Swing Pricing

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Introduction

- Certain mutual funds offer redemption opportunities that are inconsistent with the underlying asset liquidity
  - Corporate bond funds offer daily redemption while bonds trade about once a month
- Bond funds grown massively since 2008
  - U.S. Corporate Bond Mutual funds now hold $2 trillion as of 2021Q2
- During March 2020, heavy redemptions and large price dislocations
- Swing Pricing: *"a mechanism to apportion the costs of redemption and purchase requests on the shareholders whose orders caused the trades"*

This Paper

- New evidence on firesales
- Build a model to describe firesales that is consistent with the facts
- Use the model to explore how a planner would design swing pricing to mitigate firesales

Outline

Mechanics of Bond Mutual Fund Redemption

- When an investor redeems, she receives the net asset value (NAV) of a share, which is determined by the fund
    - Based on the fund's ***assessment*** of the value of all holdings divided by the number of shares
- Net redemptions may lead to the fund trading underlying assets and can generate price pressure

First Mover Advantage

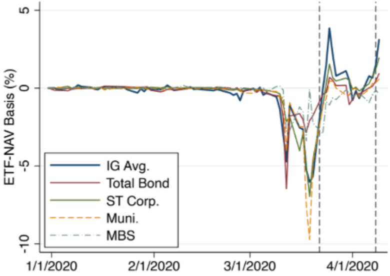
- In the U.S., because of the role of intermediaries in distribution, the fund knows little about total outflows when it strikes the NAV
- During periods of large net outflows, the fund has to estimate the price impact of redemptions $\Rightarrow$ Stress and normal periods may differ
- If price impact or trading costs for illiquid is *not* account for in NAV $\Rightarrow$ early redeemers get better prices than those who stay invested $\Rightarrow$ incentive to redeem early
    - Classic **strategy complementarity**: your choice to redeem increases my incentive to do so

Policies for Dealing with Runs

- Swing Pricing: adjust NAV to account for expected price impact of redemptions
  - ETF prices swing (almost) perfectly
- Increase notice periods
- Gating
- Redemption-in-kind

Literature

- Bond market disruption: Haddad, Moreira and Muir (2021)



- Bond-fund fragility: Jiang, Ng and Goldstein (2017), Falato, Goldstein and Hortacsu (2021), Ma, Xiao and Zeng (2021)
- Policies for dealing with runs : Jin, Kacperczyk, Kahraman and Suntheim (2019), Li, Li, Macchiavelli and Zhou (2020)

Outline

Data Sources

- ETF and Mutual Fund information from Morningstar Direct
  - Mutual funds daily NAV, ETF daily price
  - Prospectus benchmarks, investment style etc
- Consider corporate bond funds: available since 2011 and are domiciled in U.S., Luxembourg, Ireland and France.
- Match funds as described next to identify pairs that hold identical or nearly identical underlying bonds.

Matching Mutual Funds and ETFs

- Same benchmark and currency
  - Morningstar category, Morningstar index, prospectus benchmark or Dow Jones benchmark
- Start date before 11/2011; end date 12/2020
- Correlation between mutual fund NAV and ETF returns during "non-stress periods" ≥ 0.9
  - Calculated either during first 01/2011-04/2011, if available
  - Otherwise calculated over 09/2012 to 12/2012
- Final sample: 20 mutual funds and 4 ETFs

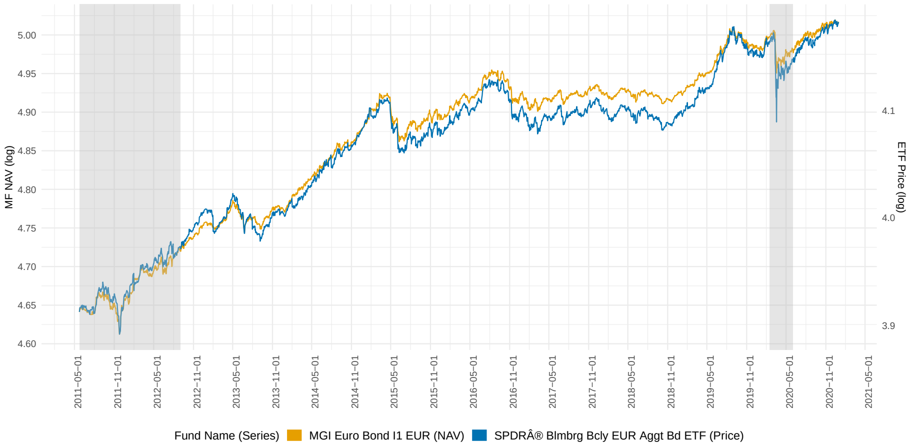
Stress Periods

GFC, Euro Crisis, Fall 2014, Brexit, Covid

- U.S.
  - 2008-09-15 to 2009-05-31
  - 2014-08-15 to 2014-12-18
  - 2020-02-15 to 2020-06-01
- Europe + Eurozone
  - 2008-09-15 to 2009-05-31
  - 2011-05-01 to 2012-08-31
  - 2020-02-15 to 2020-06-01
- U.K.
  - 2008-09-15 to 2009-05-31
  - 2016-06-23 to 2016-07-31
  - 2020-02-15 to 2020-06-01

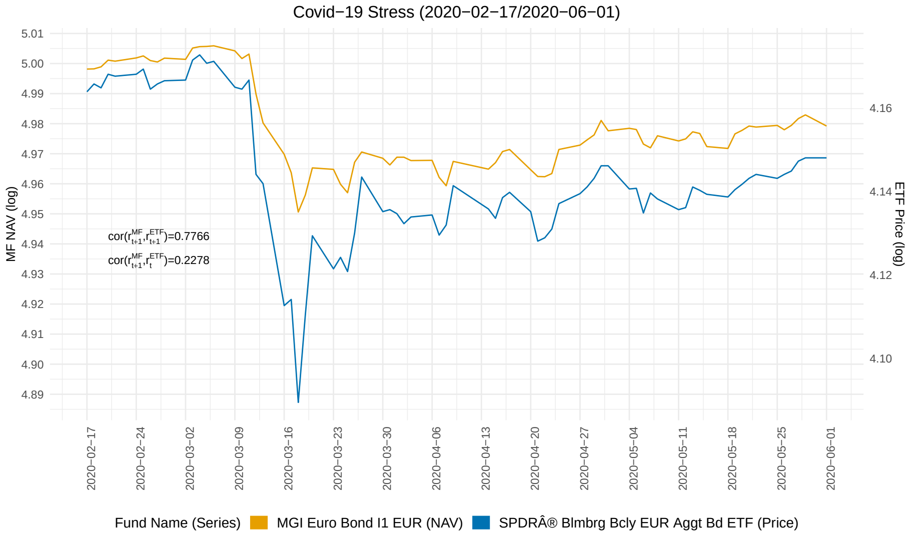
Example 1: Full Period

State Street ETF and Mercer Global Investment Mutual Fund, 2011-2020



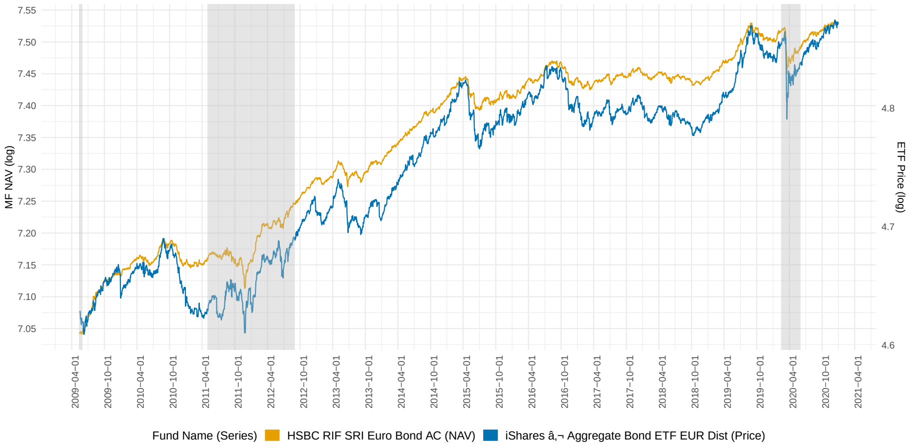
Example 1: Covid

State Street ETF and Mercer Global Investment Mutual Fund



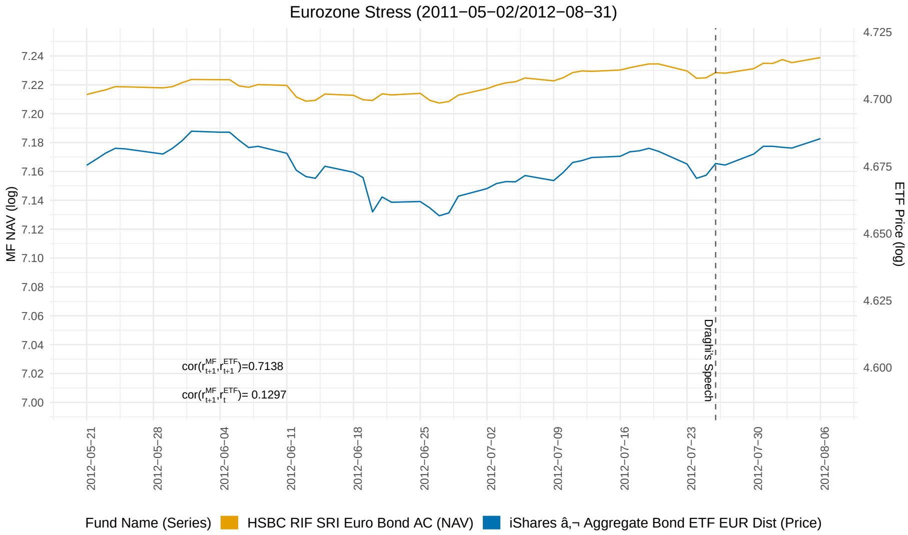
Example 2: Full Period

iShares ETF and HSBC Mutual Fund, 2009-2020

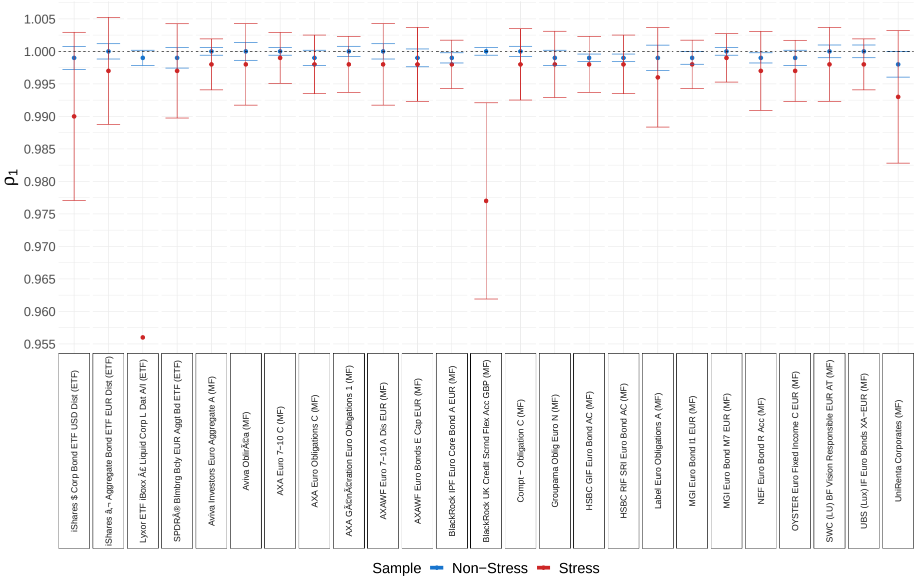


Example 2: Euro Crisis

iShares ETF and HSBC Mutual Fund



$$y_{t+1} = \rho_0 + \rho_1 y_t + \varepsilon_{t+1}$$

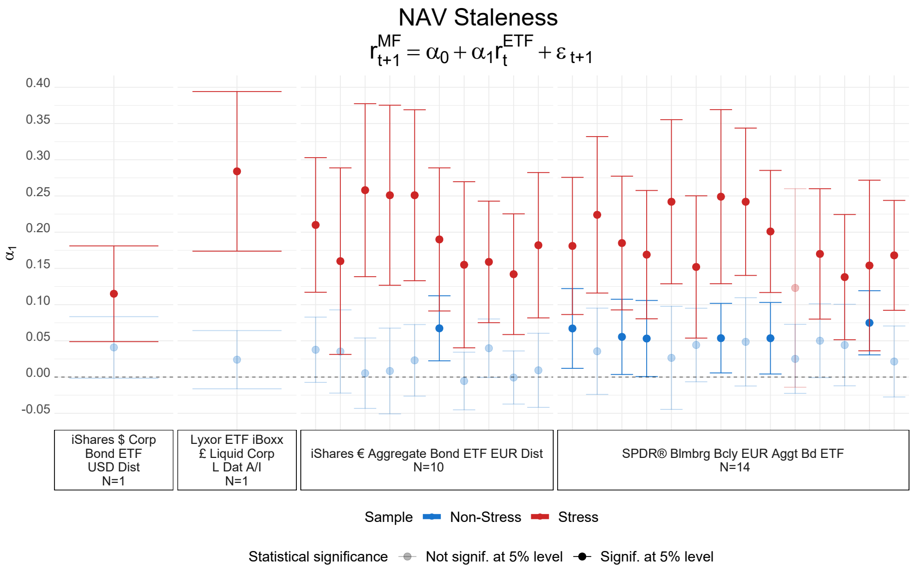


Regression Specification

- For each ETF and mutual fund pair, run separately for stress and non-stress periods

$$R_{mf,t+1} = \alpha_0 + \alpha_1 R_{eft,t} + \epsilon_t \tag{1}$$

Graph α_1 separating stress periods and non-stress periods


NAV Staleness
$r_{t+1}^{MF} = \alpha_0 + \alpha_1 r_t^{ETF} + \varepsilon_{t+1}$
α_1
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
iShares $ Corp Bond ETF USD Dist N=1
Lyxor ETF iBoxx £ Liquid Corp L Dat A/I N=1
iShares € Aggregate Bond ETF EUR Dist N=10
SPDR® Blmbrg Bcly EUR Aggt Bd ETF N=14
Sample Non-Stress Stress
Statistical significance Not signif. at 5% level Signif. at 5% level

Summary of Empirical Results

- ETF prices and mutual fund NAVs track each other
- During normal times, mutual fund returns are unpredictable
- In stress, NAVs are stale, and lagged ETF returns help predict future mutual fund returns

Outline

Set-up

- Period 0, 1, 2, 3
- One unit of a risky asset that pays dividend at end of period 3,

$$D \sim N(\mu, \sigma_D^2)$$

- Perfectly elastic supply of risk free bonds with unit return
- Measure $\frac{1}{2}$ of "direct investors" (who buy securities themselves)

Fund Investors

- Measure $\frac{1}{2}$ of fund investors (can only hold the risky asset via mutual funds)
- Period 0: invest in the mutual fund, number of shares normalized to 1
- Period $t = 1, 2$, each investor i receives an endowment shock $e_{i,t}(D - \mu)$, generates trading
- Period 3: dividend pays off
- All investors have CARA utility over period 3 consumption

$$\mathbb{E}[-\exp(-\gamma(xD + B))]$$

Endowment Shock Details

$t = 1, 2$

- $e_{i,t} \sim N(\mu_{e,t}, \sigma_e^2)$, i.i.d. across agents and time
- $e_{i,t}$ motivates redemption at the individual level (redeemers receive NAV_t per share)
- Positive $e_{i,t}$ can be interpreted as labor income more correlated with the aggregate state $\Rightarrow$ withdraw from the mutual fund
- $\mu_{e,t} \sim N(0, \sigma_{\mu_e}^2)$ is an i.i.d. aggregate shock (so trading volume fluctuates)

(To rule out idiosyncratic risk being reflected in the NAV, we assume separate insurance market opens to trade securities on $e_{i,t}$) Details

Information Structure

- At the beginning of period 1, the mutual fund observes signal v_1

$$v_1 = \mu_{e,1} + \epsilon_1 \qquad \epsilon_1 \sim N(0, \sigma^2_{\epsilon_1})$$

$\Rightarrow NAV_1(v_1)$

- At the beginning of period 2, the mutual fund observes $\mu_{e,1}$ and v_2:

$$v_2 = \mu_{e,2} + \epsilon_2 \qquad \epsilon_2 \sim N(0, \sigma^2_{\epsilon,2})$$

$\Rightarrow NAV_2(\mu_{e,1}, v_2)$

Transactions Costs

- We proxy for the price impact of trading by assuming a transaction cost of $\frac{\delta}{2}\Delta^2$
  - Δ is the number of shares bought or sold in a given period
- Potential estimation error in NAV_t comes from not observing net outflow perfectly, and hence not knowing the transactions costs exactly

Agents' Problems

Fund investors

- Take the fund's portfolio and NAVs as given
- Chooses number of shares to hold at the end of period $t = 1, 2$
- Maximizes expected utility

Details

The mutual fund

- Takes investor's withdrawal strategy as given
- Chooses portfolio holdings and NAVs
- Maximizes investors' expected utility

Details

Benchmark Case: Perfectly Observed Flows

- The mutual fund observes total flows perfectly: $\sigma^2_{\epsilon_1} = \sigma^2_{\epsilon_2} = 0$
- Aggregating individual fund investor's FOC and using the mutual fund budget constraint, this implies **Result 1:**

$$NAV_2 = \underbrace{B_{m,1} + x_{m,1}S_2}_{\text{Per share value}} \underbrace{- \frac{\delta}{2}(x_{m,2} - x_{m,1})^2 + \delta x_{m,2}(x_{m,2} - x_{m,1})}_{\text{Adjustment for transactions costs}}$$

  where $x_{m,t}(B_{m,t})$ is the mutual fund's holding of risky (risk-free) assets at the end of period t

- **Result 2:** NAV_2 (in the perfect signal case) is equal to the price of an ETF with the same underlying portfolio as the mutual fund

▸ ETF

General Case: Partially Observed Flows

- Signal is informative but not perfect: $0 < \sigma^2_{\epsilon,t} < \infty$
- **Result 3:** ETF price $S_{e,1}$ predicts next period NAV_2:

$$corr(NAV_2(\mu_{e,1}, v_2), S_{e,1}(\mu_{e,1})|NAV_1(v_1)) > 0$$

- Intuition: ETF incorporates all information on flows whereas NAV only partially accounts for it

No swing pricing

Social v.s. Private Swing

- Social planner strikes NAV_t to maximize total welfare subject to the same budget constraints, investor demand functions and information frictions

$$\max_{NAV_1(v_1), NAV_2(\mu_{e,1}, v_2)} \omega_1(-\mathbb{E}[\exp(-\gamma U_m)]) + (1-\omega_1)(-\mathbb{E}[\exp(-\gamma U_d)])$$

  where U_d is direct investor's utility and ω_1 will be chosen to cancel redistribution effects

- **Result 4:** A social planner swings more aggressively than a mutual fund, and adjusts the NAV to offset buying/selling pressure
- Intuition: The planner recognizes NAV determines withdrawals by investors, hence the fund's trading and ultimately prices in different states

The Pecuniary Externality

- Additional term in social planner's FOC w.r.t. NAV_2, ▸ Details

$$\mathbb{E}_{\mu_{e,2}}\left[\exp(-\gamma U)\frac{\partial U}{\partial x_{m,2}}\underbrace{\frac{\partial x_{m,2}(NAV_2,S_2)}{\partial S_2}}_{\propto(x_{m,2}-x_{m,1})}\underbrace{\frac{\partial S_2}{\partial NAV_2}}_{\text{Impact on price}}\middle|\mu_{e,1},v_2\right]$$

- If the trade $x_{m,2}-x_{m,1}$ is perfectly known, then the planner would adjust NAV_2 to reduce buying/selling pressure

- Since $x_{m,2}-x_{m,1}$ is uncertain (due to v_2 being noisy), NAV_2 is adjusted to take into account the *average* impact on prices, weighted by marginal utility and the size of the pecuniary externality in each state

$$\mathbb{E}[w(\mu_{e,1},v_2)(x_{m,2}(\mu_{e,1},v_2)-x_{m,1}(v_1))|\mu_{e,1},v_1]>0\Rightarrow NAV_2^s>NAV_2$$
$$\mathbb{E}[w(\mu_{e,1},v_2)(x_{m,2}(\mu_{e,1},v_2)-x_{m,1}(v_1))|\mu_{e,1},v_1]<0\Rightarrow NAV_2^s<NAV_2$$

Conclusion

- Stale NAV leads to a first mover advantage, particularly during stress periods
- Consequently, ETF prices predict mutual fund NAVs in stress periods
- Swing pricing can limit first mover advantage
- Social planner swings the prices more aggressively than private funds

Appendix: Insurance Market

- Insurance securities security $I(e_t)$ pays 1 unit of consumption goods if individual endowment shock is e_t in period t; this security has price $\kappa(e_t)$ in period 0
- Investors choose to buy $n(e_t)$ units of security $I(e_t)$
- The first-order condition wrt $n(i_t)$ is

$$-\kappa(e_t)\gamma E[-exp(-\gamma U(e_t))] + \gamma exp(-\gamma U(e_t))f(e_t) = 0. \quad (2)$$

where f is the PDF of e_t

- Fair pricing of these securities imply

$$\kappa(e_t) = f(e_t)$$

$\exp(-\gamma U(e_t))$ is independent of e_t, i.e. investors' marginal utility is equalized in each state.

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Fund Investor's Problem

- Fund investor j takes the fund's asset holdings $(x_{m,t}, B_{m,t})$ and per share NAV_t as given, chooses number of fund shares $y_{j,t}$ to hold at end of period t

$$\max_{y_{j,1}(e_{j,1}), y_{j,2}(e_{j,1}, e_{j,2})} \quad -\mathbb{E}[\exp\{-\gamma U_m\}]$$

where

$$U_m = \underbrace{(1 - y_{j,1})NAV_1}_{\text{Redemption in period 1}} + \underbrace{(y_{j,1} - y_{j,2})NAV_2}_{\text{Redemption in period 2}}$$
$$+ \underbrace{(e_{j,1} + e_{j,2} + y_{j,2}\frac{x_{m,2}}{Y_2})D + y_{j,2}\frac{B_{m,2}}{Y_2}}_{\text{Payoff in period 3}}$$
$$+ (\text{payoff from insurance})$$

$Y_t = \int_j y_{j,t} dj$ is the total number of mutual fund shares outstanding

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Fund Investor's Problem

- First order condition w.r.t. $y_{j,2}$

$$\mu - NAV_2 + \frac{B_{m,2}}{Y_2} - (e_{j,1} + e_{j,2} + y_{j,2}\frac{x_{m,2}}{T_2})\gamma\sigma^2 = 0$$

- First order condition w.r.t. $y_{j,1}$

$$NAV_1 = \frac{\mathbb{E}[U' NAV_2 | v_1]}{\mathbb{E}[U' | v_1]}$$

▸ Back

Mutual Fund's Problem

- The mutual fund chooses asset holdings and per share prices to maximize investor's expected utility

$$\max_{\{B_{m,t}, x_{m,t}\}, NAV_1(v_1), NAV_2(\mu_{e,2}, v_2)} \quad -\mathbb{E}[\exp\{-\gamma U\}]$$

$$\begin{aligned} s.t. \quad B_{m,t} + x_{m,t} S_{t+1} = & B_{m,t+1} + x_{m,t+1} S_{t+1} + \underbrace{\frac{\delta}{2}(x_{m,t+1} - x_{m,t})^2}_{\text{Transactions costs}} \\ & + \underbrace{(Y_{t+1} - Y_t) NAV_{t+1}}_{\text{Redemption needs}} \end{aligned}$$

$$(t = 0, 1)$$

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Parallel Economy with ETF

- NAV_2 (in the perfect signal case) is identical to the price of an ETF with the same underlying portfolio as the mutual fund
- Consider a parallel economy with ETFs
- ETF secondary market
  - Investors trade ETF shares $y_{j,t}$ in response to endowment shock $e_{j,t}$, taking ETF price $S_{e,t}$ as given
  - ETF price $S_{e,t}$ clears the secondary market given number of shares outstanding Y_t

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Parallel Economy with ETF Cont.

- ETF primary market
  - The sponsor adjusts the underlying portfolio subject to budget constraint (same as the mutual fund)
  - Authorized participants (APs) can choose to create (or redeem) Δ additional shares to maximize their payoffs

$$\max_{\Delta} \quad \Delta S_{e,2} - \Delta\left(\frac{x_{m,2}}{Y_2} S_2 + \frac{B_{m,2}}{Y_2}\right) - \underbrace{\left[\frac{\delta}{2}\left(x_{m,2} + \Delta \frac{x_{m,2}}{Y_2} - x_{m,1}\right)^2 - \frac{\delta}{2}\left(x_{m,2} - x_{m,1}\right)^2\right]}_{\text{Incremental transactions costs}}$$

$$\Rightarrow \quad S_{e,2} = NAV_2$$

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Appendix: Perfect Signal

- The mutual fund observes total flows perfectly: $\sigma^2_{\epsilon_1} = \sigma^2_{\epsilon_2} = 0$
- First order condition w.r.t. NAV_2 (conditional on $\mu_{e,1}, \mu_{e,2}$),

$$\frac{\partial U}{\partial y_{j,2}} \underbrace{\frac{\partial y_{j,2}}{\partial NAV_2}}_{=0 \text{ Envelop theorem}} + \frac{\partial U}{\partial x_{m,2}} \frac{\partial x_{m,2}}{\partial NAV_2} + \underbrace{\frac{\partial U}{\partial NAV_2}}_{=0 \text{ Redistribution}} = 0$$

$$\Rightarrow \mu - S_2 - \delta(x_{2,m} - x_{1,m}) = \gamma\sigma^2(\mu_{e,1} + \mu_{e,2} + x_{2,m})$$

▸ Back

Appendix: No Swing Pricing

- Either $\sigma^2_{\epsilon,t} = \infty$ or NAV_t is restricted to not depend on $v_t \Rightarrow$ Corresponds to the current state in the U.S.
- NAV_1 is simply a constant; NAV_2 depends on past flows $\mu_{e,1}$
- First order condition w.r.t. NAV_2 (conditional on $\mu_{e,1}$),

$$\mathbb{E}_{\mu_{e,2}}\left[\exp(-\gamma U)\frac{\partial U}{\partial x_2}\frac{\partial x_2(NAV_2, S_2)}{\partial NAV_2}\Big|\mu_{e,1}\right] = 0$$

- $NAV_2(\mu_{e,1})$ is correlated with $S_{e,1}(\mu_{e,1})$ conditional on NAV_1 (a constant)

$$corr(NAV_2(\mu_{e,1}), S_{e,1}(\mu_{e,1})|NAV_1) > 0$$

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Appendix: Social v.s. Private Swing

- Recall the private agent's FOC w.r.t. NAV_2,

$$\mathbb{E}_{\mu_{e,2}}\left[\exp(-\gamma U)\frac{\partial U}{\partial x_{m,2}}\frac{\partial x_{m,2}(NAV_2,S_2)}{\partial NAV_2}\Big|\mu_{e,1},v_2\right]$$

- Private agents use v_2 to update distribution of states $(\mu_{e,1},\mu_{e,2})$, but take prices $(S_2(\mu_{e,1},\mu_{e,2}))$ in different states as given

- Social FOC w.r.t NAV_2

$$\mathbb{E}_{\mu_{e,2}}\left[\exp(-\gamma U)\frac{\partial U}{\partial x_{m,2}}\left(\frac{\partial x_{m,2}(NAV_2,S_2)}{\partial NAV_2}+\frac{\partial x_{m,2}(NAV_2,S_2)}{\partial S_2}\frac{\partial S_2}{\partial NAV_2}\right)\Big|\mu_{e,1},v_2\right]$$

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