Nonlinearity and Flight-to-Safety in the Risk-Return Tradeoff for Stocks and Bonds

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Motivation: Flight-to-Safety and Nonlinearities

- Investor Flight-to-Safety is pervasive in times of elevated risk
  - Longstaff (2004), Beber, Brandt, and Kavajecz (2009), Baele, Bekaert, Inghelbrecht, and Wei (2013)
- Theories of Flight-to-Safety predict highly nonlinear pricing functions
  - Vayanos (2004), Weill (2007), Caballero and Krishnamurthy (2008)
- Natural question: Should Flight-to-Safety (elevated risk + nonlinear pricing) have implications for risk-return tradeoff?

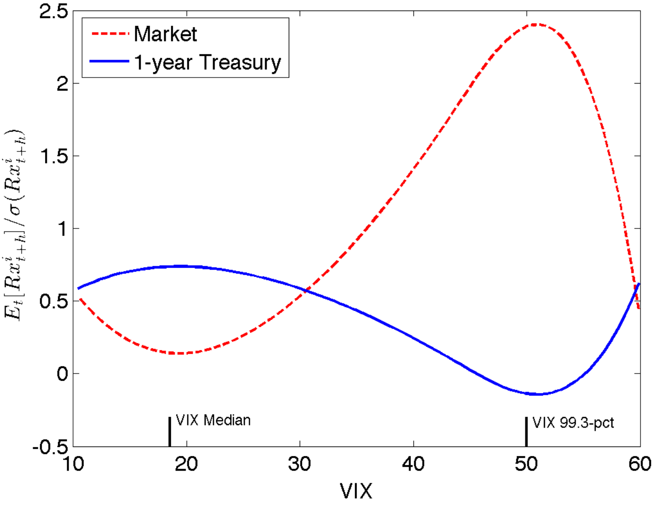
Motivation: Risk-return Tradeoff

- Economic theory suggests a risk-return tradeoff:
  an increase in riskiness should be associated with
  1. a contemporaneous drop in the asset price
  2. an increase in expected returns

- While 1. is easy to verify, 2. has proven hard to show
  - Regression of asset returns on lagged measures of risk is either insignificant (Bekaert and Hoerova (2014), Bollerslev, Osterrieder, Sizova, and Tauchen (2013)) or inconclusive: sometimes positive, sometimes negative (Lundblad (2007))

- This paper: stock and bond returns reveal
  - Risk-return tradeoff is nonlinear
  - Nonlinearity is consistent with flight-to-safety

Preview:
Flight-to-Safety in the Nonlinear Risk-Return Tradeoff



Our Approach

1. Propose Sieve Reduced Rank Regression SRRR estimator

$$Rx^i_{t+h} = a^i_h + b^i_h \cdot \phi_h(v_t) + \varepsilon^i_{t+h}, \qquad i = 1, \ldots, n,$$

2. Document strongly significant nonlinear risk-return tradeoff (univariate and jointly)
3. Robustness to controls, subsamples, different test assets
4. Out-of-sample performance
5. Forecasting relationship within a dynamic asset pricing model
6. Theories that generate increased risk aversion as a function of volatility provide a conceptual framework for our findings
7. Macroeconomic consequences

Literature

- Flight-to-safety
  - Vayanos (2004), Weill (2007), Caballero and Krishnamurthy (2008), Brunnermeier and Pedersen (2009), Vayanos and Woolley (2013)
- Econometric approach
  - Chen, Liao, and Sun (2014), Hodrick (1992), ACM(2013, 2014)
- Asset return forecasting
  - Lettau and Van Nieuwerburgh (2008), Pesaran, Pettenuzzo, and Timmermann (2006), Rossi and Timmermann (2010)
- Dynamic asset pricing with stocks and bonds
  - Mamaysky (2002), Bekaert, Engstrom, and Grenadier (2010), Lettau and Wachter (2010), Koijen, Lustig, and van Nieuwerburgh (2013)

Outline

Motivating Univariate Evidence

Sieve Reduced Rank Regressions

Economics of Flight-to-Safety

Conclusion

Motivation: Univariate Evidence

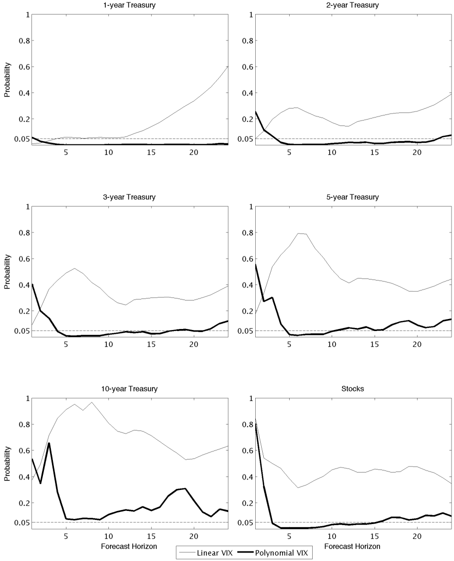
1-year Treasury Excess Returns

	$h = 6$ months				$h = 12$ months				$h = 18$ months			
VIX^1	1.91	4.13		5.01	1.86	3.60		5.02	1.13	3.21		4.73
VIX^2		-4.08		-4.77		-3.61		-4.86		-3.37		-4.71
VIX^3		3.89		4.66		3.51		4.76		3.38		4.64
$MOVE^1$			0.26	-0.57			-0.58	-1.94			-0.23	-2.21
$MOVE^2$			0.17	0.81			1.00	2.14			0.54	2.43
$MOVE^3$			-0.35	-0.97			-1.16	-2.27			-0.69	-2.57
DEF				-0.99				-0.99				-1.23
VRP				2.49				2.84				3.87
TERM				-1.45				-2.76				-3.47
DY				3.34				3.58				3.24
const	1.40	-3.42	-0.14	0.58	1.65	-2.75	1.05	1.57	2.17	-2.19	1.19	1.63
p-value	0.057	0.001	0.089	0.000	0.064	0.005	0.303	0.000	0.260	0.004	0.845	0.000

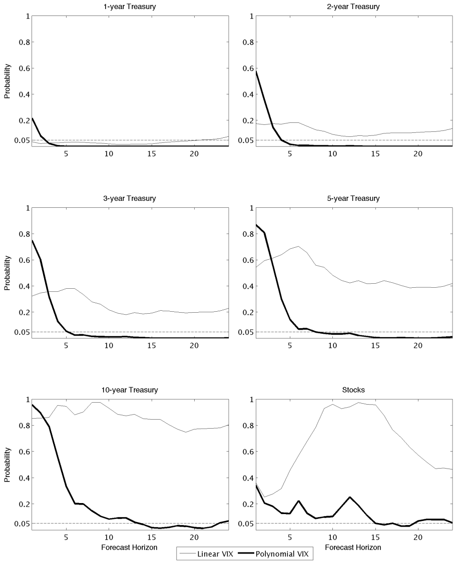
Stock Excess Returns

	$h = 6$ months				$h = 12$ months				$h = 18$ months			
VIX^1	1.00	-3.18		-2.68	0.74	-2.47		-1.98	0.78	-1.87		-1.35
VIX^2		3.36		2.90		2.61		2.22		2.01		1.54
VIX^3		-3.24		-2.68		-2.45		-2.15		-1.87		-1.48
$MOVE^1$			0.15	0.27			1.14	1.26			0.13	0.33
$MOVE^2$			-0.06	-0.23			-1.17	-1.35			-0.07	-0.41
$MOVE^3$			-0.01	-0.01			1.20	1.23			0.16	0.40
DEF				-0.58				-0.62				-0.34
VRP				-2.34				-2.03				-2.33
TERM				0.47				0.94				1.03
DY				1.17				1.51				1.63
const	-0.15	3.28	0.13	2.43	0.50	2.68	-0.65	2.06	0.58	2.10	0.15	2.01
p-value	0.316	0.007	0.991	0.018	0.460	0.032	0.674	0.075	0.439	0.088	0.810	0.112

P-values by Forecast Horizon 1990-2014



P-values by Forecast Horizon 1990-2007



Motivation for Sieve Reduced Rank Regressions

- Consider some function $\phi_h^i(v_t)$ such that

$$Rx_{t+h}^i = \phi_h^i(v_t) + \varepsilon_{t+h}^i$$

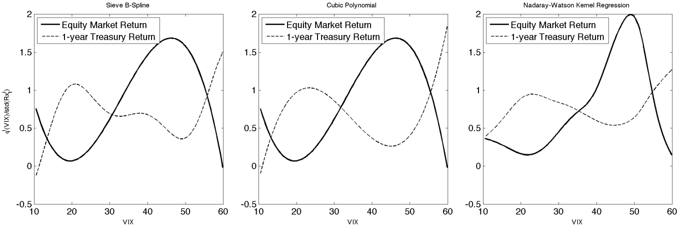
- Can estimate the unknown function $\phi_h^i(v_t)$ via
  - Polynomials approximation
  - Method of sieves (Chen (2007))
  - Kernel regression
- We focus on Sieves:
  - Assume $\phi_h^i \in \Phi$ general function space
  - Approximate ϕ_h^i with finite dimensional basis functions $B_j(v)$,

$$\phi_{m,h}(v) = \sum_{j=1}^{m} \gamma_j^h \cdot B_j(v) = \gamma^{h\prime} X_m$$

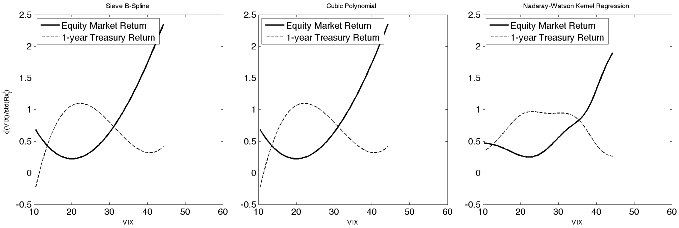
with $m = m_T \to \infty$ as $T \to \infty$.

Nonlinear Forecasting using SRRR Regressions 1990-2014

$\phi_h^i(VIX)$ 1990:1 to 2014:9



$\phi_h^i(VIX)$ 1990:1 to 2007:7



Outline

SRRR: Sieve Reduced Rank Regressions

- Idea: use cross-sectional information across assets to estimate $\phi_h(v)$
- Suppose that excess returns for $i = 1, \ldots, n$ assets are

$$Rx^i_{t+h} = a^i_h + b^i_h \cdot \phi_h(v_t) + f^i_h z_t + \varepsilon^i_{t+h}$$

- We can rewrite this as

$$Rx^i_{t+h} = a^i_h + b^i_h (\gamma'_h X_{m,t}) + f^i_h z_t + \tilde{\varepsilon}^i_{t+h}$$

where $\tilde{\varepsilon}^i_{t+h} = \varepsilon^i_{t+h} + b^i_h \cdot (\phi_h(v_t) - \gamma'_h X_{m,t})$

- Note reduced rank restriction: γ_h common across assets: $\text{rank}(b\,\gamma'_h) = 1$
- We normalize $b^{Market}_h = 1$ as reference asset

Inference

- E.g. since $b_h^{Market} = 1$, how to test market predictability?
- In this paper there are three primary hypotheses of interest:

$$\begin{array}{ll} \mathbb{H}_{1,0} : b_h^j \, \phi_h = 0 & \mathbb{H}_{1,A} : b_h^j \, \phi_h \neq 0 \\ \mathbb{H}_{2,0} : \mathbf{b}_h \phi_h = \mathbf{0}_n & \mathbb{H}_{2,A} : \mathbf{b}_h \phi_h \neq \mathbf{0}_n \\ \mathbb{H}_{3,0} : \phi_h \left(\bar{v} \right) = 0 & \mathbb{H}_{3,A} : \phi_h \left(\bar{v} \right) \neq 0 \end{array}$$

- Proposition

$$\begin{aligned} \left[\text{vec} \left(\hat{b}_h^j \hat{\gamma}_h \right)' \hat{\mathcal{V}}_1 \text{ vec} \left(\hat{b}_h^j \hat{\gamma}_h \right) - (m+1) \right] / \sqrt{m+1} &\rightarrow_{d, \mathbb{H}_{1,0}} \mathcal{N}(0,1) \\ \left[\text{vec} \left(\hat{\mathbf{b}}_h \hat{\gamma}_h \right)' \hat{\mathcal{V}}_2 \text{ vec} \left(\hat{\mathbf{b}}_h \hat{\gamma}_h \right) - (m+n-1) \right] / \sqrt{m+n-1} &\rightarrow_{d, \mathbb{H}_{2,0}} \mathcal{N}(0,1) \\ \frac{\hat{\phi}_{h,m} \left(\bar{v} \right) - \phi \left(\bar{v} \right)}{\hat{\mathcal{V}}_3} &\rightarrow_{d, \mathbb{H}_{3,0}} \mathcal{N}(0,1) \end{aligned}$$

- Standard errors based on reverse regressions and 1B Hodrick (1992)

Nonlinear Forecasting using SRRR 1990-2014

$$Rx^i_{t+h} = a^i + b^i \cdot \phi_h(v_t) + f^i_h z_t + \varepsilon^i_{t+h}, \qquad i = 1, \ldots, n,$$

Horizon h = 6

	(1) Linear VIX		(2) Nonlinear VIX		(3) Nonlinear VIX and Controls					
	a^i	b^i	a^i	b^i	a^i	b^i	f^i_{DEF}	f^i_{VRP}	f^i_{TERM}	f^i_{DY}
MKT	−0.01	1.00	1.00*	1.00***	0.31	1.00***	0.05**	−1.42***	−0.01	0.17
cmt1	0.00	0.07*	−0.05*	−0.07***	−0.09**	−0.20***	0.00	0.03*	0.00*	0.02***
cmt2	0.01	0.09	−0.11*	−0.14***	−0.15*	−0.32***	0.00	0.08**	0.00	0.02**
cmt5	0.03	0.04	−0.26	−0.31***	−0.25	−0.60***	−0.02*	0.23**	0.01**	0.01
cmt7	0.04	0.04	−0.31	−0.38**	−0.27	−0.70***	−0.03**	0.32**	0.02**	0.00
cmt10	0.05	−0.08	−0.30	−0.37**	−0.25	−0.66**	−0.03**	0.39**	0.03***	0.01
cmt20	0.08	−0.22	−0.39	−0.49	−0.23	−0.74	−0.05***	0.51*	0.05***	−0.03
cmt30	0.10	−0.52	−0.58	−0.68	−0.29	−0.98	−0.07***	0.70*	0.06***	−0.06
Joint p-val		0.273		0.000		0.000				

Nonlinear Forecasting using SRRR 1990-2014

$$Rx^i_{t+h} = a^i + b^i \cdot \phi_h(v_t) + f^i_h z_t + \varepsilon^i_{t+h}, \qquad i = 1, \ldots, n,$$

Horizon h = 12

	(1) Linear VIX		(2) Nonlinear VIX		(3) Nonlinear VIX and Controls					
	a^i	b^i	a^i	b^i	a^i	b^i	f^i_{DEF}	f^i_{VRP}	f^i_{TERM}	f^i_{DY}
MKT	0.03	1.00	0.64	1.00*	0.09	1.00*	0.03**	−0.70***	0.00*	0.18
cmt1	0.00	0.11*	−0.05	−0.10***	−0.08	−0.36***	0.00	0.03**	0.00**	0.02***
cmt2	0.01	0.22	−0.08	−0.18**	−0.12	−0.57***	0.00	0.05**	0.00	0.03***
cmt5	0.02	0.33	−0.18	−0.39*	−0.21	−1.03**	−0.01	0.08*	0.01	0.03
cmt7	0.02	0.35	−0.23	−0.48*	−0.24	−1.23*	−0.02*	0.12*	0.01**	0.02
cmt10	0.03	0.15	−0.22	−0.47*	−0.25	−1.25*	−0.02**	0.13*	0.02**	0.03
cmt20	0.05	0.12	−0.31	−0.65	−0.27	−1.52	−0.04**	0.16	0.03***	0.00
cmt30	0.06	−0.17	−0.44	−0.88	−0.33	−1.92	−0.05**	0.21	0.04***	−0.01
Joint p-val		0.380		0.002		0.000				

Nonlinear Forecasting using SRRR 1990-2014

$$Rx^i_{t+h} = a^i + b^i \cdot \phi_h(v_t) + f^i_h z_t + \varepsilon^i_{t+h}, \qquad i = 1, \ldots, n,$$

Horizon h = 18

	(1) Linear VIX		(2) Nonlinear VIX		(3) Nonlinear VIX and Controls					
	a^i	b^i	a^i	b^i	a^i	b^i	f^i_{DEF}	f^i_{VRP}	f^i_{TERM}	f^i_{DY}
MKT	0.03	1.00	0.44	1.00	−0.03	1.00	0.02**	−0.59***	0.01	0.18
cmt1	0.01	0.07	−0.04	−0.13***	−0.06	−0.60***	0.00	0.04***	0.00**	0.02***
cmt2	0.01	0.19	−0.07	−0.24**	−0.10	−0.95***	0.00	0.07***	−0.01	0.03***
cmt5	0.02	0.36	−0.14	−0.48*	−0.18	−1.65***	−0.01	0.11**	0.00	0.03**
cmt7	0.02	0.38	−0.16	−0.56	−0.19	−1.87**	−0.01*	0.14**	0.00	0.03*
cmt10	0.03	0.23	−0.15	−0.52	−0.20	−1.90*	−0.01*	0.15**	0.01*	0.04
cmt20	0.04	0.29	−0.19	−0.69	−0.20	−2.16	−0.02*	0.15	0.02**	0.01
cmt30	0.05	0.04	−0.28	−0.91	−0.24	−2.63	−0.03**	0.18	0.03**	0.00
Joint p-val		0.586		0.025		0.000				

Nonlinear Forecasting using SRRR 1990-2007

Horizon h = 6

	(1) Linear VIX		(2) Nonlinear VIX		(3) Nonlinear VIX and Controls					
	a^i	b^i	a^i	b^i	a^i	b^i	f^i_{DEF}	f^i_{VRP}	f^i_{TERM}	f^i_{DY}
MKT	0.03	1.00	0.72	1.00	0.25	1.00	−0.03	−0.84*	0.00	0.12
cmt1	0.00	0.23**	−0.09	−0.16***	−0.15	−0.59***	0.01	0.03	0.00*	0.03***
cmt2	0.00	0.29	−0.16	−0.28**	−0.22	−0.92***	0.01	0.10*	0.00	0.03***
cmt5	0.01	0.30	−0.31	−0.53*	−0.34	−1.57***	0.00	0.25*	0.01	0.03*
cmt7	0.03	0.18	−0.36	−0.62*	−0.35	−1.75**	−0.01	0.31*	0.02	0.02
cmt10	0.04	−0.23	−0.37	−0.62	−0.32	−1.74*	−0.03	0.36*	0.02*	0.02
cmt20	0.06	−0.16	−0.42	−0.72	−0.31	−1.95	−0.05	0.46**	0.03**	−0.01
cmt30	0.05	−0.27	−0.51	−0.85	−0.35	−2.25	−0.06	0.58**	0.04**	−0.03
Joint p-val		0.058		0.001		0.000				

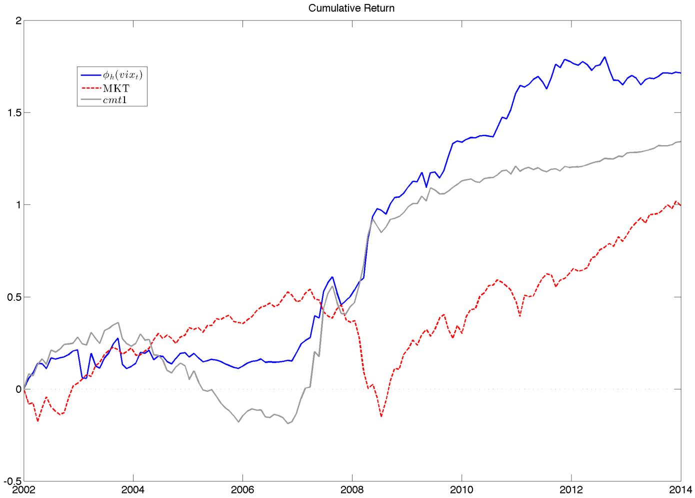
Horizon h = 12

	(1) Linear VIX		(2) Nonlinear VIX		(3) Nonlinear VIX and Controls					
	a^i	b^i	a^i	b^i	a^i	b^i	f^i_{DEF}	f^i_{VRP}	f^i_{TERM}	f^i_{DY}
MKT	0.09	1.00	0.46	1.00	−0.01	1.00	−0.03	−0.52*	0.00	0.16
cmt1	0.00	−2.09**	−0.08	−0.23***	−0.12	3.25***	0.00	0.03	0.00	0.03***
cmt2	0.00	−3.21*	−0.13	−0.40***	−0.18	5.27***	0.00	0.07*	0.00	0.03***
cmt5	0.00	−4.69	−0.24	−0.72**	−0.31	9.32***	0.00	0.12	0.01	0.04
cmt7	0.01	−3.98	−0.28	−0.84**	−0.33	10.77***	−0.01	0.13	0.01*	0.03
cmt10	0.03	−0.71	−0.27	−0.80*	−0.33	11.27**	−0.03*	0.14	0.02**	0.04
cmt20	0.04	−1.06	−0.33	−1.00*	−0.34	13.10**	−0.04**	0.14	0.03**	0.01
cmt30	0.04	−1.15	−0.40	−1.17*	−0.39	15.27**	−0.06**	0.16	0.04***	0.00
Joint p-val		0.008		0.001		0.000				

Horizon h = 18

	(1) Linear VIX		(2) Nonlinear VIX		(3) Nonlinear VIX and Controls					
	a^i	b^i	a^i	b^i	a^i	b^i	f^i_{DEF}	f^i_{VRP}	f^i_{TERM}	f^i_{DY}
MKT	0.11	1.00	0.57	1.00**	0.13	1.00	−0.03	−0.54**	0.00	0.13
cmt1	0.00	−0.36**	−0.07	−0.17***	−0.11	−0.92***	0.00	0.05**	0.00	0.03***
cmt2	0.00	−0.59	−0.13	−0.30***	−0.19	−1.55***	0.00	0.11**	0.00	0.03***
cmt5	0.00	−0.93	−0.24	−0.55***	−0.35	−2.83***	0.01*	0.19**	0.00	0.05*
cmt7	0.01	−0.86	−0.27	−0.63***	−0.39	−3.28***	0.00**	0.22**	0.01*	0.05
cmt10	0.03	−0.25	−0.25	−0.59***	−0.40	−3.44***	−0.01**	0.24**	0.01**	0.06
cmt20	0.04	−0.45	−0.29	−0.70**	−0.41	−3.81***	−0.02**	0.20*	0.02**	0.03
cmt30	0.03	−0.43	−0.37	−0.85**	−0.50	−4.55***	−0.03**	0.25**	0.03***	0.03
Joint p-val		0.019		0.000		0.000				

Out-of-Sample Evidence

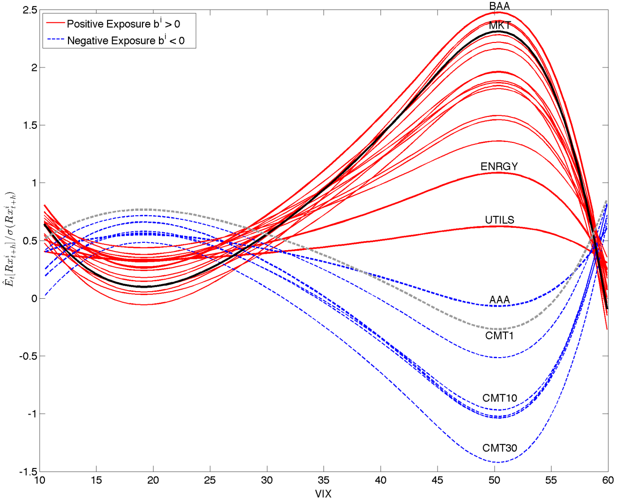


Outline

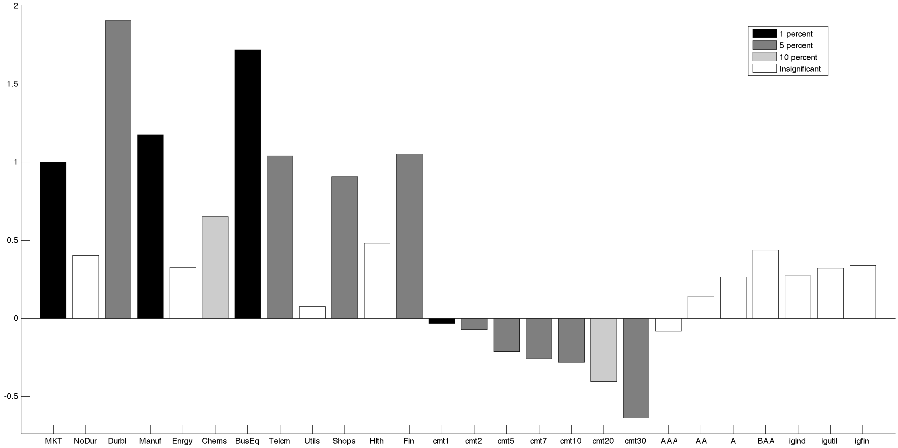
SRRR Estimation using Broader Test Assets

- All results so far were using the market return and Treasury returns
- Is the shape of the nonlinearity robust to broader asset classes?
  - 12 industry sorted equity portfolios from Ken French
  - 7 credit and industry sorted credit portfolios from Barclays
  - 7 maturity sorted bond portfolios from CRSP
- The broader set of test assets improves our economic insight

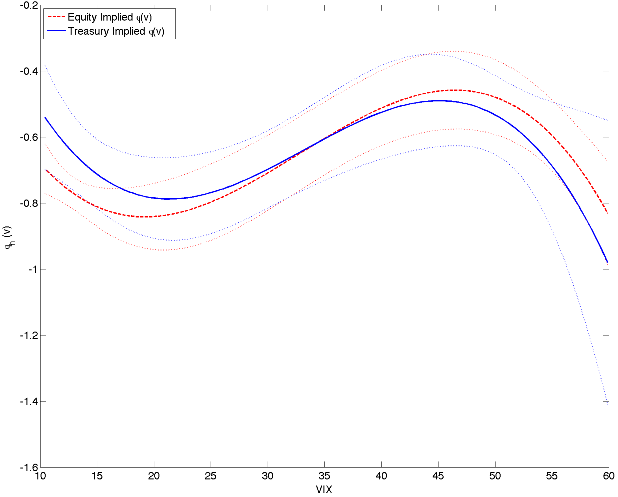
Expected Excess Returns across Portfolios



Industry Sorts, Treasuries, Credit: SRRR Loadings $\hat{b}_h^i$



SRRR $\phi_h(v_t)$ Separately Estimated for Stocks and Bonds



Dynamic Asset Pricing Theory

- Asset pricing theory suggests that the cross-sectional intercepts a^i and slopes b^i are cross-sectionally related to risk factor loadings

$$E_t[Rx^i_{t+1}] \quad = \quad \alpha^i + \beta^i \left(\lambda_0 + \lambda_1 \phi(v_t) + \Lambda_2 x_t\right)$$

where

  - β^i denotes a $(1 \times K)$ vector of risk factor loadings
  - λ_0 is the $(K \times 1)$ vector of constants for the prices of risk
  - λ_1 is the $(K \times 1)$ vector mapping $\phi(v_t)$ into prices of risk
  - Λ_2 is the $(K \times p)$ matrix of the price of risk of additional risk factors
  - α^i represent deviations from no-arbitrage

Dynamic Asset Pricing Estimation

- We estimate

$$Rx^i_{t+1} = \underbrace{(\alpha^i + \beta^i \lambda_0)}_{a^i} + \underbrace{\beta^i \lambda_1}_{b^i} \phi(v_t) + \beta^i u_{t+1} + \varepsilon^i_{t+1}$$

  where

  - $\hat{\phi}(v_t)$ is taken as given from the unrestricted first step regression
  - u_{t+1} represent the VAR innovations to risk factors X_t:
    1. the market return
    2. the one-year Treasury return
    3. the nonlinear volatility factor $\phi(v_t)$
  - We estimate $\phi(v_t)$ from a SRRR with $h = 1$

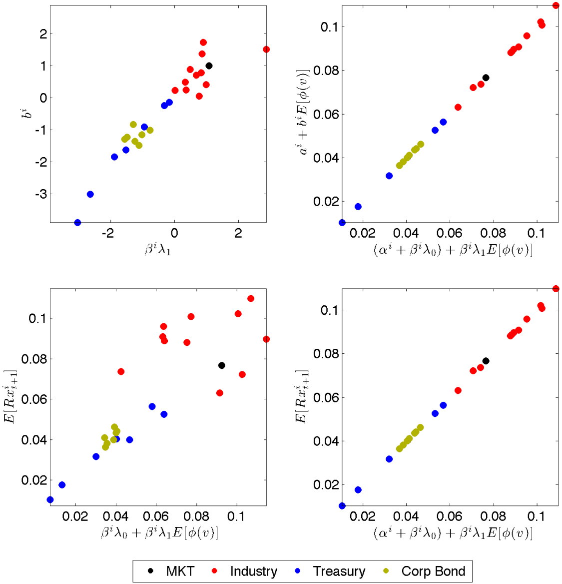
- We use reduced rank regression approach to dynamic asset pricing models of Adrian, Crump, and Moench (2014) to get $\beta, \lambda_0, \lambda_1$

Dynamic Asset Pricing: Risk Factor Exposures

Exposures	β^i_{MKT}	β^i_{TSY1}	$\beta^i_{\phi(v)}$	$\beta^i\lambda_1$	$(\alpha^i + \beta^i\lambda_0)$
MKT	1.00***	−0.24***	0.02	1.08***	0.33***
NoDur	0.61***	0.45	0.01	0.49**	0.21***
Durbl	1.19***	−2.24**	1.90**	0.68	0.23
Manuf	1.09***	−0.86	0.85***	0.83***	0.30***
Enrgy	0.71***	−1.11	1.11	0.36	0.18
Chems	0.75***	−0.80	0.20	0.87***	0.30***
BusEq	1.44***	−1.76**	−1.47***	2.88***	0.80***
Telcm	0.94***	0.06	0.27	0.77*	0.25**
Utils	0.39***	0.10	0.59	0.01	0.08
Shops	0.86***	−0.64	0.10	0.99***	0.32***
Hlth	0.69***	1.04	0.12	0.33	0.18**
Fin	1.08***	1.26	−0.24	0.90**	0.30***
cmt1	0.00	0.73***	−0.07	−0.16**	−0.03*
cmt2	−0.01	1.40***	−0.14	−0.32**	−0.06*
cmt5	−0.03*	2.90***	0.16	−0.95***	−0.19***
cmt7	−0.04*	3.55***	0.77*	−1.52***	−0.32***
cmt10	−0.04	3.90***	1.19***	−1.88***	−0.41***
cmt20	−0.08*	4.76***	1.96***	−2.64***	−0.57***
cmt30	−0.12**	5.45***	2.23*	−3.03***	−0.67***
AAA	0.02	2.54***	0.68	−1.11***	−0.23***
AA	0.06***	2.28***	0.71	−1.02***	−0.21***
A	0.09***	2.00***	1.24***	−1.24***	−0.26***
BAA	0.12***	1.55***	1.58***	−1.29***	−0.26***
igind	0.08***	1.90***	1.67***	−1.48***	−0.31***
igutil	0.07**	1.99***	1.73***	−1.56***	−0.33***
igfin	0.11***	1.83***	0.57	−0.76***	−0.14**

Prices of Risk	MKT	$TSY1$	$\phi(v_t)$
λ_1	1.02***	−0.28**	−0.62**

Cross-Sectional Pricing



Related Theories

- Fund managers exhibit Flight-to-Safety, Vayanos (2004): redemption risk of managers generates liquidity preference and time varying risk aversion as a nonlinear function of volatility
- Intermediary asset pricing, Adrian and Boyarchenko (2012): intermediaries face VaR constraints that bind with volatility $\Rightarrow$ pricing kernel as a function of volatility
- Consumption based asset pricing, Campbell and Cochrane (2000): a nonlinear function of surplus consumption ratio induces time variation in consumption volatility, increasing Sharpe ratios

Equilibrium Asset Pricing of Vayanos (2004)

- Equilibrium expected returns are

$$E_t\left[Rx^i_{t+1}\right] = \alpha^i_t + A\left(v_t\right) Cov_t\left(Rx^i_{t+1}, Rx^M_{t+1}\right) + Z\left(v_t\right) Cov_t\left(Rx^i_{t+1}, v_{t+1}\right)$$

  where
  - endogenously time varying effective risk aversion $A\left(v_t\right)$
  - endogenously time varying liquidity premium $Z\left(v_t\right)$
  - α^i_t related to transactions costs

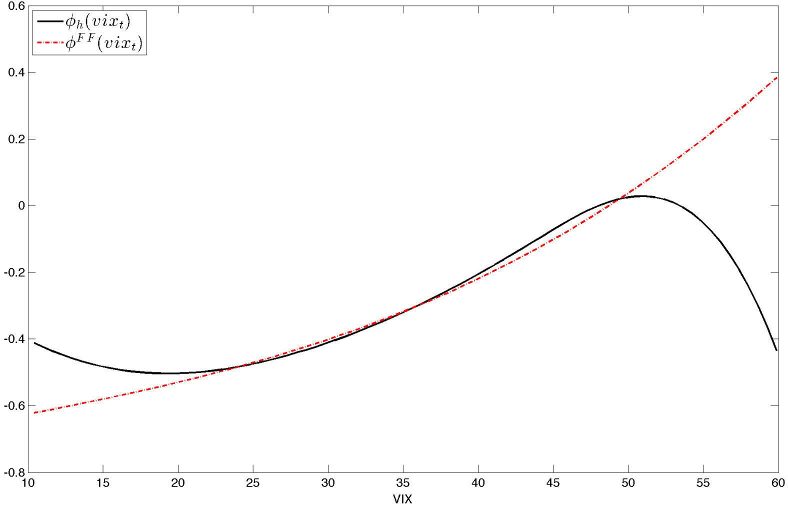
- Shape of $A\left(v_t\right)$ is similar to $\phi\left(v_t\right)$: convex when vol is high enough

Flight-to-Safety in Global Mutual Fund Flows

$$Flows_t^i = a^i + b^i \phi^{FF}(vix_t) + \varepsilon_t^i$$

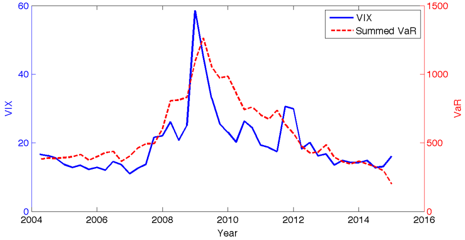
	Sample: 1990 - 2014		Sample: 1990 - 2007	
	a^i	b^i	a^i	b^i
us equity	0.50*	−1.00***	−0.29	−1.00
world equity	0.88	−1.77***	−1.06	−3.60***
hybrid	0.94*	−1.89***	−1.10	−3.75***
corporate bond	0.16	−0.32	0.02	0.08
HY bond	−0.02	0.05	0.04	0.12
world bond	0.34	−0.68	−0.29	−1.00
govt bond	−0.63*	1.27***	1.08	3.68***
strategic income	0.02	−0.04	0.35	1.18
muni bond	−0.01	0.03	−0.05	−0.16
govt mmmf	−0.42	0.85	0.39	1.33
nongovt mmmf	−0.02	0.03	0.36	1.23
national mmmf	0.00	0.00	0.16	0.56
state mmmf	0.28	−0.56**	0.10	0.35
Joint p-value		0.000		0.000

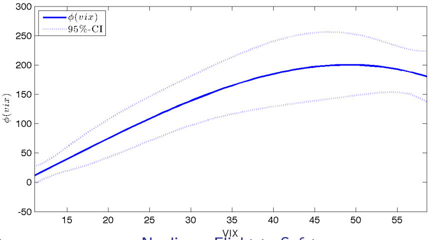
Flight-to-Safety in Global Mutual Fund Flows



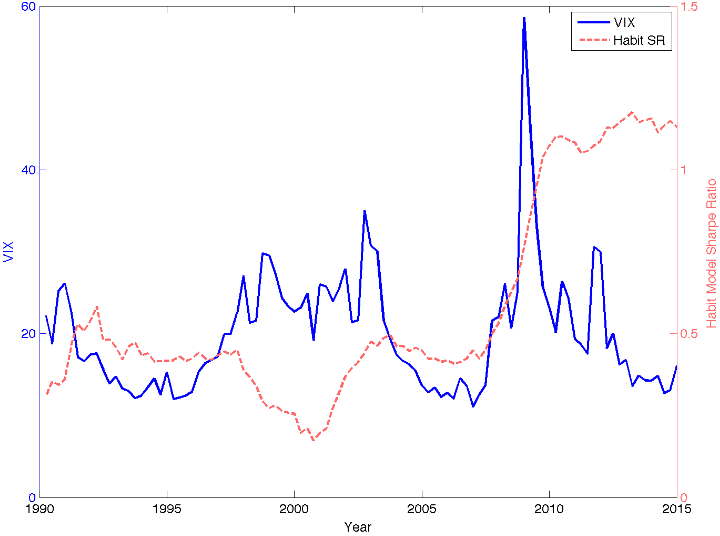
Intermediary VaR Constraints and Volatility

$$VaR_t^i = a^i + b^i \phi^{VaR}(vix_t) + \varepsilon_t^i$$





Consumption Habit-Formation Model



Outline

Conclusion

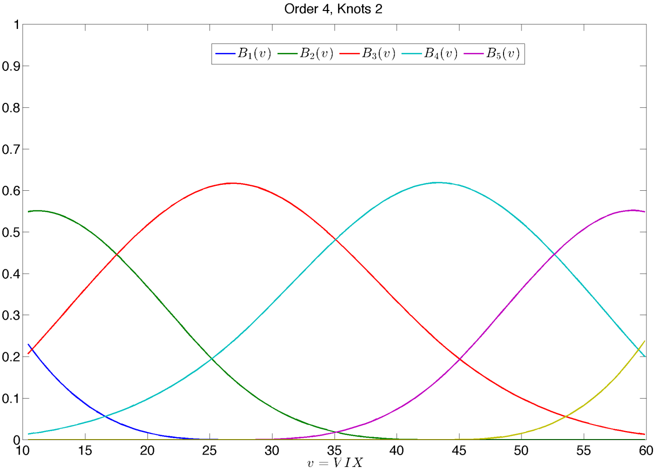
- Evidence of nonlinearities and flight-to-safety in the risk-return tradeoff
  - We propose SRRR to extract a nonlinear function of stock return volatility $\phi_h(v)$ that forecasts stock and bond returns at horizons up to two years
  - The forecasting function $\phi_h(v)$ is the same across diverse sets of stock, bond, and credit returns, up to affine transformations
  - Mirror image property is evidence of flight-to-safety

- Link SRRR to theories of
  - Dynamic asset pricing
  - Asset management pricing
  - Intermediary asset pricing
  - Consumption-based asset pricing

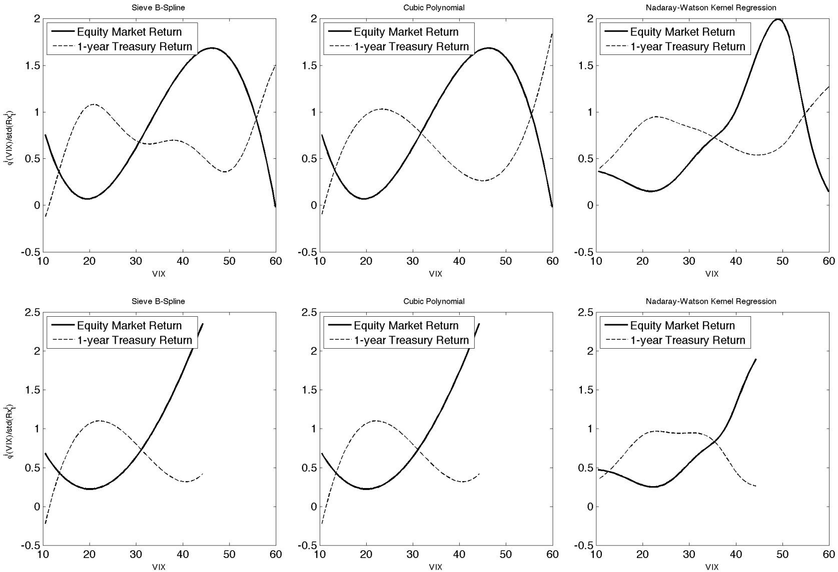
Outline

Appendix

Appendix: B-Spline Basis Functions



Sieve, Polynomial, and Kernel Regressions



Appendix: Reverse Regression Intuition

- Intend to predict $R_{t+h}^{(h)} = R_{t+1} + R_{t+2} + \cdots + R_{t+h}$,
$$R_{t+h}^{(h)} = \mathbf{a}_h + \mathbf{A}_h X_t + \varepsilon_{t+h}, \qquad \mathbf{A}_h = \mathbb{C}\left(R_{t+h}, X_t\right)\mathbb{V}\left(X_t\right)^{-1}$$
- Reverse regression sets $X_t^{(h)} = X_t + X_{t-1} + \cdots + X_{t-h}$
$$R_{t+1} = \mathbf{a} + \mathbf{A}X_t^{(h)} + \varepsilon_{t+1}, \qquad \mathbf{A} = \mathbb{C}\left(R_{t+1}, X_t^{(h)}\right)\mathbb{V}\left(X_t^{(h)}\right)^{-1}$$
- $\mathbf{A}_h$ and $\mathbf{A}$ are related by
$$\begin{aligned}
\mathbf{A}_h &= \mathbb{C}\left(R_{t+h}^{(h)}, X_t\right)\mathbb{V}\left(X_t\right)^{-1} \\
&= \mathbb{C}\left(R_{t+1}, X_t^{(h)}\right)\mathbb{V}\left(X_t^{(h)}\right)^{-1}\mathbb{V}\left(X_t^{(h)}\right)\mathbb{V}\left(X_t\right)^{-1} \\
&= \mathbf{A}\mathbb{V}\left(X_t^{(h)}\right)\mathbb{V}\left(X_t\right)^{-1}.
\end{aligned}$$
- Under **cov. station.** and full rank, row i of $\mathbf{A}_h = 0 \Leftrightarrow$ row i of $\mathbf{A} = 0$

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