Passive Funds Actively Affect Prices: Evidence from the Largest ETF Markets

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Motivation

- Recent years have seen a surge in passive investment
  - ETFs: \$0.2 trillion of AUM in 2004; \$5 trillion in 2018
  - Commoditization makes investing simple and cost-efficient, but could reduce price informativeness and create systemic risks
- ETFs in VIX and commodities – beneficial setting to study price impact of passive funds
  - Larger fraction of the market compared to stocks. VIX: 25%, S&P 500: <2%
  - Easier to measure non-fundamental price distortions
  - Price impact of different types of trading. Leverage-induced trading

Preview of main results

- ETFs **affect prices** of underlying assets
  - Trading demand from ETFs is strongly related to prices
  - Propose a model-independent approach to replicate the value of a VIX futures. Isolate **non-fundamental part of the VIX futures premium** of 18.5 % p.a., strongly related to ETF demands

- **Decompose** ETF **demands**
  - Calendar rebalancing
  - Flow rebalancing
  - Leverage rebalancing

- **Analyze** the risk of **leverage rebalancing**
  - Amplifies price changes and introduces unhedgeable risks for ETF counterparties
  - Document **new ETF anomaly**: trading against leverage rebalancing earns large abnormal returns and SR-s above two across markets
  - Puzzling: exposed to 'right-way risk'

Isolate ETF-induced price distortions

- ETF price impact manifests itself through an increase in the non-fundamental part of prices
- **Model-independent** approach for replicating the fundamental value of a VIX futures contract
  - Construct a synthetic futures contract from option prices
  - **No** parametric or distributional **assumptions**: simply use the definition of variance. Robust to jumps
- Price of the replicated contract was close to that of the traded one before the introduction of ETFs but diverged consistently thereafter
- The **gap** between the two prices (18.5% per year, on average) is **strongly related to ETF demand**

ETF demand decomposition

- Propose a novel **decomposition** of **ETF demand**
- **Calendar rebalancing**: arises because futures are finite-maturity instruments. ETFs have to gradually roll their exposure
- **Flow rebalancing**: driven by fund flows
- **Leverage rebalancing**: arises due to the maintenance of a constant daily leverage by leveraged ETFs
  - Leveraged ETFs aim to deliver multiples of the daily return of their benchmark index. E.g., if the benchmark index goes up by 10%, a two-times leveraged ETF should return 20%.
  - New type of mechanic institutional demand
  - Has the **largest effects** on the gap

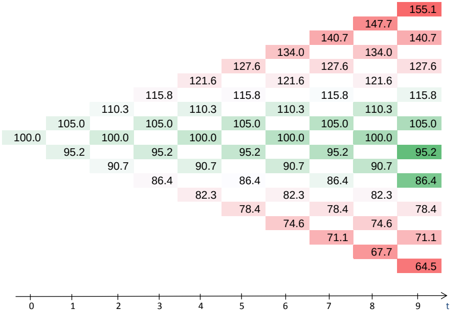
Leverage rebalancing

- **Amplifies price changes**: ETFs mechanically have to buy after price increases and sell after price decreases
- Trading against leveraged ETFs
  - Providing liquidity to investors with short horizons, who follow momentum-like strategy
  - **Introduces unhedgeable risks** for ETF counterparties (negative convexity)
- Potential distorting effect on prices can be large even in a market with a 0 net share of ETFs
  - VIX in February 2018: net market share of ETFs was close to 0
  - But potential price impact due to leverage rebalancing was **60% of the total market** size

LSE

Understanding the risks of leverage rebalancing

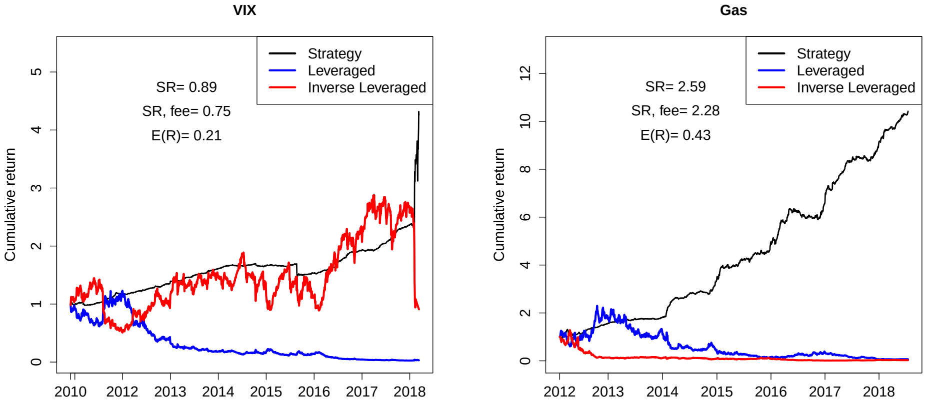
- Take an arbitrageur who trades against a pair of equal-sized **ETFs with opposite leverages** (e.g., $L = 2$ and $L = -2$)
  - Is she perfectly hedged by matching $L = 2$ demand with $L = -2$? No!
  - **Not a zero-return** strategy, but a **bet on variance**
  - Lose from price jumps, gain from small price fluctuations (contrarian)



Understanding the risks of leverage rebalancing

- **Hedging** the variance exposure is not easy
- Propose a simple strategy to understand the risks of trading against leverage rebalancing
- Document a **novel ETF-related anomaly** across markets
  - Short a pair of ETFs with opposite leverages (e.g., 2 and -2), to approximate liquidity provision to leveraged ETFs
  - Surprisingly, the returns on such a strategy are not zero, but are consistently positive across markets. α of 16.6% for VIX, 42.3 % for natural gas. SR of 0.89 and 2.59
  - Puzzling: exposed to 'right-way risk'

The short-both strategy – intra-day returns



Implications

- **Price is strongly related to ETF demand**, when ETFs control a large share of the market
  - Leverage-induced rebalancing creates a feedback effect on prices
  - Contributes to the policy debate on the desirability of commoditization and the general shift towards passive investing
- **More nuanced view of VIX** and the VIX futures premium
  - VIX and its derivatives – barometer of financial stress, used in various risk models
  - But prices are significantly disrupted by non-fundamental mechanical ETF demand
- **Novel decomposition** of ETF trading demand. Develop a strategy to capture the risk premium of leverage rebalancing

Thank you for your attention and useful comments!

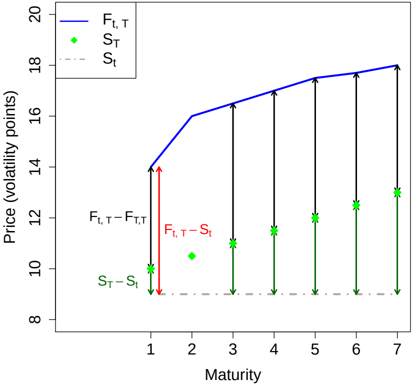
Appendix

Institutional details

- VIX and commodity ETFs obtain price exposure by entering into futures contracts
  - follow a benchmark based on the first two futures contracts
  - roll daily
- Some ETFs also aim to maintain a constant *daily* leverage ratio, L
  - Example: benchmark return is 10%, a double-leveraged ($L = 2$) ETF should return 20%; an inverse ETF ($L = -1$) should return -10%

VIX futures prices – informative about fundamentals?

- Test whether $F_{t,T}$ is informative about the fundamental spot at maturity S_T, or is influenced by premiums
- Use the identity $F_{t,T} - S_t = F_{t,T} - F_{T,T} + S_T - S_t$
- Check whether today's (negative) basis $F_{t,T} - S_t$ predicts changes of the futures (F) or the spot VIX (S), or both



Predictive power of basis

- Basis of short maturities **predicts futures** but **not spot**
- Front end of the futures curve is mostly influenced by ETFs

Spot VIX on basis: $S_T - S_t = \alpha_1 + \beta_1 \cdot (F_{t,T} - S_t) + \epsilon_{1,t}$								
	T=1m	T=2m	T=3m	T=4m	T=5m	T=6m	T=7m	T=8m
β_1	0.02	0.27	0.64***	0.72***	0.84***	0.94***	0.98***	1.01***
R^2	0.00	0.03	0.09	0.10	0.14	0.18	0.23	0.27

VIX futures on basis: $F_{T,T} - F_{t,T} = \alpha_2 + \beta_2 \cdot (F_{t,T} - S_t) + \epsilon_{2,t}$								
	T=1m	T=2m	T=3m	T=4m	T=5m	T=6m	T=7m	T=8m
β_2	-0.98***	-0.73***	-0.36***	-0.28***	-0.16***	-0.06**	-0.02	0.01
R^2	0.14	0.10	0.04	0.04	0.02	0.01	0.00	0.00

Synthetic Basis regressions

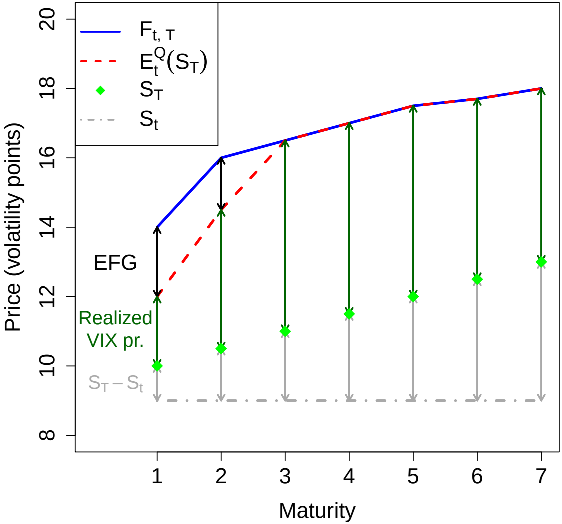
VIX ETF Futures gap (EFG)

- Decompose basis into premiums and spot change:

$$F_{t,T} - S_t = \underbrace{F_{t,T} - \mathrm{E}_t^{\mathrm{Q}}(S_T)}_{\textbf{ETF Futures gap (EFG)}} + \underbrace{\mathrm{E}_t^{\mathrm{Q}}(S_T) - S_T}_{\textit{Realized VIX Premium}} + \underbrace{S_T - S_t}_{\textit{Spot VIX change}}$$

- $F_{t,T}$ is influenced by ETF demand
- $\mathrm{E}_t^{\mathrm{Q}}(S_T)$ – fundamental value, computed from a non-ETF-influenced market
- $F_{t,T} - \mathrm{E}_t^{\mathrm{Q}}(S_T) \neq 0$ due to **market segmentation**. Non-fundamental **ETF futures gap (EFG)**

VIX ETF Futures gap (EFG)



Computing $\mathrm{E}_t^{\mathrm{Q}}(S_T) = \mathrm{E}_t^{\mathrm{Q}}(VIX_{T_1\to T_2})$

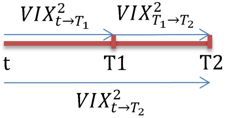
- Using the definition of variance:

$$\mathrm{Var}_t^{\mathrm{Q}}(VIX_{T_1\to T_2}) = \mathrm{E}_t^{\mathrm{Q}}\left(VIX^2_{T_1\to T_2}\right) - \left(\mathbf{E}_t^{\mathbf{Q}}(\mathbf{VIX}_{\mathbf{T_1\to T_2}})\right)^2$$

$$\iff \mathbf{E}_t^{\mathbf{Q}}(\mathbf{VIX}_{\mathbf{T_1\to T_2}}) = \sqrt{\mathrm{E}_t^{\mathrm{Q}}(VIX^2_{T_1\to T_2}) - \mathrm{Var}_t^{\mathrm{Q}}(VIX_{T_1\to T_2})}$$

- First term under the square root is forward $VIX^2_{T_1\to T_2}$:

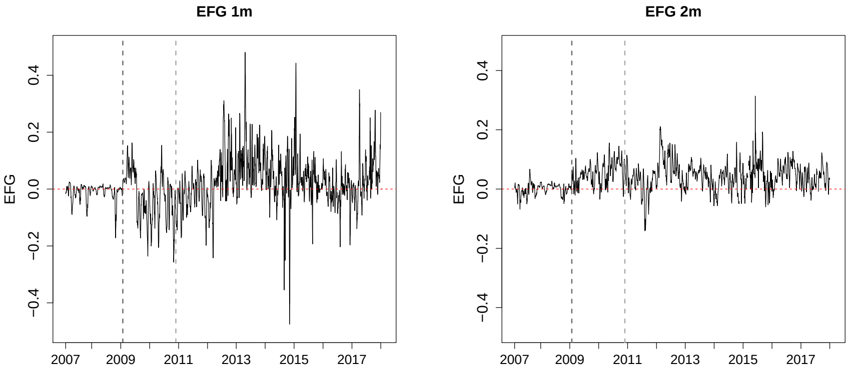
$$(T_2 - T_1)\mathrm{E}_t^{\mathrm{Q}}(VIX^2_{T_1\to T_2}) = (T_2 - t)\mathrm{E}_t^{\mathrm{Q}}(VIX^2_{t\to T_2}) - (T_1 - t)\mathrm{E}_t^{\mathrm{Q}}(VIX^2_{t\to T_1})$$



- Second term is a static portfolio of OTM VIX options:

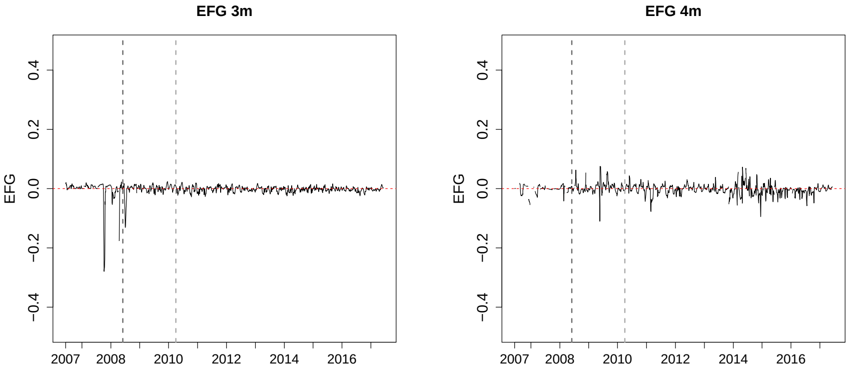
$$\mathrm{Var}_t^{\mathrm{Q}}(VIX_{T_1\to T_2}) = 2R_{f,t\to T_1}\left(\int_{K=0}^{F_{t,T_1}} P_t(K,T_1)dK + \int_{K=F_{t,T_1}}^{\infty} C_t(K,T_1)dK\right)$$

VIX ETF Futures gap $(F_{t,T} - \mathrm{E}_t^{\mathrm{Q}}(S_T))$



1m, 2m HKM

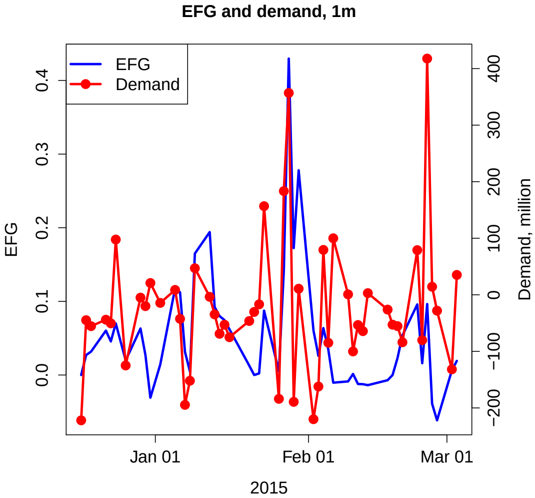
EFG for other maturities



VIX ETF Futures gap

- Model-independent. Robust to jumps Derivation for jumps Robust to jumps
- Possible **explanations** for the gap
  - Discretization error in computing $\mathrm{Var}_t^{\mathbb{Q}}(VIX_{T_1 \to T_2})$. But as calls and puts are convex, that would push EFG even higher
  - Liquidity concerns and funding constraints
  - Difference in margin requirements
  - Hedging pressure in the options market
  - Using forward variance swaps instead of options mitigates some of these problems. Produces even higher gap
  - Presence of **ETFs in the VIX futures market**

EFG ($F_{t,T} - \mathrm{E}_t^{\mathrm{Q}}(S_T)$) and demand of ETFs ($D_{t,i}^{\$,all}$)



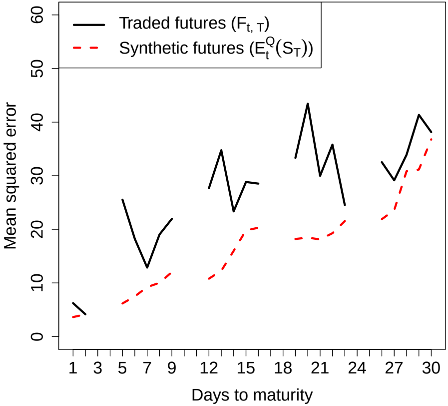
Regressions of the EFG ($F_{t,T} - \mathrm{E}_t^{\mathrm{Q}}(S_T)$)

Dependent variables	$\mathrm{EFG}_{t,1}$			$\mathrm{EFG}_{t,2}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$D^{\$,all}_{t,i}$	1.21***	**0.97****		0.57***	**0.45*****	
	(0.25)	(0.40)		(0.15)	(0.12)	
$D^{\$,all}_{t-1,i}$			**0.77*****			**0.38****
			(0.26)			(0.12)
$\mathrm{EFG}_{t-1,i}$		6.03***	6.02***		3.92***	4.09***
		(0.72)	(0.73)		(0.19)	(0.22)
$\mathrm{Liq}_{t,i}$		0.88**	0.75**		0.02	0.16
		(0.38)	(0.37)		(0.11)	(0.11)
TED_t		0.51	1.28		1.46***	1.24***
		(0.97)	(1.06)		(0.41)	(0.40)
α_t		0.62**	0.63**		-0.33***	0.18
		(0.24)	(0.25)		(0.12)	(0.11)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	1,898	1,898	1,895	1,824	1,824	1,816
R^2	0.24	0.44	0.44	0.26	0.58	0.62

Premium. Flow | Premium. Level | Returns of futures on EFG

Mean squared error

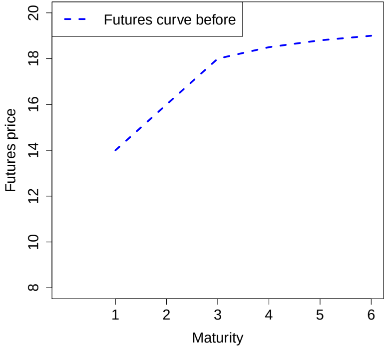
- Run predictive regressions of S_T on $F_{t,T}$ and S_T on $\mathrm{E}_t^{\mathrm{Q}}(S_T)$
- $\mathrm{E}_t^{\mathrm{Q}}(S_T)$ is a better predictor of the fundamental value S_T compared to $F_{t,T}$



MSE Time series

Calendar rebalancing

- ETFs roll from the 1st generic futures to the 2nd one. Example:
  Today: 50% in 1st futures, 50% in 2nd futures
  Tomorrow: 45% in 1st futures, 55% in 2nd futures
  ...
  In 10 business days: 0% in 1st futures, 100% in 2nd futures



- Analogous to index inclusion/exclusion for equities ETFs

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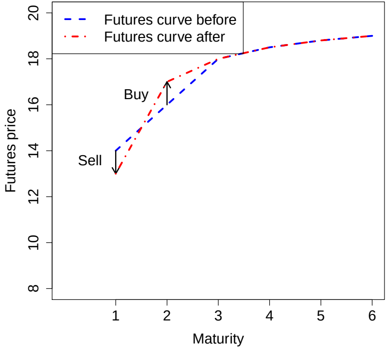

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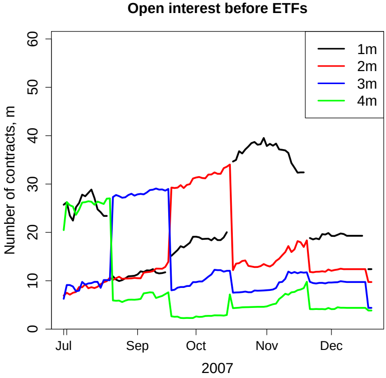
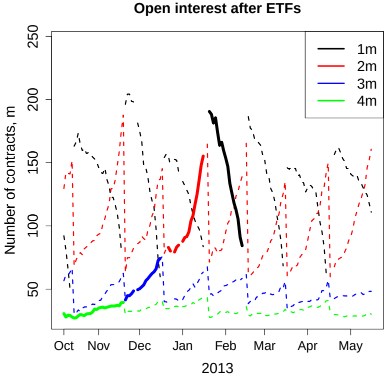
Open interest dynamics before and after ETF introduction





Calendar rebalancing forces early close of futures positions

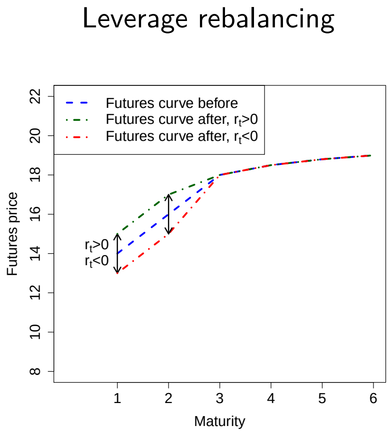
Leverage rebalancing

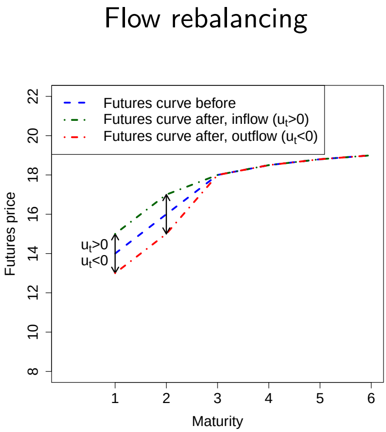
- Some ETFs are leveraged – aim to provide multiples of the daily return of the benchmark r_t
  - Leverage $L > 1$ or $L < 0$
  - Return every day Lr_t
  - E.g., if r_t is 10 %, double-long ETF ($L = 2$) should return 20 %
- Always **rebalance in the same direction** as the benchmark return
  - Daily rebalancing demand is $L(L-1)AUM_{t-1}r_t$
  - As $L(L-1) \geq 0 \; \forall L \notin [0,1]$, both long ($L > 1$) and inverse ($L < 0$) ETFs trade in the same direction as r_t
  - Potential **feedback channel** for prices

Do ETFs actually do that? | Math derivation | Feedback channel | Decomposition

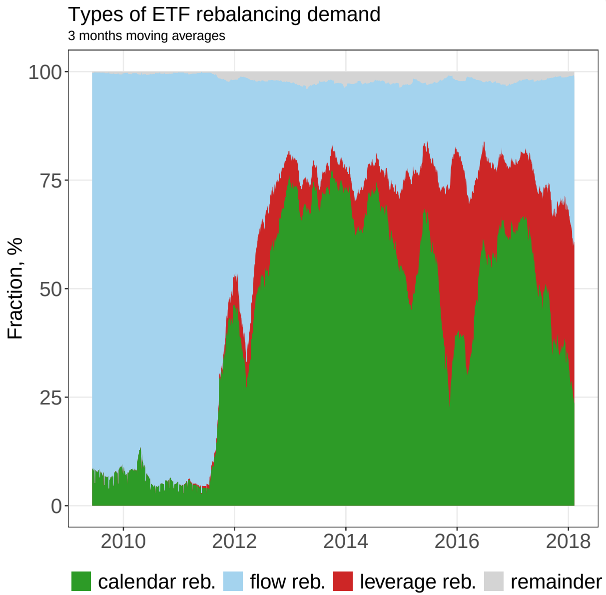
LSE

Leverage rebalancing. Flow rebalancing

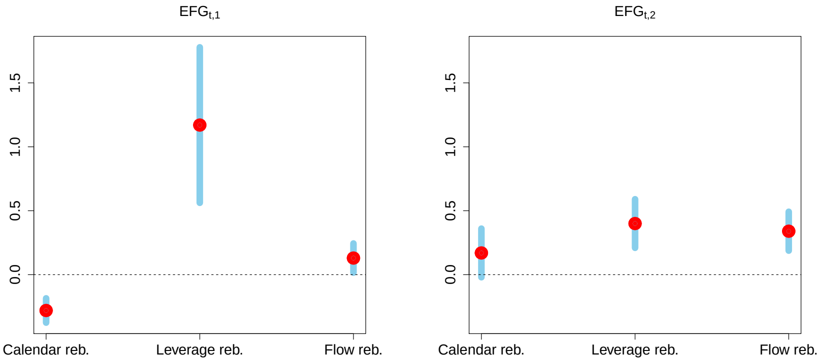




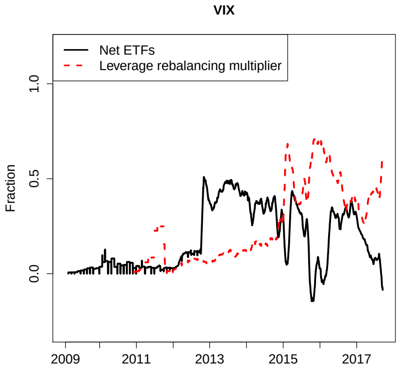
Demand decomposition. VIX ETFs

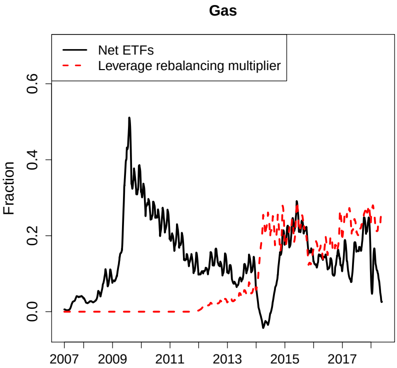


Regressions of EFG on components. VIX



ETFs' leverage rebalancing





Net ETFs$=\frac{\sum_j^N L_j AUM_j}{Mkt \;\; cap}$; L_j – leverage of ETF j

Leverage rebalancing multiplier$=\frac{\sum_j^N L_j(L_j-1)\cdot AUM_j}{Mkt \;\; cap}$