** (0.107)
Observations	428	Observations	428
R^2	0.264	R^2	0.547
Adjusted R^2	0.256	Adjusted R^2	0.542
Residual Std. Error	0.344 (df = 422)	Residual Std. Error	0.317 (df = 422)
F Statistic	30.315*** (df = 5; 422)	F Statistic	102.079*** (df = 5; 422)
Note:	*p<0.1; **p<0.05; ***p<0.01	*Note:*	*p<0.1; **p<0.05; ***p<0.01

We can confirm that finding for both, the CRSP and the Morningstar mutual fund return samples. The question here is if this shows that professional manager are more capable of focusing on the right set of risk factors. This conclusion is highly difficult to make, since we do not find a persuasive influence of all macroeconomic shocks on asset prices.

We also tested the alternative measures on both mutual fund samples:

CRSP Fund return on AR(p) Factors Risk premia estimates 01/2001-12/2006		**CRSP Fund return on AR(p) Factors Risk premia estimates 01/1995-12/2000**	
	Dependent variable:		*Dependent variable:*
	01/2001-12/2006		01/1995-12/2000
IP-AR	0.0004*** (0.0001)	IP-AR	0.001*** (0.0001)
Infl-AR	0.0001*** (0.00003)	Infl-AR	0.0001*** (0.00001)
UTS	0.005*** (0.001)	UTS	0.006*** (0.001)
UPR	-0.225*** (0.023)	UPR	-0.177*** (0.021)
Constant	0.311*** (0.020)	Constant	0.463*** (0.019)
Observations	1,289	Observations	1,289
R^2	0.097	R^2	0.408

Adjusted R^2	0.094	Adjusted R^2	0.406
Residual Std. Error	0.441 (df = 1284)	Residual Std. Error	0.451 (df = 1284)
F Statistic	34.474*** (df = 4; 1284)	F Statistic	221.057*** (df = 4; 1284)
Note:	*p<0.1; **p<0.05; ***p<0.01	*Note:*	*p<0.1; **p<0.05; ***p<0.01

Morningstar Fund return on AR(p) Factors Risk premia estimates 01/2001-12/2006		**Morningstar Fund return on AR(p) Factors Risk premia estimates 01/2001-12/2006**	
	Dependent variable:		*Dependent variable:*
	01/2001-12/2006		01/2001-12/2006
IP-AR	0.0004***	IP-AR	-0.0001
	(0.0001)		(0.0001)
Infl-AR	0.0001***	Infl-AR	-0.0001
	(0.00003)		(0.0001)
UTS	0.005***	UTS	0.011***
	(0.001)		(0.002)
UPR	-0.225***	UPR	0.074
	(0.023)		(0.048)
Constant	0.311***	Constant	0.825***
	(0.020)		(0.114)
Observations	1,289	Observations	428
R^2	0.097	R^2	0.131
Adjusted R^2	0.094	Adjusted R^2	0.122
Residual Std. Error	0.441 (df = 1284)	Residual Std. Error	0.438 (df = 423)
F Statistic	34.474*** (df = 4; 1284)	F Statistic	15.879*** (df = 4; 423)
Note:	*p<0.1; **p<0.05; ***p<0.01	*Note:*	*p<0.1; **p<0.05; ***p<0.01

CRSP Fund return on KF Factors Risk premia estimates 01/1995-12/2000		CRSP Fund return on KF Factors Risk premia estimates 01/2001-12/2006	
	Dependent variable:		*Dependent variable:*
	01/1995-12/2000		01/2001-12/2006
IP-KF	-1.353***	IP-KF	-0.457***
	(0.052)		(0.068)
Infl-KF	0.080***	Infl-KF	0.961***
	(0.021)		(0.055)
UTS	0.006***	UTS	0.004***
	(0.001)		(0.001)
UPR	0.016	UPR	-0.075***
	(0.020)		(0.022)
Constant	0.486***	Constant	0.302***
	(0.017)		(0.017)
Observations	1,289	Observations	1,289
R^2	0.466	R^2	0.279
Adjusted R^2	0.464	Adjusted R^2	0.276
Residual Std. Error	0.428 (df = 1284)	Residual Std. Error	0.395 (df = 1284)
F Statistic	280.223*** (df = 4; 1284)	F Statistic	123.971*** (df = 4; 1284)
Note:	*p<0.1; **p<0.05; ***p<0.01	*Note:*	*p<0.1; **p<0.05; ***p<0.01

Morningstar Fund return on KF Factors Risk premia estimates 01/1995-12/2000	
	Dependent variable:
	01/1995-12/2000
IP-KF	-0.269***
	(0.072)
Infl-KF	0.153***
	(0.019)
UTS	0.004***
	(0.001)
UPR	-0.080***
	(0.020)
Constant	2.041***
	(0.024)
Observations	428
R^2	0.279
Adjusted R^2	0.273
Residual Std. Error	0.340 (df = 423)
F Statistic	41.021*** (df = 4; 423)
Note:	*p<0.1; **p<0.05; ***p<0.01

Morningstar Fund return on KF Factors Risk premia estimates 01/2001-12/2006	
	Dependent variable:
	01/2001-12/2006
IP-KF	-0.925***
	(0.085)
Infl-KF	-0.385***
	(0.109)
UTS	0.014***
	(0.002)
UPR	0.153***
	(0.044)
Constant	1.194***
	(0.106)
Observations	428
R^2	0.314
Adjusted R^2	0.308
Residual Std. Error	0.389 (df = 423)
F Statistic	48.423*** (df = 4; 423)
Note:	*p<0.1; **p<0.05; ***p<0.01

As it is difficult to evaluate the significance of the risk premia in mutual fund returns without having significant premia in cross section of aggregate prices, we try an indirect path. Can the question if asset managers should be sensible to macroeconomic innovation answered by traditional performance evaluation means?

Appendix C - Covariation over time with unexplained part of Jensen's alpha measurement for fund performance

The last section shows the difference between aggregate market response to macroeconomic shocks and professional asset mangers'. This is meant as a case study, the question here is: are professional asset manager more sensitive to macro factors?

There is, however, an established method to measure the performance of portfolio managers, namely Jensen (1968) alpha measurement. This is mostly done by running time series regressions with Fama and French (1993) factors, where the intercept, or alpha, is then interpreted as return generated independently of exposure to overall market, size (SMB) and value (HML) portfolios. This framework allows for an examination if the return parts unexplained by this procedure is sensible to variations of macroeconomic shocks. This is, if the skill, α_n, together with the error term can be explained by exposure to macroeconomic shocks.

We first must run linear time series regression on both samples of mutual fund returns:

$$R_{1,t} = \alpha_1 + \beta_1 Market_t + \beta_2 SMB_t + \beta_2 HML_t + \varepsilon_{1,t} \quad (9)$$

$$R_{n,t} = \alpha_n + \beta_n Market_t + \beta_n SMB_t + \beta_n HML_t + \varepsilon_{n,t} \quad (10)$$

For each fund n and then add the intercept α_1 to each error term over time. This is done separately for each five year time period from 01/1995 to 12/2006, resulting in 1289 funds times 8 periods for the CRSP sample and the same with 428 funds for the Morningstar sample. The new unexplained part series, UPS, are then regressed on macroeconomic shocks over time, being:

$$UPS_{1,t} = \alpha_1 + \phi_{1,F1}F_{1,t} + \ldots + \beta_{1,Fm}F_{m,t} + \varepsilon_{1,t} \quad (11)$$

.

$$UPS_{n,t} = \alpha_n + \phi_{n,F1}F_{1,t} + \ldots + \beta_{n,Fm}F_{m,t} + \varepsilon_{n,t} \quad (12)$$

The UPS series for n=1717 funds where regressed on all macroeconomic shock types.

Unfortunately, there is no need to show the UPS regression tables, the coefficient ϕ for all three procedures has average t-statistics < 1. There seems not to be any linear covariation over time between the unexplained part of Jensen's alpha measurement with SMB and HML as additional regressors to market returns. This could be due to a variety of reasons, the most fundamental would be the non-existence of a link between the variables. But as we only tested a simple linear relationship the results could look more interesting if one models a possible relationship allowing for longer propagation periods or more complex functional forms.