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Overconfidence and market instability in a Brock–Hommes asset pricing model

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ABSTRACT

We study the effect of overconfidence on price dynamics in a Brock–Hommes asset pricing model. Overconfidence is modeled as a misperception of risk affecting trend-following traders. We show that this mechanism shrinks the stability region of the fundamental equilibrium and induces endogenous oscillations. A bifurcation analysis and stochastic simulations illustrate how overconfidence amplifies volatility and mispricing.

1. Introduction

Behavioral finance emphasizes that investors systematically misperceive risk and information. Among the most robustly documented behavioral biases, overconfidence – often interpreted as an underestimation of risk or an overestimation of signal precision – plays a central role in explaining excessive trading, volatility, and persistent deviations from fundamental values (Daniel et al., 1998; Barberis et al., 1998; Odean, 1998).

At the same time, heterogeneous agent models have shown that market instability can arise endogenously from the interaction of simple forecasting rules and evolutionary selection. Within this literature, the Brock–Hommes asset pricing framework provides a canonical setting in which destabilizing dynamics are typically associated with trend-following behavior, while fundamentalist traders exert a stabilizing force (Brock and Hommes, 1998; Hommes, 2006).

Several extensions of heterogeneous agent models have documented how nonlinear price dynamics, endogenous cycles, and complex fluctuations can emerge even in the absence of large exogenous shocks (Gaunersdorfer and Hommes, 2007; Chiarella et al., 2009). Related mechanisms have recently been studied in short contributions published highlighting the continued relevance of parsimonious nonlinear asset pricing models (Schmitt and Westerhoff, 2019). Related mechanisms of endogenous market instability have also been studied in noise-trader models and interacting-agent frameworks (De Long et al., 1990; Lux, 1998).

Unlike earlier behavioral asset pricing models that study overconfidence through biased signals or noise trading (e.g., De Long et al., 1990; Daniel et al., 1998; Hong and Stein, 1999; Barberis et al., 1998; Odean, 1998), this paper isolates risk misperception within a Brock-Hommes heterogeneous-agent framework and examines how it affects local stability and bifurcation properties.

In this paper, we study the destabilizing role of overconfidence within a Brock–Hommes asset pricing model. Overconfidence is introduced in a parsimonious way as a miscalibration of perceived risk affecting trend-following traders only, while fundamentalists are assumed to correctly assess risk. This asymmetric specification allows us to isolate the impact of overconfidence on the endogenous interaction between stabilizing and destabilizing trading strategies. To our knowledge, this paper provides one of the first analyses that isolates the destabilizing role of overconfidence as a *miscalibration of perceived risk* within the Brock-Hommes framework.

Our main result is that overconfidence shrinks the stability region of the fundamental equilibrium. For parameter values under which the benchmark economy converges to a steady state, sufficiently strong overconfidence induces persistent endogenous oscillations and, eventually, highly unstable price dynamics. The loss of stability is characterized analytically through a local stability condition and illustrated numerically by a bifurcation analysis.

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The contribution of the paper is deliberately parsimonious. By modifying only traders' perceived risk while keeping expectations, preferences, and the evolutionary selection mechanism unchanged, we identify a simple amplification channel through which a widely documented behavioral bias can destabilize asset prices.

2. Model

We consider a discrete-time asset pricing model with one risk-free asset yielding a gross return $R > 1$ and one risky asset with ex-dividend price p_t and constant dividend d. The risky asset is supplied in a fixed net amount S.

2.1. Excess payoff and traders' demand

The excess payoff from holding one unit of the risky asset from period t to $t+1$ is defined as

$$\rho_{t+1} = p_{t+1} + d - Rp_t, \tag{1}$$

which we refer to as the excess payoff (or excess return in levels).

Traders choose their position $z_{h,t}$ in the risky asset by maximizing mean–variance utility, yielding

$$z_{h,t} = \frac{E_{h,t}(\rho_{t+1})}{a\,\sigma_h^2}, \qquad a > 0. \tag{2}$$

2.2. Expectations

Fundamentalists base expectations on a constant fundamental price p^*,

$$E_{F,t}(\rho_{t+1}) = p^* + d - Rp_t. \tag{3}$$

Chartists extrapolate recent price trends,

$$E_{C,t}(\rho_{t+1}) = d + (1 + b - R)p_t - bp_{t-1}, \tag{4}$$

where $b > 0$ measures trend-following intensity.

2.3. Overconfidence

Overconfidence is modeled as a miscalibration of perceived risk affecting chartists only:

$$\sigma_F^2 = \sigma^2, \qquad \sigma_C^2 = \kappa\,\sigma^2, \quad 0 < \kappa \le 1. \tag{5}$$

Lower values of κ correspond to stronger overconfidence. In the mean–variance demand framework, this specification implies that chartists take more aggressive positions when κ decreases, since their demand is inversely proportional to perceived risk.

2.4. Market clearing

Let $n_{h,t}$ denote the fraction of traders of type h at time t, with $n_{F,t} + n_{C,t} = 1$. Market clearing requires

$$n_{F,t}z_{F,t} + n_{C,t}z_{C,t} = S, \tag{6}$$

where S denotes the fixed net supply of the risky asset. Substituting the demand functions into the market-clearing condition yields a linear equation in the current price,

$$A_t\,p_t + B_t = a\sigma^2 S, \tag{7}$$

where

$$A_t \equiv -(1 - n_{C,t})\,R + \frac{n_{C,t}}{\kappa}\,(1 + b - R), \tag{8}$$

$$B_t \equiv (1 - n_{C,t})\,(p^* + d) + \frac{n_{C,t}}{\kappa}\,(d - bp_{t-1}). \tag{9}$$

Therefore, provided that $A_t \neq 0$, the market-clearing price is uniquely determined as

$$p_t = \frac{a\sigma^2 S - B_t}{A_t}. \tag{10}$$

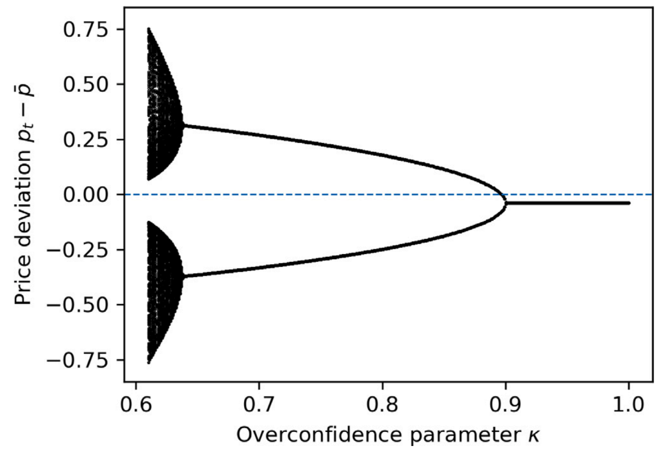

Fig. 1. Bifurcation-style diagram with respect to overconfidence, obtained by setting: $R = 1.01$, $d = 1$, $a = 1$, $b = 0.46$, $\beta = 0.6$, $\sigma^2 = 1$, $S = 0.02$.

2.5. Evolutionary switching

Profits are given by

$$\pi_{h,t} = z_{h,t-1}\rho_t, \qquad \rho_t = p_t + d - Rp_{t-1}. \tag{11}$$

Population shares evolve according to

$$n_{h,t+1} = \frac{\exp(\beta\pi_{h,t})}{\sum_j \exp(\beta\pi_{j,t})}, \qquad \beta \ge 0. \tag{12}$$

2.6. Fundamental equilibrium

A fundamental equilibrium is defined by constant prices and population shares. With non-zero asset supply, the equilibrium price incorporates an endogenous risk premium. A non-zero supply ensures a well-defined local stability analysis. Throughout the paper, we refer to the deterministic steady-state price $\bar{p}$ as the fundamental equilibrium.

3. Dynamics and stability

To study the local dynamics around the deterministic steady state, let

$$x_t \equiv p_t - \bar{p}$$

denote the deviation of the price from the fundamental equilibrium. Linearizing the price dynamics around $\bar{p}$ yields the one-dimensional difference equation

$$x_t = \phi_p(\kappa)\,x_{t-1}, \tag{13}$$

where $\phi_p(\kappa)$ captures the local price feedback mechanism.

Using $\sigma_F^2 = \sigma^2$ and $\sigma_C^2 = \kappa\sigma^2$, the slope of the linearized price dynamics can be written as

$$\phi_p(\kappa) = \frac{\bar{n}_C\,b}{\bar{n}_C(1 + b - R) - \kappa(1 - \bar{n}_C)R}. \tag{14}$$

Local stability of the fundamental equilibrium requires $|\phi_p(\kappa)| < 1$.

Proposition 1. *As the overconfidence parameter κ decreases, the local stability of the deterministic steady state $\bar{p}$ is weakened and eventually lost. For the parameter values considered, the loss of stability occurs through a flip (period-doubling) bifurcation.*

Economically, a lower value of κ reduces chartists' perceived risk and induces more aggressive trend-following positions, which increases the effective price feedback and shrinks the stability region of the fundamental equilibrium.

Table 1
Simulation statistics (stochastic extension).

	Benchmark ($\kappa = 1$)	Weak OC ($\kappa = 0.8$)	Strong OC ($\kappa = 0.61$)
Std. dev. of returns	0.0005	0.0043	0.0081
Excess kurtosis (returns)	0.1250	−1.9590	−1.1366
Mean abs. mispricing	0.0190	0.2117	0.3536
Mean share chartists	0.4997	0.4707	0.3930

Notes: Simulations include dividend shocks $d_t = d + \varepsilon_t$ with $\varepsilon_t \sim \mathcal{N}(0, \sigma_d^2)$ and $\sigma_d = 4 \times 10^{-3}$. Statistics are computed on the full simulated series after burn-in (no temporal thinning). Returns are log-returns and mispricing is measured relative to the deterministic steady-state price $\bar{p}$.

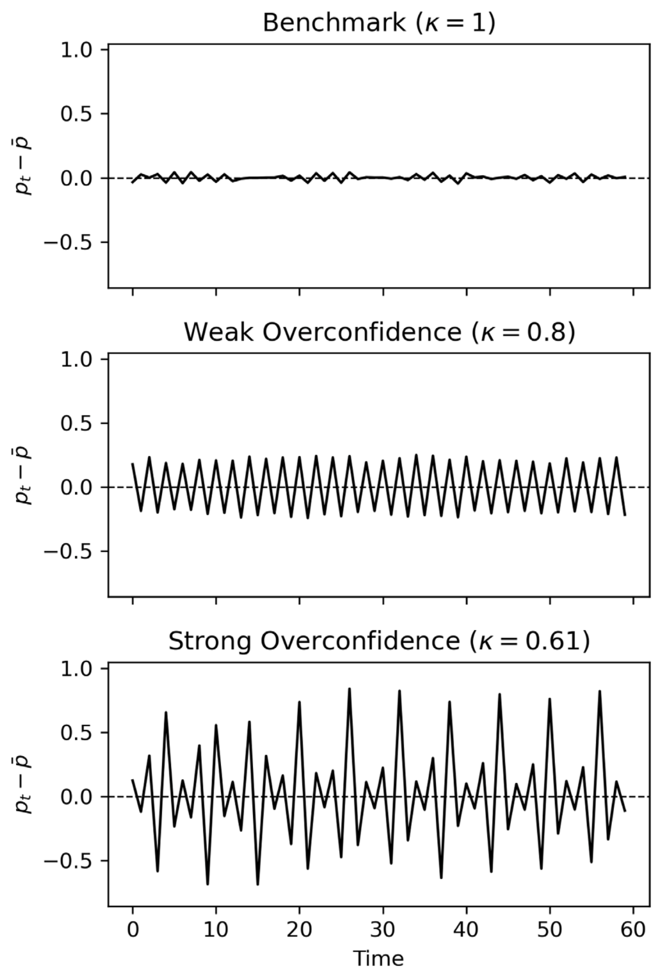

Fig. 2. Price dynamics with small dividend shocks. The figure reports zoomed time series of deviations from the deterministic steady-state price $\bar{p}$ for three values of the overconfidence parameter. The top panel shows the benchmark economy ($\kappa = 1$), the middle panel a weakly unstable regime with regular oscillations ($\kappa = 0.8$), and the bottom panel a highly unstable regime ($\kappa = 0.61$) characterized by large and irregular fluctuations.

Fig. 1 illustrates this transition. For high values of κ, the system converges to the fundamental equilibrium. As κ decreases, persistent oscillations emerge, and for sufficiently low values of κ the price dynamics become highly unstable and dominated by endogenous fluctuations.

4. Simulations

We illustrate the model's implications through numerical simulations. The deterministic system highlights the stability boundary and the destabilizing role of overconfidence, consistent with the analytical results. In what follows we introduce a noise term and we set $R = 1.01$, $d = 1$, $a = 1$, $b = 0.46$, $\beta = 0.6$, $\sigma^2 = 1$ and $S = 0.02$.

4.1. Stochastic extension

To assess the quantitative implications of overconfidence, we introduce small dividend shocks $d_t = d + \varepsilon_t$, where $\varepsilon_t \sim \mathcal{N}(0, \sigma_d^2)$. Fig. 2 reports time paths of price deviations from the deterministic steady-state price $\bar{p}$.

Fig. 2 illustrates how price dynamics change across different levels of overconfidence. In the benchmark case ($\kappa = 1$), deviations from the fundamental equilibrium remain small and are rapidly absorbed. With moderate overconfidence ($\kappa = 0.8$), price fluctuations become persistent and display regular oscillatory patterns. Under strong overconfidence ($\kappa = 0.61$), price dynamics are characterized by large and irregular fluctuations, indicating a highly unstable regime.

Table 1 reports volatility, average mispricing, and the average market composition in the benchmark and overconfident economies. Overconfidence substantially amplifies return volatility and mispricing, while also affecting the endogenous market share of trend-following traders. The decline in the average market share of chartists reflects the fact that overconfidence leads to excessively aggressive positions, which are penalized by the evolutionary selection mechanism once price fluctuations become large. The excess kurtosis reflects the increasingly regular nature of fluctuations close to the instability threshold. Although overconfidence destabilizes prices, it reduces the relative performance of trend-following traders, leading to a lower average market share under evolutionary selection.

5. Conclusion

This paper studies the destabilizing role of overconfidence in a Brock–Hommes asset pricing model with heterogeneous expectations and evolutionary switching. Overconfidence shrinks the stability region of the fundamental equilibrium and induces persistent endogenous oscillations. The stochastic extension shows that these mechanisms substantially amplify volatility and mispricing. The analysis highlights a simple and transparent channel through which behavioral biases can destabilize asset prices.

Declaration of Generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this manuscript, the author used ChatGPT (OpenAI) to support the organization of the text and improve clarity and readability. The author reviewed and edited all content and takes full responsibility for the content of the published article.

Data availability

No data was used for the research described in the article.

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