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**.
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. $\alpha$ 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

VIX

- Cumulative return
- SR = 0.89
- SR, fee = 0.75
- E(R) = 0.21

Strategy
Leveraged
Inverse Leveraged


Gas

- Cumulative return
- SR = 2.59
- SR, fee = 2.28
- E(R) = 0.43

Strategy
Leveraged
Inverse Leveraged

2012 2013 2014 2015 2016 2017 2018

Passive funds actively affect prices
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!
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.

![Diagram showing price volatility points over maturity for $F_{t,T}$, $S_T$, and $S_t$.]
Predictive power of basis

- Basis of short maturities **predicts futures but not spot**

- Front end of the futures curve is mostly influenced by ETFs

<table>
<thead>
<tr>
<th>Spot VIX on basis: $S_T - S_t = \alpha_1 + \beta_1 \cdot (F_{t,T} - S_t) + \epsilon_{1,t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T=1m$</td>
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<tr>
<td>$\beta_1$</td>
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<tr>
<td>$R^2$</td>
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<tr>
<th>VIX futures on basis: $F_{T,T} - F_{t,T} = \alpha_2 + \beta_2 \cdot (F_{t,T} - S_t) + \epsilon_{2,t}$</th>
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<tbody>
<tr>
<td>$T=1m$</td>
</tr>
<tr>
<td>$\beta_2$</td>
</tr>
<tr>
<td>$R^2$</td>
</tr>
</tbody>
</table>

**Synthetic**  **Basis regressions**
VIX ETF Futures gap (EFG)

- Decompose basis into premiums and spot change:

  \[ F_{t,T} - S_t = \underbrace{F_{t,T} - \mathbb{E}_t^Q(S_T)}_{\text{ETF Futures gap (EFG)}} + \underbrace{\mathbb{E}_t^Q(S_T) - S_T}_{\text{Realized VIX Premium}} + \underbrace{S_T - S_t}_{\text{Spot VIX change}} \]

- \( F_{t,T} \) is influenced by ETF demand

- \( \mathbb{E}_t^Q(S_T) \) – fundamental value, computed from a non-ETF-influenced market

- \( F_{t,T} - \mathbb{E}_t^Q(S_T) \neq 0 \) due to market segmentation. Non-fundamental ETF futures gap (EFG)
VIX ETF Futures gap (EFG)

\[ F_{t,T} \]
\[ E_t^Q(S_T) \]
\[ S_T \]
\[ S_t \]

Realized VIX pr.

\[ S_T - S_t \]

Maturity

Price (volatility points)

EFG

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Passive funds actively affect prices
Computing $E_t^Q(S_T) = E_t^Q(VIX_{T_1 \to T_2})$

- Using the definition of variance:

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

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

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

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

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

$$\text{Var}_t^Q(VIX_{T_1 \to T_2}) = 2R_{f, t \to T_1} \left( \int_{K=0}^{F_t, T_1} P_t(K, T_1) dK + \int_{K=F_t, T_1}^{\infty} C_t(K, T_1) dK \right)$$
VIX ETF Futures gap \( (F_{t,T} - \mathbb{E}_t^Q(S_T)) \)

1m, 2m HKM

Passive funds actively affect prices
EFG for other maturities

EFG 3m

EFG 4m

 Passive funds actively affect prices
VIX ETF Futures gap

- Model-independent. Robust to jumps

- Possible explanations for the gap
  - Discretization error in computing $\text{Var}_t^Q(\text{VIX}_{T_1 \rightarrow T_2})$. 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 \( (F_t, T - \mathbb{E}_t^Q(S_T)) \) and demand of ETFs \( (D_{t,i}^{\text{all}}) \)

**Diagram:**
- **Title:** EFG and demand, 1m
- **X-axis:** Jan 01, Feb 01, Mar 01
- **Y-axis:** EFG and demand, million
- **Legend:**
  - EFG
  - Demand
- **Note:** Passive funds actively affect prices
Regressions of the EFG ($F_{t,T} - E_t^Q(S_T)$)

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>EFG$_{t,1}$</th>
<th>EFG$_{t,2}$</th>
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<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
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<tr>
<td>$D_{t,i}^{$} \text{all}$</td>
<td>1.21***</td>
<td>0.97**</td>
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<tr>
<td></td>
<td>(0.25)</td>
<td>(0.40)</td>
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<tr>
<td>$D_{t-1,i}^{$} \text{all}$</td>
<td></td>
<td>0.77***</td>
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<tr>
<td></td>
<td></td>
<td>(0.26)</td>
</tr>
<tr>
<td>EFG$_{t-1,i}$</td>
<td>6.03***</td>
<td>6.02***</td>
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<tr>
<td></td>
<td>(0.72)</td>
<td>(0.73)</td>
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<tr>
<td>Liq$_{t,i}$</td>
<td>0.88**</td>
<td>0.75**</td>
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<td></td>
<td>(0.38)</td>
<td>(0.37)</td>
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<td>TED$_t$</td>
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<td></td>
<td>(0.97)</td>
<td>(1.06)</td>
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<tr>
<td>$\alpha_t$</td>
<td>0.62**</td>
<td>0.63**</td>
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<tr>
<td></td>
<td>(0.24)</td>
<td>(0.25)</td>
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<table>
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<th>Controls</th>
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<td>$R^2$</td>
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<td>0.44</td>
<td>0.44</td>
<td>0.26</td>
<td>0.58</td>
<td>0.62</td>
</tr>
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</table>
Run predictive regressions of $S_T$ on $F_{t,T}$ and $S_T$ on $E_t^Q(S_T)$

$E_t^Q(S_T)$ is a better predictor of the fundamental value $S_T$ compared to $F_{t,T}$
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
Calendar rebalancing

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  ...
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Open interest dynamics before and after ETF introduction

Calendar rebalancing forces early close of futures positions

Passive funds actively affect prices
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 $L r_t$
  - 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
Leverage rebalancing. Flow rebalancing

Leverage rebalancing

Flow rebalancing

Futures curve before
Futures curve after, \( r_t > 0 \)
Futures curve after, \( r_t < 0 \)

Futures curve before
Futures curve after, inflow (\( u_t > 0 \))
Futures curve after, outflow (\( u_t < 0 \))

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Demand decomposition. VIX ETFs

Types of ETF rebalancing demand

3 months moving averages

- Calendar reb.
- Flow reb.
- Leverage reb.
- Remainder

Fraction, %

2010 2012 2014 2016 2018

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Regressions of EFG on components. VIX

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ETFs’ leverage rebalancing

Net ETFs = \( \frac{\sum_j L_j AUM_j}{Mkt \ cap} \); \( L_j \) – leverage of ETF \( j \)

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

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