Managing Overreaction During a Run

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Overreaction and runs

- Runs are often associated to "investors' overreaction"
- Some policies aimed at attenuating runs are attempts to curb overreaction
- Example: Suspensions that are prevalent in financial markets around run-like events
  - Circuit breakers in virtually all stock exchanges
  - Suspension of flows in mutual funds (e.g., Europe following Covid shock)
  - Freezing of crypto accounts (e.g., following run on Terra Luna)
- Such policies are often defended with "behavioral arguments"
  - When bad news arrives, investors need time to properly process it

“Exchange officials argue that circuit breakers curb the effects of overreaction in markets and restore financial confidence by providing market participants with a cooling off period”

—Ackert, Hao and Hunter, 1997

“[trading halts] give participants a time-out to take a deep breath, evaluate the situation and perhaps interrupt the sense of panic. With a brief time to think again, perhaps some sellers will withdraw to the sidelines and value buyers will enter the market.”

—Brady and Glauber, 2020

My contribution

1. A model of runs in which agents are not rational and overreact to news
2. A formal treatment of the behavioral arguments used to justify suspensions during a run

Step 1:

- Global games model of runs with non-rational (diagnostic) expectations
  - Agents overreact to both positive and negative news

Step 2:

- Allow expectations to (partially) revert to rationality after some time

Step 3:

- Suspensions: Agents are prohibited from acting before "taking a deep breath"
  - Suspensions only affect investors behavior by curbing overreaction

Preview of results

Positive results:

- Small overreaction about fundamentals can lead to large overreaction about action of others
  - As first-order beliefs converge to rationality (i.e., investors converge to rationality)...
  - ...beliefs about the **action of others** do not necessarily converge in equilibrium

Normative results:

- Suspensions **amplify** runs during bad times
  - When bad public news arrive and/or investment returns are low
  - And in fact attenuate it in good times (when runs are already mild)
- Result driven by opposing effect of suspensions on beliefs of **average** and **marginal** investor

Related literature

Global games:

- Carlsson and Van Damme (1993), Morris and Shin (1998), Morris and Shin (2004), Goldstein and Pauzner (2005), Sakovics and Steiner (2012) and many others
  - But here with non-bayesian agents

Diagnostic expectations:

- Bordalo, Gennaioli and Shleifer (2018), Bordalo et al. (2019), Bordalo et al. (2021), Bianchi, Ilut and Saijo (2022) and many others
  - But here on a model of runs with strategic interactions

Suspensions in financial markets:

- Gorton (1985), Kodres and O'Brien (1994), Hautsch and Horvath (2019) and many others
  - Here: Focus on behavioral arguments

Outline

1. A model of runs with diagnostic investors
2. Reversion toward rationality
3. Suspensions

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A model of runs with diagnostic investors

- Continuum of risk-neutral investors with \$1 invested
- Two actions:
  - Renew or cancel the investment
- Payoff of canceling (run) = 1
- Payoff of renewing:

fundamental shock

$$v(\eta, \ell) = z + \eta - \gamma \ell$$

ex-ante returns — proportion that run

with $\gamma > 0$

Why do strategic complementarities arise?

- Asset market runs (sudden selloffs)
  - Loss limits [Morris and Shin, 2004]
  - Relative performance concerns [Morris and Shin, 2016]
  - Balance sheet constraints and liquidity shocks [Eisenbach and Phelan, 2023]
  - Transaction motives, if crypto [Sockin and Xiong, 2022]
- Mutual fund runs
  - NAV does not reflect liquidation costs [Chen, Goldstein and Jiang, 2010]
- Classical bank runs
  - Early liquidation depletes value of banks' assets [Diamong and Dybvig, 1983]

Information

- Investors share a common prior about the fundamental shock:

$$\eta \sim N(0, 1/\tau_0)$$

- Investors receive two pieces of information
  1. Private signal:

  $$x_i = \eta + \varepsilon_i$$

  2. Public signal:

  $$y = \eta + \omega$$

- Errors: normally distributed, iid, zero mean
  - Precisions: τ_x and τ_y
- All other parameters: common knowledge

How agents update beliefs

Agents do not follow Bayes rules, but instead have diagnostic expectations:

[Bordalo, Gennaioli and Shleifer, 2018]

diagnostic parameter (> 0)

$$f^{\theta}(\eta \mid x_i = \hat{x}, y = \hat{y}) = f(\eta \mid x_i = \hat{x}, y = \hat{y})\,\mathcal{R}(\eta, \hat{x}, \hat{y})^{\theta} C$$

rational beliefs

representativeness index

with

$$\mathcal{R}(\eta, \hat{x}, \hat{y}) = \frac{f(\eta \mid x_i = \hat{x}, y = \hat{y})}{f(\eta \mid x_i = 0, y = 0)}$$

In a nutshell:

- Agents have **limited** and **selective** memory
- Representative states (with high $\mathcal{R}$ given signal) come more easily to mind

example

- As usual in models with diagnostic expectations, normality of posteriors in preserved:

Lemma: Diagnostic beliefs with normal signals

After observing signals x_i and y, investors believe η is normally distributed with mean $\tilde{\mu}_1(x_i, y)$ and variance $1/\tilde{\tau}_1$, where

$$\tilde{\mu}_1(x_i, y) = \frac{(1+\theta)\left(\tau_x x_i + \tau_y y\right)}{\tau_0 + \tau_x + \tau_y},$$

$$\tilde{\tau}_1 = \tau_0 + \tau_x + \tau_y.$$

- Investors overreact to good and bad news

Equilibrium

Equilibrium characterization

- Equilibrium concept ≈ PBE but with expected payoffs computed with distorted beliefs
  - Distorted beliefs about fundamental ⇒ distorted beliefs about action of others

Proposition: Investors run when signals are low

Suppose that the following condition holds:

$$\gamma \frac{\tau_0 + \tau_y - \theta \tau_x}{1+\theta} \sqrt{\frac{\tau_0 + \tau_x + \tau_y}{\tau_x \left(\tau_0 + 2\tau_x + \tau_y\right)}} < \sqrt{2\pi}.$$

Then, the model has an essentially unique equilibrium, in which agents renew if $x_i > x^*$ and run if $x_i < x^*$, where x^* is the unique solution to

$$z + \tilde{\mu}_1 \left(x^*, y\right) - \gamma \Phi \left(\sqrt{\frac{\tilde{\tau}_1 \tau_x}{\tilde{\tau}_1 + \tau_x}} \left(x^* - \tilde{\mu}_1 \left(x^*, y\right)\right) \right) = 1.$$

Diagnostic expectations helps uniqueness

- Strategic complementarities $\Rightarrow$ self-fulfilling runs
  - With complete information $\Rightarrow$ multiple equilibria (as usual)
  - With sufficient private information $\Rightarrow$ unique equilibrium (as usual)

- Diagnostic expectations plays in favor of uniqueness:
  - Unique equilibrium for $\theta = 0 \implies$ unique equilibrium for $\theta > 0$
  - But converse is not true

- Hereafter: Parameters are such that equilibrium is unique for any $\theta \geq 0$:

$$\gamma \left(\tau_0 + \tau_y\right) \sqrt{\frac{\tau_0 + \tau_x + \tau_y}{\tau_x \left(\tau_0 + 2\tau_x + \tau_y\right)}} < \sqrt{2\pi}$$

  - Main results unchanged if it does not hold but instead we focus on extreme equilibria

Equilibrium overreaction even when agents are almost rational

- Small overreaction on fundamental beliefs $\Longrightarrow$ Large overreaction on beliefs about size of run
- **Example:** Limiting case with sufficiently precise private signal ($\tau_x \longrightarrow \infty$)
  - $\theta = 0$ (rational): Marginal investor holds **uniform belief** about action of others (ℓ)
  - $\theta \approx 0$ (almost rational): Marginal investor holds **degenerate belief** about ℓ
    - Believes $\ell = 0$ if marginal investor observes good news (low ex-ante returns)
    - Believes $\ell = 1$ if marginal investor observes bad news (high ex-ante returns)

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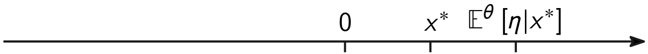
- Consider low ex-ante returns (and τ_x large):



- If one is (wrongly) certain fundamental is a bit higher than its signal...
- ...then one thinks almost everyone observed signal above hers if signals have little dispersion

  $\Longrightarrow$ Threshold type x^* is very optimistic about ℓ in that case

formal statement

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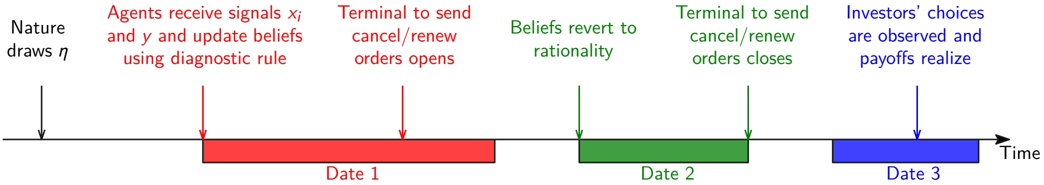
Given time, expectations revert to rationality

- Same model and payoffs as before, but now three dates:



- Investors can decide to run/renew at dates 1 or 2
- Early mover advantages: Late (date 2) decisions imply a cost δ
- Investors play a game with their future self

$$\text{beliefs of date 2 self} \neq \text{beliefs of date 1 self}$$

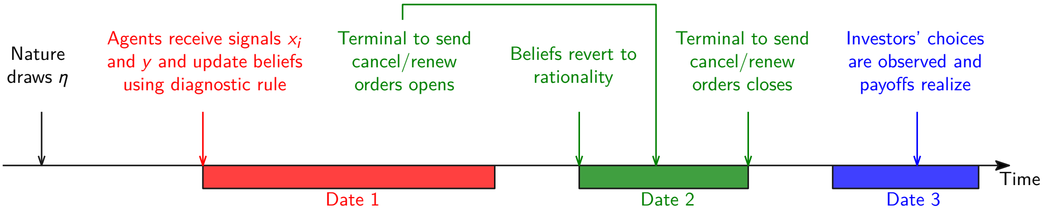
Equilibrium

- Investors decide as soon as they receive information
- Late decisions have two costs (from investors' point of view)
  - Delegating to a future self that may disagree with investor
  - Exogenous cost δ
- Capture notion of "irrational panics" as an equilibrium outcome
  - Investors receive info, rush to conclusions and act on it
  - Later, they may regret it...

Outline

Closing the terminal until investors take a deep breath

- Authority can now suspend terminal at date 1
- Akin to trading halts, suspension of flows in crypto/mutual funds



- Authority wishes to minimize expected size of run (after observing public signal)

Suspensions AMPLIFY runs in bad times

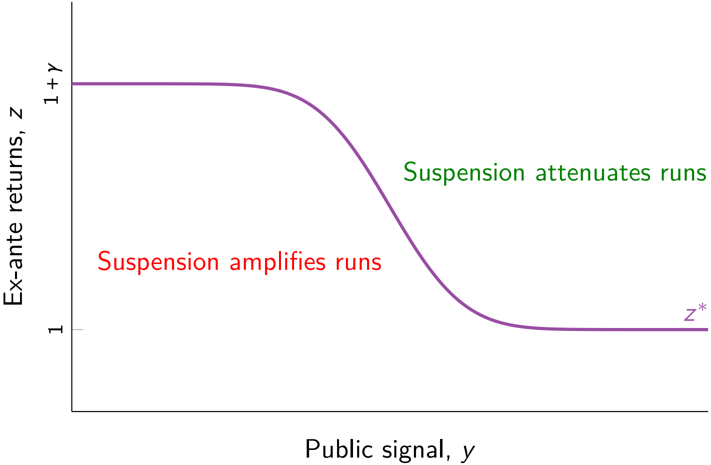
Proposition

A suspension attenuates runs in good times and amplifies them in bad times: The authority implements a suspension if $z > z^*$*, does not implement it if* $z < z^*$*, and is indifferent when* $z = z^*$*, where*

$$z^* = 1 + \gamma \Phi\left(-y\tau_y \sqrt{\frac{\tau_0 + \tau_x + \tau_y}{\left(\tau_0 + 2\tau_x + \tau_y\right)\tau_x}}\right).$$

Moreover, the authority is less prone to implement a suspension after bad public news arrives: $\frac{\partial z^*}{\partial y} < 0$.

Suspensions AMPLIFY runs in bad times



How are suspensions affecting beliefs when bad news arrive?

- $\Delta_i = \mathbb{E}\left[\eta | x_i, y\right] - \mathbb{E}^{\theta}\left[\eta | x_i, y\right]$ = "change in beliefs" from date 1 to 2 for investor i
- From the authority point of view

$$\mathbb{E}\left[\Delta_i | y\right] = -\frac{\theta \tau_y}{\tau_0 + \tau_y} y \quad \text{and} \quad \Pr\left(\Delta_i > 0 | y\right) = \Phi\left(-y \tau_y \sqrt{\frac{\tau_0 + \tau_x + \tau_y}{\tau_x\left(\tau_0 + \tau_y\right)}}\right)$$

- On average, agents **improve** beliefs at date 2 when $y < 0$:

$$y < 0 \implies \mathbb{E}\left[\Delta_i | y\right] > 0$$

- Almost everyone **improves** beliefs as $y \longrightarrow -\infty$:

$$\lim_{y \to -\infty} \Pr\left(\Delta_i > 0 | y\right) = 1$$

- Why not suspend then?

What common wisdom is missing

(i) What matters is not how suspension affects average beliefs or beliefs of most investors...
- ...but how it affects the beliefs of investors likely to change their decisions
- i.e, those close to indifference, the **marginal investors**

(ii) As public news worsen (worse info arrives), investors likely to change their decisions are the few receiving good news when combining public and private info

Why (ii)?

Public signals affect higher order beliefs

- Suppose public and private signal are equally precise ($\tau_x = \tau_y$)

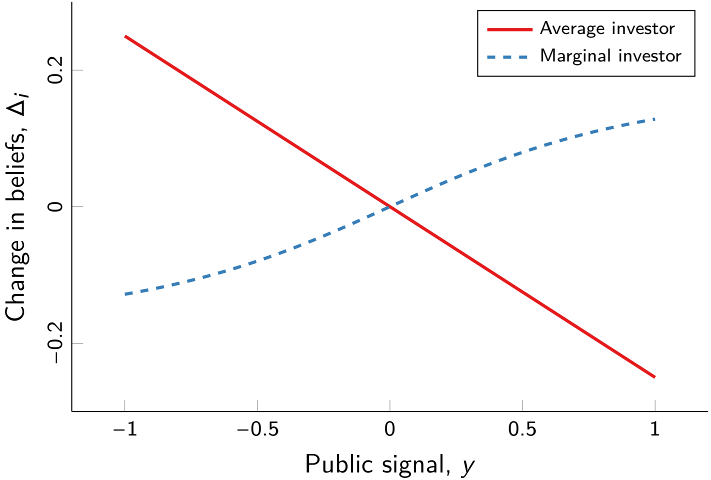
scenario A	scenario B
$x_i = -1, \quad y = 1$	$x_i = 1, \quad y = -1$

- Who is more prone to renew?
  - Both hold same beliefs about fundamental
  - But investor in scenario *A* is more optimistic about what others think about it
- Then, as public news worsens:
  - Investors are more prone to run, for a **given level of expected fundamentals**
  - Agents close to indifference must be those receiving good news (overall) about fundamental
  - Suspension worsens beliefs of those key agents, precisely because it curbs overreaction

Ex-ante returns and suspensions

- Low ex ante returns:
  - $\Longrightarrow$ Investors are prone to run ex ante
  - $\Longrightarrow$ Marginal investors are those observing good news overall
  - $\Longrightarrow$ Suspension may make those investors give up renewing by curbing their excessive optimism
- High ex-ante returns or good public news:
  - $\Longrightarrow$ Marginal investors observed bad news overall
  - $\Longrightarrow$ Suspension attenuates runs (but those are already smaller)

Example: Δ expectations induced by suspension



Extensions and other results in the paper

1. Regime change (discontinuous) payoffs ⏩ details
2. Parametric assumption for equilibrium uniqueness does not hold ⏩ details
3. Partial reversion to rationality ⏩ details
4. Effect of information quality on desirability of suspensions ⏩ details

Final remarks

- **Methodological contribution:**
  - Combine global games with diagnostic expectations
  - Small overreaction in first-order beliefs can imply large overreaction on higher-order beliefs
    - Large overreaction of beliefs about others' actions
  - Could be useful to study other problems
- **Normative insights:**
  - Suspensions can amplify runs after bad news arrive or during bad times in general
  - Even when almost all agents are receiving bad news and overreacting to it
  - And even though suspensions only operate by curbing overreaction

Proposition: Agents overreact even with $\theta \approx 0$

Suppose $\tau_x \to \infty$ and denote by x^* the equilibrium cutoff strategy. Then:

1. *For $z < 1+\gamma/2$, the investor observing $x_i = x^*$ is indifferent between both actions if she believes that $\ell = 0$ with probability one, and hence the equilibrium cutoff x^* solves*

$$z + (1+\theta)\,x^* = 1.$$

2. *For $z > 1+\gamma/2$, the investor observing $x_i = x^*$ is indifferent between both actions if she believes that $\ell = 1$ with probability one, and hence the equilibrium cutoff x^* solves*

$$z + (1+\theta)\,x^* - \gamma = 1.$$

3. *For $z = 1+\gamma/2$, the equilibrium cutoff is $x^* = 0$.*

back

Games of regime change

- A common payoff used in model of runs is also:

$$v(\eta, \ell) = \begin{cases} z & \text{if } \gamma \ell \leq \eta, \\ \alpha z & \text{if } \gamma \ell > \eta, \end{cases}$$

where $z > 1$, $\alpha z < 1$ and $\gamma > 0$ (e.g., similar to Angeletos, Hellwig and Pavan 2007)

Main result goes through

Proposition: Suspensions in coordination game of regime change

The authority implements a suspension if $z > z^*$, does not implement it if $z < z^*$, and is indifferent when $z = z^*$, where

$$z^* = \left[1 - (1-\alpha)\Phi\left(\tilde{\eta}\sqrt{\tau_0 + \tau_x + \tau_y}\right)\right]^{-1},$$

and $\tilde{\eta}$ solves $\gamma\Phi\left(-\sqrt{\tau_x}\left(\frac{\tau_y}{\tau_x}y + \tilde{\eta}\right)\right) = \tilde{\eta}$. Moreover, $\frac{dz^*}{dy} < 0$.

back

Equilibrium multiplicity

- Suppose the parametric condition for uniqueness does not hold
- Two selection criteria:
  - S1: Investors always play according to the largest stable cutoff equilibrium
  - S2: Investors always play according to the smallest stable cutoff equilibrium
- Stability = local convergence of best-reply dynamics

Proposition: Suspensions with extreme stable equilibria

Suppose that either S1 or S2 holds. Then, there is a z^{**} such that the authority implements a suspension if $z > z^{**}$ and does not implement it if $z < z^{**}$. Moreover, z^{**} is a decreasing and non-constant function of the public signal y.

back

Partial reversion to rationality

- Suppose that at date 2 investors are still diagnostic but with lower θ
- Main result goes through as well, bound z^* is unchanged

back

Information quality and the desirability of suspensions

- Suspension is desirable whenever $y > y^*$

Proposition

Consider $z \in (1, 1+\gamma)$. *Then,*

1. *If* $z < 1+\gamma/2$, $\frac{d\Pr(y>y^*)}{d\tau_y} > 0$ *and* $\frac{d\Pr(y>y^*)}{d\tau_x} < 0$;
2. *If* $z > 1+\gamma/2$, $\frac{d\Pr(y>y^*)}{d\tau_y} < 0$ *and* $\frac{d\Pr(y>y^*)}{d\tau_x} > 0$.

- **Example:** $\tau_y = 0$
  - Agents ignore public info
  - Low $z \implies x^*$ is high $\implies$ suspension is not desirable for sure
  - $\uparrow \tau_y \implies$ agents no longer ignore $y \implies$ suspension may become desirable if high y realizes

back

Example: Updating Pr(brankruptcy) after negative report

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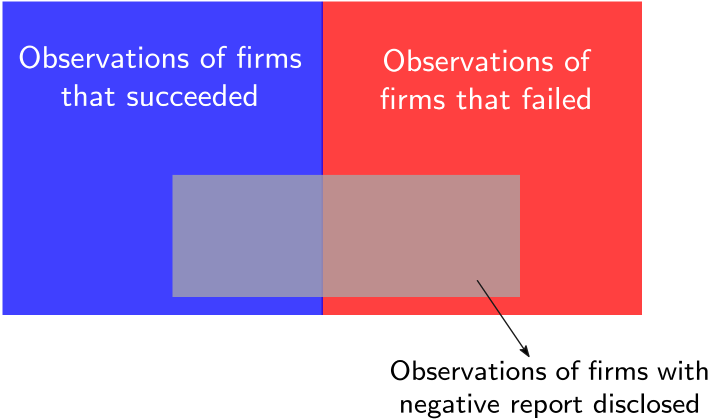

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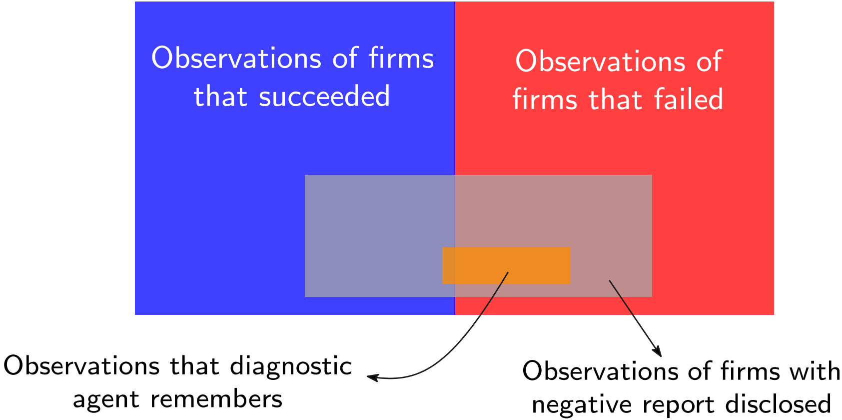

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Back to how agents update beliefs

$$\mathcal{R}(\eta, \hat{x}, \hat{y}) = \frac{f\,(\eta \mid x_i = \hat{x}, y = \hat{y})}{f\,(\eta \mid x_i = 0, y = 0)}$$

- Positive signals $x_i = \hat{x}_+ > 0$ and $y = \hat{y}_+ > 0$ are representative of positive realizations of η:

$$\mathcal{R}(\eta, \hat{x}_+, \hat{y}_+) = \begin{cases} > 1 & \text{for } \eta > 0 \\ < 1 & \text{for } \eta < 0 \end{cases}$$

- Agents overreact to positive news
- Also, overreact to negative news
- θ summarizes strength of **limited** and **selective** memory in our brain

back