The Rise of Factor Investing: "Passive" Security Design and Market Implications

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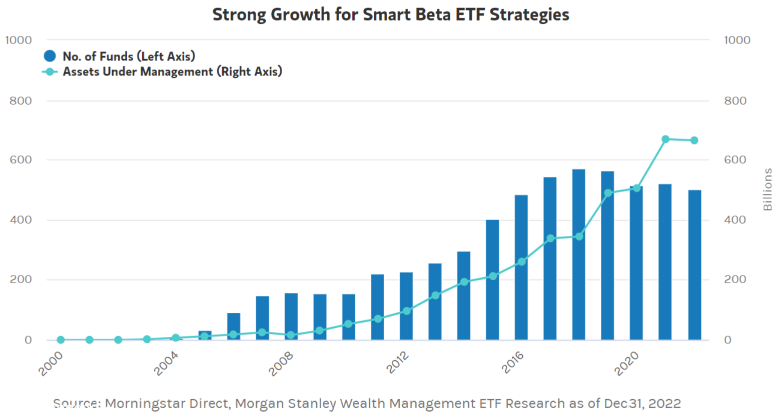
Outline

Introduction

- The last two decades have witnessed a drastic growth in passive investing.
  - AUMs of passive funds and ETFs has increased from 2% of the U.S. equity market capitalization in 1998 to about 14% in March 2020.
  - AUM of Exchange-traded funds (ETFs) has exceeded 10 trillion U.S. dollars in 2021 and the number of product offerings is about 10,000 by the end of 2022.



Preview of the model

- The impact of passive investing on financial markets remains little understood.
- Research on the security design of these so-called “passive investing” products is limited.

- We propose a Kyle-type model with multiple assets.
  - Each asset’s payoff has an asset-specific component and a systematic componnent.
  - Two types of speculators: one (**asset speculators**) and (**factor speculators**)
  - Factor speculators need to pay costs to trade financial assets.
  - Competitive financial intermediaries introduce and design composite securities (CSs).
    - The payoffs of CSs are linear combinations of underlying assets.
    - CSs are “passthrough” vechiles (e.g., ETFs).
    - Factor speculators also need to pay costs to trade CSs.

Preview of the results

- The optimal CS design entails underlying asset weights **proportional to their factor exposure** and **inversely proportional to price impacts**.
  - This CS products can best help factor speculators reap their information rents.
- Introducing CSs can avoid duplicated trading costs and effectively increase participations of factor speculators.
- Cosequently, introducing CSs can have rich asset implications.
  - It incorporates more factor information and leads to greater informational efficiency, higher price variability, and return co-movements.
  - It can has non-monotonic impacts on underlying liquidity.
  - It can increase asset-specific information acquisition and pricing efficiency for and only for assets with greater factor exposure and low asset-specific risk

Literature

- Empirical studies on composite securities and ETFs:
  Ben-David et. al. (2014), Madhavan & Sobczyk (2014), Krause et. al. (2014), Hamm (2014), Da & Shive (2013), Bradley and Litan (2010)
- Recent empirical studies on ETF and informational efficiency:
  Israeli et. al. (2016), Glosten et. al. (2016), Huang, O'Hara, and Zhong (2020); Bhojraj, Mohanram, and Zhang (2020)
- Theory papers on composite securities:
  Subrahmanyam (1991), Gorton & Pennacchi (1990, 1993), Bond and Garcia (2022)
- Other theory:
  Gorton & Pennacchi (1990), Malamud (2015), Pan & Zeng (2016), Koont, Ma, Pastor, and Zeng (2022), Bhattacharya & O'Hara (2016)

Contribution

- We propose a simple theory of composite securities and a conceptual framework to understanding the economics of factor investing (reducing duplicated costs).
- The framework can reconcile mixed evidence.
  - While some studies (e.g., Ben-David et. al. (2014), Madhavan and Sobczyk (2014), Krause et. al. (2014), Hamm (2014)) find evidence that ETFs deprive liquidity of the underlying basket with elevated intra- day return volatility, Ye (2019) finds that corporate ETFs improve liquidity.
  - Da and Shive (2018) and Leippold, Su, and Ziegler (2015) document ETFs and index futures increased underlying asset co-movements.
  - While Israeli et. al. (2016) find reduced firm-specific pricing efficiency, Glosten et. al. (2016) find that ETF trading increases co-movement and informational efficiency.
  - Huang, O'Hara, and Zhong (2020) and Bhojraj, Mohanram, and Zhang (2020a) document that industry ETFs can improve information efficiency among stocks with high industry exposure and low idiosyncratic risk.

Outline

Model Setup

- $K > 1$ underlying assets: Asset $k \in \{1, 2, \cdots, K\}$ has liquidation value v_k

$$v_k = \bar{v}_k + \beta_k \gamma + \alpha_k.$$

  where α_k is the asset-specific component, β_k is the exposure of Asset k to the common component γ.
  - $\gamma \sim \mathcal{N}(0, \sigma_\gamma)$, and $\alpha_k \sim \mathcal{N}(0, \sigma_{\alpha_k})$.

- Composite securities (CSs) can potentially be introduced by CS sponsors.
  - CSs are bundles of the underlying assets, with weights $\{w_k, k = 1, 2, \cdots, K\}$, subject to $\sum_{k=1}^{K} w_k = 1$.
  - The payoff is simply: $\sum_{k=1}^{K} w_k v_k$.

Market participants and information

- The model features three types of investors and potential CS sponsors.
  - One representative **asset speculator** for each asset: observeing α_k and maximizing profit from trading Asset k.
  - Numerous profit-maximizing **factor speculators**: factor speculator i observes $s_i = \gamma + \epsilon_i$, where $\epsilon_i \sim \mathcal{N}(0, \sigma_\epsilon)$.
  - An independent group of **liquidity traders** for each asset k with an exogenous aggregate group demand for liquidity $n_k \sim \mathcal{N}(0, \sigma_{n_k})$.
  - Competitive **(potential) CS sponsors** designing CSs and deciding on which one(s) to launch to maximize profits, if launching any at all.
  - One competitive and specialized **market maker** for each underlying asset market.

Timeline and trading protocols

- At $t = 0$, competitive CS markets open.
  - Each potential CS sponsor decides whether to pay a fixed cost $\hat{C}$ to enter.
  - Each CS sponsor offers the CS(s) upon entry, all to maximize the anticipated fee revenue subject to at least breaking even (participation constraint).
  - A CS product specifies the portfolio weights $(w_1, \ldots, w_K)$ and the management fee F.
  - Factor speculators decide which CS product(s) to purchase.
  - **The fee can be contingent on the number of speculator purchases.**
- At $t = 1$, asset markets open.
  - Fee-paying speculators can trade both (had they chosen so) the underlying assets and shares of CSs from the CS sponsors, and other speculators can only trade the underlying assets.
    - CSs are "passthrough" vechiles: CS sponsors mechanically trade the underlying assets with the corresponding weights according to the CS designs.
  - Trading of either CS products or underlying assets will incur a fixed cost $C > 0$ before trading.
  - All speculators and CS sponsors submit market orders to market makers.
  - Each market maker observes the total order flows for her own asset market.
- At $t = 2$, the payoffs are realized for all the assets.

Equilibrium definition

Definition 2.1 (**Generalized Factor Investing Equilibrium (FIE)**)

An FIE is a subgame perfect equilibrium with CS being traded. It consists of $\left\{\hat{\kappa}_k, \hat{\eta}_k, \hat{\lambda}_k, \hat{N}_k, P_k\right\}_{k=1}^{K}$, $\{w_k^j\}_{k=1}^{K}$, $\left\{\eta_{CS}^j\right\}$, $\left\{N_{CS}^j\right\}$, *and* $\{F^j\}$, *where* $j \in \mathbb{J}$ *indexes the countable set of CSs offered, such that:*

1. *Entrant CS sponsors offer CS product* $j \in \mathbb{J}$ *at* $t = 0$ *by specifying the weights* $\left(w_1^j, w_2^j, \ldots, w_K^j\right)$ *and fee* F^j *to maximize her anticipated fee revenue at* $t = 1$ *when the product is launcned. A sponsor enters only if she expects to at least break even.*
2. *Asset* k *speculator submits order* $x_k = \hat{\kappa}_k \cdot \alpha_k$ *to maximize her expected trading profit.*
3. $\hat{N}_k$ *factor speculators directly trade Asset* k *at* $t = 1$ *by each submitting an order* $\hat{y}_k = \hat{\eta}_k \cdot s$ *to break even net of trading costs* (C)*;*
4. N_{CS}^j *factor speculators choose to trade via the* j*th CS product, with an order* $y_{CS,j} = \eta_{CS,j} \cdot s$*, to break even after CS fees and trading costs* $(C + F^j)$*;*
5. *The market maker for Asset* k *sets* $P_k(\omega_k) = \lambda_k^{CS}\omega_k$*.*

Discussion of the model

- Key friction: trading costs associated underlying and CSs
  - Examples include: the lack of access to trading opportunities, search cost, participation cost, information cost, attention/research cost.
  - Consequence: Factor speculators are not able to trade all underlying assets
- CSs emerge because they can mitigate trading costs.
  - CS sponsors need to incur an entry cost $\hat{C}$ (close to $K \cdot C$).
  - The full competition leads to an endogenous management fee $F_i = \frac{\hat{C}}{N_i^{CS}}$, where N_i^{CS} is the number of customers that purchase the service offered by sponsor i.
- In the equilibrium, $\hat{N}_k$ and N_{CS}^j satisfy:

$$\hat{\Pi}_k^F - C = 0, \Pi_{CS}^{F,j} - C - F^j = 0,$$

where $\hat{\Pi}_k^F$ is the trading profit of direclty trading in Asset k, and $\Pi_{CS}^{F,j}$ is the trading profit of trading $j$the CS.

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An Illustration

- Stylized assumptions include:
  1. only two underlying assets, i.e., $K = 2$
  2. perfect signals, i.e., $\sigma_\epsilon^2 = 0$
  3. no asset-specific information asymmetry, i.e., $\sigma_{\alpha_1} = \sigma_{\alpha_2} = 0$
  4. $\sigma_{n_1}^2 = \sigma_{n_2}^2 = \sigma_n^2$
  5. $\beta_1 > \beta_2 > 0$.
- A benchmark without CS
  - The number of factor speculators trading Asset k ($k = 1, 2$) is N_k
  - The market maker for Asset 1 (MM1) receives total order flows $\omega_1 = N_1\eta_1\gamma + n_1$, and sets price $P_1 = \mathbb{E}[\beta_1\gamma|\omega_1] = \lambda_1\omega_1$.
  - Market maker for Asset 2 (MM2) sets $P_2 = \lambda_2\omega_2$, where $\omega_2 = N_2\eta_2\gamma + n_2$
- The optimization problem for a factor speculator who trades Asset k is:

$$\Pi_k^F \equiv \max_{y_k} \mathbb{E}\left[y_k\left(\beta_k\gamma - P_k(\omega_k)\right)|\gamma\right].$$

An Illustrative benchmark

- Like standard Kyle-style models, we have

$$Y_k(\gamma) = \frac{\beta_k \gamma}{(N_k + 1)\lambda_k} \quad \text{and } \lambda_k = \frac{N_k \beta_k \eta_k \sigma_\gamma^2}{N_k^2 \eta_k^2 \sigma_\gamma^2 + \sigma_n^2}.$$

- In the equilibrium, we have: The above equation system yields:

$$\lambda_k = \frac{\beta_k \sigma_\gamma}{\sigma_n} \frac{\sqrt{N_k}}{N_k + 1} \quad \text{and} \quad \Pi_k^F = \frac{\beta_k \sigma_\gamma \sigma_n}{(N_k + 1)\sqrt{N_k}}.$$

- Two observations:
    - The expected trading profit of factor speculators is increasing in β_k
    - The expected trading profit of factor speculators is decreasing in N_k.
- High-β assets would have more factor speculators trading them in equilibrium.
    - When $\frac{\beta_2 \sigma_\gamma \sigma_n}{2} < C < \frac{\beta_1 \sigma_\gamma \sigma_n}{(N+1)\sqrt{N}}$, all factor speculators trade Asset 1 only.

An Illustration with CS

- Consider introducing CS with portfolio weight w_k on Asset k, where $k \in \{1, 2\}$ and $w_1 + w_2 = 1$.
- With more than two speculators trading this CS product, the management fee, $\frac{\hat{C}}{N_{CS}}$, is smaller than C (since $\hat{C} < 2C$).
- Given the choice of jth factor speculator in the CS market $\{w_{k,j}\}_{k\in\{1,2\}}$, jth factor speculator then chooses the CS product(s) to trade and the amount to trade:

$$\max_{y_{CS,j},\{w_{k,j}\}_{k\in\{1,2\}}} E\left[\sum_{k=1}^{2} y_{CS,j} w_{k,j} \left(\beta_k \gamma - \lambda_k^{CS}\left(\sum_{i\in J \text{ and } i\neq j} \eta_{CS,i} w_{k,i}\gamma + n_k + y_{CS,j} w_{k,j}\right)\right)\middle| \gamma\right]$$

- The effective trading aggressiveness of CS traders in asset market k is: $\eta_{CS,j} * w_{k,j} (= \eta_{CS,k})$.
- In equilibrium, $\widehat{\eta}_{CS,k} = \frac{\beta_k}{(N_{CS}+1)\lambda_k^{CS}}$.

Implications

- The choice of asset weights satisfying $w_1^S : w_2^S = \left(\beta_1/\lambda_1^{CS}\right) : \left(\beta_2/\lambda_2^{CS}\right)$.
  - Intuition: CS is a vehicle for factor investing, and the factor exposure/price impacts should matter when designing its weight.
- Introducing CSs can weakly increase the number of speculators in financial markets for two reasons.
  1. factor speculators can trade Asset 2 indirectly via CSs and generate additional trading profit.
  2. as more factor speculators trade CS products, the management fees and trading cost F are lowered via a "duplication reduction".
- Asset pricing implications:
  - The increase in the number of factor speculators improves the factor-specific informational efficiency $Var(\gamma|P_k)$
  - The return variability, $Var(P_k)$, also increases after introducing CS.
  - The increase in the number of factor speculators increases the co-movement $COV(P_1, P_2)$

Outline

Factor Investing Equilibrium

- **Proposition on the optimal CS design**

  Assume Asset 1 is the asset that has the maximum number of factor speculators trading in the equilibrium before CS. In an economy with competitive CS sponsoring, the FIE has one only CS sponsor, and it is described by either of the following two cases:

  1) $\hat{N}_1 > 0$ and $\hat{N}_k = 0$ for $k = 2, \ldots, K$. In this case, $N_{CS} + \hat{N}_1 = N_1$, $N_{CS} \geq N_k$ for $k = 2, \ldots, K$, and the weights of the CS traded in equilibrium satisfy:

  $$w_1 : w_2 : \ldots : w_K = \frac{\beta_1}{\lambda_1^{CS}(N_{CS} + N_1^* + 1 + 2\frac{\sigma_\varepsilon^2}{\sigma_\gamma^2})} : \ldots : \frac{\beta_K}{\lambda_K^{CS}(N_{CS} + 1 + 2\frac{\sigma_\varepsilon^2}{\sigma_\gamma^2})}$$

  2) $\hat{N}_k = 0$ for $k = 1, \ldots, K$. In this case, $N_{CS} \geq N_1$ and the weights of the CS traded in equilibrium satisfy:

  $$w_1 : w_2 : \ldots : w_K = \frac{\beta_1}{\lambda_1^{CS}} : \frac{\beta_2}{\lambda_2^{CS}} : \ldots : \frac{\beta_K}{\lambda_K^{CS}}$$

Asset implications on informational efficiency

- Three types of inforamtional efficiency:
  - asset-specific efficiency: $1/Var(\alpha_k|P_k)$
  - factor-specific efficiency: $1/Var(\gamma|P_k)$
  - total efficiency: $1/Var(v_k|P_k)$
- **Proposition on the informational efficiency**

  Introducing CS increases factor-specific efficiency and total efficiency but decreases asset-specific efficiency in asset prices.
- They are consistent with a large litereature of empirical studies on ETFs.
  - Glosten, Nallareddy, and Zou (2021) find that ETF trading increases information efficiency on industry or systematic components.
  - Bhojraj, Mohanra, and Zhang (2020) show that sector ETFs have improved informational efficiency by facilitating the transmission of information.
  - The decreased asset-specific information efficiency associated with CS introduction is also consistent with Israeli, Lee, and Sridharan (2017).

Asset implications on return Variability and co-movements

- We define the asset return variability of Asset k as $Var(P_k)$ and define the return co-movement between Assets i and j as $corr(P_i, P_j)$
- **Proposition on return Variability and co-movements**
  Introducing CS increases the return variability and co-movement in the underlying asset markets.
- They are consistent with a large litereature of empirical studies on ETFs.
  - Ben-David, Franzoni, and Moussawi (2018) who find that stocks included in ETSs (CSs) exhibit significantly higher intraday and daily volatility.
  - Crawford, Roulstone, and So (2012); Da and Shive (2018) and Glosten, Nallareddy, and Zou (2021) document that ETF trading increases return co-movement among underlying stocks

Asset implications on liquidity

- **Proposition on return Variability and co-movements**
  (i) If $N_{CS} \leq \frac{\sigma_\gamma^2 + 2\sigma_\epsilon^2}{\sigma_\gamma^2}$, introducing CS increases the price impacts.
  (ii) If $N_{CS} > \frac{\sigma_\gamma^2 + 2\sigma_\epsilon^2}{\sigma_\gamma^2}$, introducing CS increases the price impact of trading assets with $N_k < \frac{\left(\frac{\sigma_\gamma^2 + 2\sigma_\epsilon^2}{\sigma_\gamma^2}\right)^2}{N_{CS}}$, but decreases the price impact of trading assets with $N_k > \frac{\left(\frac{\sigma_\gamma^2 + 2\sigma_\epsilon^2}{\sigma_\gamma^2}\right)^2}{N_{CS}}$.
- The economic mechanisms for the above effects are similar to that in Subrahmanyam and Titman (1999).
  1. As more informed factor speculators participate in the market, market makers face more adverse selection, increasing pricing impact (*information effect*).
  2. More severe competition among informed factor speculators reduce the trading aggressive of each factor speculator, lowering price impact (*competiting effect*).

Asset implications on liquidity

- When β is low or asset-specific component volatility σ_α^2 is high, the number of factor speculators before CS introduction is likely to be small. As such, introducing CS increases price impact in these markets.

- When β is high or asset-specific component volatility σ_α^2 is low, the number of factor speculators trading in these markets are likely to be already high even before the introduction of CS trading.The competition effect dominates, and introducing CS trading would decrease the price impact.

Empirical supports on CS designs

- We now empirically test how stock characteristics affect ETF sponsors' choices of portfolio weights within ETFs.

$$w_{ijt} = \alpha_0 + \alpha_1 \cdot \beta_{ijt-1} + \alpha_2 \cdot \lambda_{it-1} + \alpha_3 \cdot X + \epsilon_{ijt}, \tag{1}$$

- w_{ijt} is the excess portfolio weight on stock i in ETF j at quarter t, β_{ijt-1} is the stock i's loading on factor j prior to quarter t, λ_{it-1} is Amihud's illiquidity measure of stock i prior to quarter t.
- X represents the set of control variables: Firm size (Ln(Mktcap)), Book-to-market ratio (BM), Institutional ownership (IO), Past twelve-month return (MOM), Analyst coverage (#Analyst), Idiosyncratic volatility (IVOL).
- Across all specifications, we include ETF and time fixed effects and calculate standard errors double clustered by ETF and time.

Empirical supports on CS designs

	(1)	(2)	(3)	(4)
Illiquidity	-0.0127***	-0.0190***	-0.0125***	-0.0193***
	(-4.54)	(-4.62)	(-4.50)	(-4.59)
Beta	0.0436***	0.0296***	0.0459***	0.0283***
	(2.99)	(2.86)	(3.17)	(2.77)
Ln(Mktcap)	-0.0895***	-0.1627***	-0.0913***	-0.1664***
	(-5.49)	(-4.88)	(-5.48)	(-4.82)
BM	0.0018	-0.0080*	0.0026	-0.0063
	(0.53)	(-1.69)	(0.75)	(-1.41)
Mom	0.0093*	0.0290***	0.0093*	0.0296***
	(1.95)	(3.11)	(1.75)	(3.15)
IO	0.2682***	0.2898***	0.2711***	0.2864***
	(5.93)	(5.80)	(5.95)	(5.86)
#Analysts	-0.0012	-0.0029**	-0.0011	-0.0026**
	(-1.13)	(-2.24)	(-0.95)	(-2.06)
IVOL	-1.2642***	-1.3320***	-1.2860***	-1.2336***
	(-4.43)	(-4.47)	(-4.34)	(-4.36)
Controls	Yes	Yes	Yes	Yes
ETF FE	No	Yes	No	Yes
Time FE	No	No	Yes	Yes

An Extension: endogenous asset-specific informative trading

- The potential asset speculator in each underlying Asset k faces a discrete choice of whether to incur a fixed cost C_A to become informed about Asset k and thus trade in the asset market k.
- We find: when $N_{CS} > \frac{\sigma_\gamma^2 + 2\sigma_\epsilon^2}{\sigma_\gamma^2}$, there exists a cut-off value β^* such that introducing CS weakly decreases (increases) the participation of asset speculators and asset-specific information efficiency for assets with $\beta_k < \beta^*$ ($\beta_k > \beta^*$).
  - When the number of factor speculators is already high before CS introduction (high β), the competition effect dominates, and thus, introducing CS decreases price impact and increases participation of asset speculators.
  - When the number of factor speculators is low before CS introduction (low β), the information effect dominates, and thus, introducing CS increases price impact and decreases participation of asset speculators.
- These results are consistent with empirical findings of Huang, O'Hara, and Zhong (2020); Bhojraj, Mohanram, and Zhang (2020).

Outline

Conclusion

- We propose a simple theory of composite securities and a conceptual framework to understanding the economics of factor investing (**reducing duplicated costs**).
- This model is simple but has rich implications.
  - The optimal CS design entails the underlying asset weights **proportional to their factor exposure** and **inversely proportional to price impacts**.
    - We conduct empirical exercises and have consistent empirical evidence.
  - The asset pricing implications are as follows
    - It incorporates more factor information and leads to greater informational efficiency, higher price variability, and return co-movements.
    - It can has non-monotonic impacts on underlying liquidity.
    - It can increase asset-specific information acquisition and pricing efficiency for and only for assets with greater factor exposure and low asset-specific risk (**in an extension with endogenous asset-specific information.**)