Self-destroying Expectations in Financial Crisis

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Abstract

Self-fulfilling expectations and self-destroying expectations are two appealing phenomena in financial market where people’s expectations and market’s realizations co-evolve with each other. While the former is largely investigated, the latter has not received the same level of academic scrutiny and acceptance. A deterministic heterogeneous agent model (HAM) is built to examine self-destroying expectations in financial market where agents can choose to be a fundamentalist or a chartist. We find that self-destroying expectations do exist in financial market. The model shows that generally a profitable strategy can become unprofitable and results in self-destroying phenomenon when more and more agents begin to exploit it. We particularly demonstrate this process in three types of commonly observed financial crisis, that is, disturbing crisis, sudden crisis and smooth crisis.

Keywords: Self-fulfilling, Self-destroying, Heterogeneous belief, Discounted profit, Financial crisis

JEL classification: C61, G10, G19

1 The sequence of authorship is arranged by alphabetical order.
1. Introduction

The essential difference between socio-economic systems and physical systems is the involvement of human behaviours. Rational individuals form expectations when facing uncertainty, make best decisions based on their expectations, and constantly update their strategies when outcomes are observed. If there were only one individual in the world, the outcome would be consistent with the expectations formed, assuming no random shocks. However, in reality, many individuals with no appreciable power are involved in the socio-economic systems. It is then their aggregate actions rather than individual action that determine the observed outcome, which may or may not be consistent with individuals’ expectations.

A general statement of self-fulfilling and self-destroying prophecy was first introduced by Merton (1948) in sociology, where self-fulfilling (self-destroying) prophecy was defined as an originally false (true) prediction or expectation that becomes true (false) because of public reactions to the prediction. In general, if the aggregate outcome is consistent (inconsistent) with an individual’s expectation, the individual’s expectation is said to be self-fulfilling (self-destroying). One classical example for self-fulfilling expectation is bank run, where a large number of depositors feel that the best strategy is to withdraw their deposits because they believe the bank is, or may become insolvent. This expectation is self-fulfilled when there are increasing numbers of withdrawals. Similar examples include rational asset bubbles (Hunter, et al., 2003) and several currency crises, such as Mexico Peso crisis in 1994 and Asian financial crisis in 1997.

On the contrary, El Farol Bar problem and Cobweb cycles can be classified as self-destroying. In the El Farol Bar problem, if all believe only a few will go, all will go, which would invalidate the original belief. Similarly, if all believe most will go, nobody will go, again invalidating the original belief (Arthur, 1994). In the Cobweb cycles model, if all farmers expect high price this season to prevail next season, all will produce high output. This will render the price in next season to be low, contradicting the original expectation.
In these two cases, the aggregate realizations will always go against the individual’s expectation. To explore the underlying reason, Sardoni et al. (1999) pointed out that the collective action irreversibly destroys the conditions which are essential to the validation of individual’s expectation. This can be illustrated using the famous Paradox of thrift, popularized by John Maynard Keynes. The paradox states that during recession individuals want to increase savings. However, if everyone tries to tighten their pockets during recession, then aggregate demand will shrink and in turn lower aggregate savings and therefore individual savings. In this case, aggregate saving actions worsen the economic condition and invalidate the assumption of individuals when they make saving decisions.

Although literally self-fulfilling and self-destroying prophecies are contradicting to each other, can they co-exist in the socio-economic systems? The financial market is such a complicated system, where people’s expectations and market’s realizations co-evolve with each other, that we suspect these two phenomena may co-exist. On the one hand, the stock price will usually rise if many individuals bull the market and buy in accordingly. On the other hand, if one profitable trading strategy becomes prevailing, it will be exploited by more and more traders. The aggregate expectations and actions by all the traders will finally erode profits and yield losses, that is, public knowledge of predictions in economics inherently self-defeated themselves (Morgenstern, 1928). Both phenomena are especially noticeable during financial crisis, as described in Kindleberger and Aliber (2005). In a more optimistic environment, banks make more loans and investors buy in more stocks. The optimism increases and creates a self-fulfilling bubble until it evolves into a mania. Nevertheless, when people’s expectations are incorporated into the price, that is, the coordination of their expectations leads their wish to come true in advance, it becomes less profitable or even yields losses. This self-destroying event causes the bubble to burst and provokes panics.

While various studies focus on the qualitative analysis of self-fulfilling and self-destroying prophecies, formal quantitative analysis is rarely explored. Gao and Li (2010) is one of the few exceptions. Based on a multi-agent model with trend-following and trend-reversing expectation rules, they find that the process in which one strategy goes
from showing superior performance to being unprofitable as it is gradually exploited, realized, and taken advantage of. The result also holds when fundamentalist rule is added into the market.

In this paper, since the main focus is the co-evolution between individual expectation and market realization, we employ a different theoretical model - an endogenous deterministic heterogeneous agent model (HAM), to investigate the underlying mechanism which may generate self-fulfilling or self-destroying phenomenon in the financial market. The theoretical framework is based on Huang et al. (2010). In this market-maker framework, forward-looking investors update their trading strategies (fundamentalist or chartist) according to their price and profit expectations. The switches between trading strategies lead to price dynamics that subsequently moves price up and down. Our model departs from Gao and Li (2010) in several dimensions. First, instead of using a stochastic model, we use a deterministic model. Second, we adopt a market-maker framework, which incorporates more economics intuitions. Third, we emphasize not only on the general case but also on three commonly observed financial crisis scenarios. Since the deterministic HAM model in Huang et al. (2010) is capable of generating different types of crises that match with real historical scenarios, we believe our model which follows closely the framework of Huang et al. (2010) should capture some of the key factors of financial crises. Therefore, our analysis of self-destroying phenomena in financial crises is, if not all, justifiable.

Despite the fact that in our setup, agents trade in each period and there is no holding period of the stock, we draw similar conclusions as in Gao and Li (2010). That is, a profitable strategy can become unprofitable when more and more agents begin to exploit it. This is more appreciable in crisis scenarios, where the price changes more swiftly and deeply.

The rest of paper is organized as follows. Section 2 lays out the theoretical HAM framework. Section 3 provides and discusses the numerical simulation results. Section 4 concludes.
2. The Model

An artificial financial market is constructed based on individual’s investment process. Following Day and Huang (1990), agents in the market are classified into two broad categories according to their investment strategies. The agents can be fundamentalists or chartists. Each category possesses a different form of expectation. An agent observes the market, takes actions based on his or her expectation for the next period’s price and profit, evaluates the rule used and decides whether or not to switch investment strategy. Agents trade risky assets with a market-maker, who buys in when agents place sell orders and sells out when agents place buy orders. Their aggregate actions form an excess demand to the market maker, which is defined as the difference between the number of shares demanded and the number of shares supplied. The market-maker constantly quotes price according to a price impact function that relates the excess aggregate demand at any time to prices. Driven by agents’ realized profit, prices and different expectation rules co-evolve in the system, which close the market.

2.1 Individual demand function

There are \( N \) agents in the market. Each agent determines the number of shares purchased with a mean variance preference in expected return:

\[
n_{i,t} = q_i \frac{p_{i,t+1}^e - (1 + r)p_i}{V(p_{i,t+1}^e)}
\]

(1)

where \( i = 1, 2, ..., N \), \( q_i \) is the degree of risk tolerance and \( q_i > 0 \). \( p_{i,t+1}^e \) is the expected future price, \( p_i \) is the realized price at period \( t \), \( r \) is the constant interest rate and \( V(p_{i,t+1}^e) \) is the expected price variance.

2.2 Heterogeneous expectation functions

According to their investment strategies, agents are categorized into two groups: fundamentalists denoted by \( \alpha \) and chartists denoted by \( \beta \). Without the loss of generality and for the purpose of simplicity in derivation, agents taking the same strategy are assumed to be identical in terms of price expectation, variance expectation and degree of risk tolerance.
Aggregate market expectation: Aggregate market expectation is assumed to follow an exponentially weighted moving average pattern, based on technical analysis defined by Murphy (1999). First, market action discounts everything. In other words, anything that could possibly affect price is reflected in the price of the market. All historically realized prices are embedded into the market expectation. Second, according to Newton’s Law of Motion, an object in motion tends to continue in motion until some external forces cause it to change its direction. Thus, price moves in trends, or more accurately, the latest trend. Thus, weights are exponentially distributed to realized prices. Third, history repeats itself, assuming human psychology remains unchanged. Therefore, traders tend to react the same way when confronting the same situation. This justifies the use of a time-invariant parameter in the expectation form. Mathematically, the expectation form is expressed in an error correction form as:

$$p_{t+1}^e = \sum_{j=0}^{\infty} b(1-b)^j p_{t-j} = bp_t + (1-b)p_t^e = p_t^e + b(p_t - p_t^f)$$

(2)

where $b$ denotes the weight put on the latest realization and $b \in (0,1)$. It is calculated by minimizing the in-sample sum of squared errors of 1-step ahead Dow Jones Industrial Average (DJIA) forecasts based on exponential smoothing method.

Fundamentalists: Fundamentalists are professional traders who do not correct the vagaries of private investors and are only concerned with predicting asset prices with the influence of mass psychology, which in our case is the aggregate market expectation, for short-run profit (Westerhoff, 2002). However, they also reserve a place for the fundamental value of the risky asset, which they believe the price would eventually converge to (Huang et al., 2010). As a result, a combination of fundamental value and aggregate market expectation is used to construct fundamentalist’s expectation. Since impatient fundamentalists may be pessimistic about their beliefs, switching between strategies (i.e. chartists) is allowed in our framework. This assumption is crucial in our analysis of self-destroying phenomenon. Explicitly, the expected price and variance are:

$$p_{\alpha,t+1}^e = \bar{p}_\alpha + (1-d)p_{t+1}^e$$

and

$$V_{\alpha}(p_{t+1}^e) = \sigma_{\alpha}^2,$$

where $\bar{p}_{\alpha}$ denotes the fundamental value and $d \in (0,1)$ is the weight allocated to fundamental value in fundamentalist’s expectation.
Chartists: Chartists only pay close attention to non-fundamental information and are subject to waves of optimistic and pessimistic sentiments (Westerhoff, 2002). We assume that chartists hold constant expected price variance:

\[ V_p(\pi_{t+1}) = \sigma_p^2 \]

and update their price expectation constantly according to the following function:

\[ p_{\beta,t+1}^e = p_t + \tau(p_t - \bar{p}_{\beta,t}), \]

where \( \bar{p}_{\beta,t} \) is the short-term estimated fundamental value for chartists and \( \tau \in (0,1) \) is the adjustment speed, at which chartists adjust their expectation according to past estimation bias. Chartists who believe in the persistence of the estimation bias would buy in (sell out) when the price goes beyond (falls below) the previous period’s short-term fundamental value. The fundamental value follows a regime dependent belief updated constantly according to the rule specified in Huang et al. (2010).

2.3 Evolutionary strategy switch

Agents also interact with each other while updating their expected prices. They would either stick to their original strategy or opt for an alternative, which is expected to be better than the original one. It is then the evolutionary strategy switch that reshuffles market structure and affects the realization of prices. Specifically, agents evaluate the performance of strategies based on the discounted expected profit, which is given by:

\[ \pi_{j,t}^e = s_{j,t} \theta_{j,t}^e, j = \alpha, \beta \]

where \( \theta_{j,t}^e \) is the expected profit per share before discounting, and \( s_{j,t} \) is the discount factor, which is time-variant and varies across agent groups.

Given the existence of market-maker, the market needs not clear at every period. In other words, agents are allowed to hold on to the risky asset for as long as they believe to be optimal (Huang et al., 2010). In particular, chartists adjust their price expectations every period, while fundamentalists partially hold their expectations at the fundamental value. As a result, chartists capitalize asset return every period regardless of gain or loss (Lux and Marchesi, 1999). Therefore, their discount factor \( s_{\beta,t} \) is assumed to be one. While fundamentalists might choose to hold the asset if they think the asset is currently
undervalued and they expect the price to rise in due course. Explicitly, their discount factor is assumed to be a function of contemporaneous price, that is, $s_{a,t} = |p_{a,t}^* - p_t|/p_{a,t}^*$. It shows that the further the realized price deviates from the fundamental value, the higher the chance it is to reverse towards fundamental value. As a result, the discounted expected profit per share for fundamentalists and chartists are:

$$\pi_{a,t}^e = s_{a,t-1} |p_{a,t}^e - (1 + r)p_{t-1}^e| - C, \text{ and } \pi_{\beta,t}^e = \tau(p_{t-1} - \bar{p}_{\beta,t-1}) - rp_{t-1} \right|,$$

where $C$ is the information cost of switching from chartists to fundamentalists. The above two equations show the expected gain from investing in the financial market relative to investing in risk-free assets which is assumed to be perfectly elastic. Additionally, for the purpose of identifying self-destroying phenomenon, expected profits are to be compared with real profits, which are defined as follows:

$$\pi_{a,t} = s_{a,t} |p_t - p_{a,t}^e| \text{ and } \pi_{\beta,t} = |p_t - p_{\beta,t}^e|,$$

The above equations describe the profits that agents gain from each transaction. Suppose the agent expects the price to rise (fall) in the next period, he or she is likely to place buy (sell) order in the current period. Analogous to the concept of consumer surplus, the agent’s real profit is then defined as the difference between the realized price and his or her reservation price.

Following Brock and Hommes (1998) we make use of a market fraction index with the following discrete choice probability to trace agents’ evolutionary switch:

$$\eta_{j,t}(p_t) = \exp(\rho \pi_{j,t}^e(p_t))||\exp(\rho \pi_{\alpha,t}^e(p_t)) + \exp(\rho \pi_{\beta,t}^e(p_t))||, j = \alpha, \beta$$

where $\rho > 0$ measures the speed of switching to a different trading strategy. Agents are inclined to switching to the strategy that produces higher discounted expected profit with some insisting on their original strategies. Explicitly, the market fraction index is defined as the difference between the market fractions of fundamentalists and chartists:

$$m_t = \eta_{\alpha,t}(p_t) - \eta_{\beta,t}(p_t) = \tanh\left(\frac{\rho}{2}(\pi_{a,t}^e - \pi_{\beta,t}^e)\right),$$

which is in the range of [-1, 1]. Its sign indicates that the group with superior discounted expected profit attracts a dominant number of investors.
2.4 Price dynamics

At each period, the price is updated endogenously according to a price impact function defined as follows:

\[ p_{t+1} = p_t + \gamma D_t, \]

Here \( D_t \) refers to normalized aggregate excess demand, following Gennotte and Leland (1990):

\[
D_t = \frac{\sigma^2_\delta (1+m_t)[\tilde{p}_a - (1+r)p_t] + \sigma^2_\alpha \delta \tau (p_t - \tilde{p}_{\beta,t}) - \rho p_t]}{\sigma^2_\rho \sigma^2_{\delta}(1+\delta) + (1+\delta)m_t},
\]

and \( \gamma > 0 \) measures the adjustment speed of the realized price and \( \delta \) measures the relative risk tolerance of the chartists against the fundamentalists.

3. Results of Numerical Simulations and Discussions

In this study, our simulations cover a general case and three types of crisis such as disturbing crisis, sudden crisis and smooth crisis. All the simulations show the same pattern of self-destroying phenomenon. The pattern is more conspicuous in crises, where price deviates largely from the fundamental value. In this section, we specifically demonstrate the self-destroying phenomenon using the simulation results from the general case and the disturbing crisis. The simulation results for the sudden and smooth crises are presented in the appendix.

3.1 The general case

We simulate the general case over 1000 steps. The parameters are set as follows:

\( \gamma=2.16, \delta=1.12, \tau=0.5, r=10^{-5}, \rho=0.9, C=0.2, \lambda=13.18, \tilde{p}_a=50, d=0.5 \) and \( \sigma_\alpha^2=\sigma_\delta^2=1 \),

\( P(1)=77.41, P(2)=82.78, P(3)=76.40 \). All numbers are rounded into two decimal places for presentation clarity. Figure 3.1 depicts the simulated price indexes. It is found that generally price fluctuates around a certain level, which is slightly above the fundamental value, with only a few exceptions. It is noted that the fundamentalists’ discounted

\(^2\) The three crises are classified according to their length and depth (see Rosser (2000) for details).
expected profits rely partially on the deviation of the simulated price from the fundamental value. Therefore, we look closely at those exceptions when self-destroying phenomenon is investigated from the aspects of market fraction index and difference in discounted expected profits.

[Insert Figure 3.1 here]
[Insert Figure 3.2 here]

Along with the evolution of prices, the market fraction index fluctuates frequently, as shown in Figure 3.2. This indicates that during the evolving process, fundamentalists and chartists usually take turns to dominate the market. Few agents will stick to one strategy for a long period of time, as they constantly compare the expected profits for chartists and fundamentalists and choose the strategy which will be more profitable in the next period. Because the expected profit for the minority group in the near future is going to turn higher than that for the majority group, majority (minority) strategy will become the minority (majority) strategy at that time. In particular, when the market fraction index approaches -1, chartists are likely to switch to fundamentalists in the near future, expecting that they will earn higher profits by playing a fundamentalist role. However, whenever the market fraction index approaches 1, it will drop suddenly to -1 in the next period. The agents who are fundamentalists currently will switch to be chartists in the following period, tempted by chartists’ higher expected profit. Moreover, it is noted that the market fraction index is denser in the lower panel of Figure 3.2. This is because fundamentalists’ discount factor is far less than one. Unless the price deviates much from the fundamental value, otherwise fundamentalists’ discounted expected profit will be lower than the chartists’ expected profit. The pattern is determined by the theoretical setup and is substantiated by Boswijk et al. (2007). In other words, the opposite pattern, that is, the market fraction index assembles in the upper panel of Figure 3.2, is implausible to be observed in simulations based on our model.

While the market fraction index fluctuates (solid line) dramatically from the peak to the bottom or the other way round, it is denser around -1 implying that more agents choose to be chartists most of the times. This can be justified by comparing the profits of the two types of agents directly. Figure 3.3 plots the difference between the realized
profit of fundamentalists and that of the chartists together the market fraction index. It can be shown that, most of the times, being a chartist is more profitable than being a fundamentalist with some exceptions when the market fraction index is exceptionally greater than zero. Now the key questions are: why do chartists switch strategy in the first place? And why do they switch back so swiftly?

[Insert Figure 3.3 here]

These two questions can be answered with the movement in the market fraction index and price dynamics. Fundamentalists calculate their expected profit based on the deviation of realized price from their reservation price. When the price deviates largely from the fundamental value, fundamentalists’ expected profit will be large as they believe that the price will eventually converge to the fundamental value. The opportunity for large profit attracts more agents to switch to fundamentalists. This can be justified by the pattern of price movements in Figure 3.1 and the market fraction index in Figure 3.2, where the larger the price deviates from the fundamental value, the higher the market fraction index. This is particularly true for the three periods of 98/356/679, where the price drops below 40 and market fraction index shoots up to almost one, i.e. all agents choose to become fundamentalists.

As more agents choose to become fundamentalists, their market power increases and drags the price towards its fundamental value. This can be shown by the pattern when the market fraction index rises above zero indicating that fundamentalists begin to dominate the market. Fundamentalists’ profit will greatly outperform that of the chartists as shown in Figure 3.3. At this point, being fundamentalists is self-fulfilling in the sense that the aggregate actions of switching to fundamentalists by the agents who expect a higher profit for fundamentalists comparing to chartists next period indeed bring more profit to them. However, the opportunity for such a high profit is only transient because the expected price is realized so soon by the fundamentalists’ aggregate market power that there is little room for the following agents to exploit this previously profitable expectation rule. In the next period, when price approaches the fundamental value again,

3 From Figure 3.1, it is noted that the price index fluctuates around 50.
the expected profit of fundamentalists’ will be small compared to that of chartists’ so that agents will switch back to chartists, renders the market fraction index to drop below zero. Agents who stick to being fundamentalists will suffer a huge loss compared to what they may gain as chartists.

[Insert Figure 3.4 here]
[Insert Figure 3.5 here]

A general pattern of the expected profit and realized profit for fundamentalists and chartists is shown in Figures 3.4 and 3.5. It is interesting to note that while chartists’ expected profit is in general below the realized profit, the situation for the fundamentalists is the reverse. The reason behind the fact that fundamentalists always overestimate their profit can be generalized from the previous analysis. Fundamentalists’ ability to make more profit than chartists depends on the deviation of price from its fundamental value and their market power which in turn depends on the aggregate action of being fundamentalists. However, as more and more agents detect and take advantage of this profitable expectation rule, their aggregate action will accelerate the price convergence which renders the discount factor to decrease. As a result, fundamentalists will always make less profit than they expected. In other words, being a fundamentalist will first be self-fulfilling but be self-destroying later on as to complete one expectation rule’s life cycle (Timmermann, 2008). On the other hand, being chartists is self-fulfilling in most of the cases. Because chartists always capitalize their capital gains or losses immediately, neither expected nor realized profit will be influenced by the discount factor.

3.2 Disturbing crisis

In this section, we explore particularly the self-destroying phenomenon in disturbing crisis, a type of commonly observed financial crisis. In such a crisis, the price experiences a visible drop first, and then relapses. After several rounds of movements, the price eventually decreases to a relatively lower level. Frequent switches of strategies are observed because agents are uncertain about the future and intend to use their acumen to remain profitable or reduce losses. However, aggregate action of agents leads to salient self-destroying phenomenon at the beginning and the end of the crisis.
We simulate the disturbing crisis over 1000 steps. The parameters are set as follows: \( \gamma=2.16, \delta=1.12, \tau=0.5, r=10^{-5}, \rho=0.6, \lambda=13.18, \bar{P}_a=50, d=0.5 \), and \( \sigma_a^2=\sigma^2=1 \). P(1)=76.41, P(2)=83.78, P(3)=76.32. All numbers are rounded into two decimal places for presentation clarity. Figure 3.6 shows the simulated price from period 1 to 100. There is a typical disturbing crisis pattern starting from period 30, where the price shoots up to a relatively high level, plunges and lingers around the fundamental value and eventually ends at a level between 30 and 40 at period 60. In addition, as shown in Figure 3.7, the market fraction index shoots up to almost 1 and drops suddenly at the beginning and the end of the crisis. Figures 3.8 and 3.9 compare the expected prices and simulated prices for fundamentalists and chartists, respectively. It should be noted that immediately following the time when the market fraction index changes dramatically, the differences between expected and realized price enlarge, especially for chartists. In order to investigate the self-destroying phenomenon, we then proceed to analyse the expected and realized profits of fundamentalists and chartists during the crisis period.

In particular, we take a closer look at the crisis period from 30 to 60. First, at period 31, agents observe a high price, which deviates substantially from the fundamental value. Accordingly, fundamentalists and chartists update their expected profits respectively, and believe that fundamentalists will outperform chartists in the next period. This is because compared to chartists, fundamentalists reserve a weight of the fundamental value in their expectations and have the belief that the price would ultimately revert towards the fundamental value when the price deviates from it. As a result, they have a relatively lower expected price than chartists, who put a larger weight on the latest observed price regardless of the fundamental value in their expectations. Based on the setup of their discounted expected profits, fundamentalists’ expected profits are larger than chartists’.
We take this expectation as the originally true prediction in Merton (1948)’s definition for self-destroying prophecy. It could also be visualized by the high expected profit for fundamentalists and the low expected profit for chartists at period 32 in Figure 3.10.

Based on the discounted expected profits for both groups, agents choose their strategies for the next period (period 32) accordingly. As shown in Table 3.1, most agents who are currently chartists would choose to switch to fundamentalists as the expected profit from being a fundamentalist is significantly higher than the expected profit from being a chartist (3.40>0.41). This can be justified by the shoot-up in market fraction index at period 31. Given the market fraction index which forms the aggregate excess demand in the market, period 32’s price is then realized through the price impact function as defined in Section 2. It is noted that due to the swarm of agents choosing to be fundamentalists, the realized price (57.36) plunges towards the fundamental value (50) and even goes below fundamentalist’s expected price (60.83). This could be explained by the dominant market power of fundamentalists as reflected by the market fraction index. However, the drop in the realized price is so dramatic that it distorts fundamentalists’ realized profit. The difference between realized and expected price is lower for fundamentalists than chartists. As a result, fundamentalists’ realized profits shrink while chartists’ realized profits inflate. This is attributed to the violation of the implicit assumption that the realized price does not change dramatically from the last period. So long as the gap between realized and expected prices persists, fundamentalist could benefit by selling and buying in when the price eventually drops to the fundamental level. Nevertheless, agents’ aggregate action renders the drop in the prices so immediately that fundamentalists could not buy in at the same period and thus could not gain as expected. By contrast, chartists enjoy an impressive profit due to the huge difference between their expected high price and the realized low price. According to the Merton (1948)’s definition, this is a self-destroying phenomenon. The originally true expectation becomes false. This is in fact also consistent with Timmermann (2008)’s life cycle pattern that one strategy goes from showing superiority to being unprofitable whereby the cycle is so continuous and transitory that the strategy’s superiority is not realized in neither the current nor the succeeding period.
Following the initial drop, the realized price lingers around the fundamental value and gradually drops to the level of 40 during the period from 33 to 54. Additionally, chartists dominate the market and could have their expected profits realized most of the time. When the price falls to 32.51 at period 55, another self-destroying phenomenon could be identified. The situation is pretty similar to the one at the beginning of the crisis. An unprecedentedly low price level leads to a higher expected price for fundamentalists than chartists. As fundamentalists have the belief that the price would eventually rise towards the fundamental value, the discounted expected profit is raised for fundamentalists, in other words, the strategy of fundamentalist is expected to show superiority over the strategy of chartists. Hence, the market fraction index shoots up to 0.94. As the fundamentalists are dominating the market at period 56, the price is really reversing closely to fundamentalists’ expected price level. Again, the aggregate action invalidates the implicit assumption of profitability and then brings a lower realized profit of fundamentalists compared to that of chartists. The strategy showing superiority is over-exploited and becomes unprofitable. Also, the originally true expectation becomes false due to public reaction.

In sum, one strategy that shows apparently superiority can be exploited and then becomes unprofitable. This is the self-destroying phenomenon in financial market. It is especially transitory in our model because the switch in strategies is instantaneous and not costly. The disturbing crisis scenario provides an easy framework to visualize such phenomenon.

4. Conclusion

The involvement of human behaviours essentially differentiates socio-economic systems and physical systems. Prior to taking actions, individuals form expectations, and constantly update their strategies when outcomes are observed. In reality, many individuals who involve in the socio-economic systems have no significant power. It is then their aggregate actions rather than individual action that determine the observed
outcome. This is especially conspicuous in financial market, where people’s expectations and market’s realizations co-evolve with each other. If the aggregate outcome is consistent (inconsistent) with an individual’s expectation, the individual’s expectation is said to be self-fulfilling (self-destroying). While the self-fulfilling prophecy is largely investigated since the pioneer work of Metron (1948), the self-destroying prophecy has not received the same level of academic scrutiny and acceptance, especially in the financial markets, where people’s expectations and market’s realizations co-evolve with each other.

This paper investigates the self-destroying phenomenon from a general case and three crisis scenarios in financial market using a modified heterogeneous agent model (HAM) based on the one in Huang et al. (2010), which is capable of generating three types of crises that match well with real historical scenarios. Self-destroying phenomenon can be identified in simulations of a general case and three crisis scenarios. Conclusions similar to that of Gao and Li (2010) can be drawn, that is, a profitable strategy can become unprofitable when more and more agents begin to exploit this strategy. However, compared to Gao and Li (2010) whose model is stochastic, we draw same conclusion in a deterministic framework.

This paper focuses only on the self-destroying phenomenon in financial markets, leaving many other dimensions unexplored. First, it is assumed in our setup that agents make decisions in the switch in strategies instantaneously while in real life the decision periods may be much longer. Second, the assumption that interest rate is constant could be released to test the robustness of the current setup. Third, the field of vision regarding self-destroying phenomenon could be extended to other social economic systems such as the foreign exchange markets.
Appendix

A. Sudden Crisis

We simulate the sudden crisis over 1000 steps. The parameters are set as follows: $\gamma=2.16$, $\delta=1.12$, $\tau=0.5$, $r=10^{-5}$, $\rho=0.8$, $C=0.2$, $\lambda=13.18$, $\bar{p}_a=50$, $d=0.5$ and $\sigma_a^2=\sigma_\beta^2=1$, $P(1)=73.42$, $P(2)=78.58$, $P(3)=77.15$. All numbers are rounded into two decimal places for clarity.

Figure A1 Sudden crisis - price indexes

Figure A2 Sudden crisis - market fraction index

Figure A3 Sudden crisis – fundamentalist’s expected price vs. simulated price

Figure A4 Sudden crisis – chartist’s expected price vs. simulated price
Figure A5: Sudden crisis – realized profit vs. expected profit
B. Smooth crisis

We simulate the smooth crisis over 1000 steps. The parameters are set as follows: $\gamma=2.16$, $\delta=1.12$, $r=0.6$, $r=10^{-5}$, $\rho=1.6$, $\lambda=13.18$, $\bar{p}_a=50$, $d=0.5$ and $\sigma_a^2=\sigma_p^2=1$, $P(1)=74.42$, $P(2)=78.58$, $P(3)=76.15$. All numbers are rounded into two decimal places for clarity.
Figure B5 Disturbing crisis – realized profit vs. expected profit
References


Figures

Figure 3.1 General case - price indexes

Figure 3.2 General case – market fraction index
Figure 3.3 General case – difference between fundamentalist’s and chartist’s profit

Figure 3.4 General case – fundamentalist’s realized and expected profit

Figure 3.5 General case – chartist’s realized and expected profit
Figure 3.6 Disturbing crisis - price indexes

Figure 3.7 Disturbing crisis - market fraction index

Figure 3.8 Disturbing crisis - fundamentalist’s expected price vs. simulated price

Figure 3.9 Disturbing crisis - chartist’s expected price vs. simulated price
Figure 3.10 Disturbing crisis – realized profit vs. expected profit
### Tables

#### Table 3.1 Selected figures from simulation

<table>
<thead>
<tr>
<th>Period</th>
<th>$p_t$</th>
<th>$p_{\alpha,t}^e$</th>
<th>$p_{\beta,t}^e$</th>
<th>$m_t$</th>
<th>$\pi_{\alpha,t}^r$</th>
<th>$\pi_{\alpha,t}$</th>
<th>$\pi_{\beta,t}^r$</th>
<th>$\pi_{\beta,t}$</th>
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</thead>
<tbody>
<tr>
<td>31</td>
<td>71.67</td>
<td>57.66</td>
<td>68.33</td>
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<td>2.28</td>
<td>1.49</td>
<td>3.34</td>
<td>3.01</td>
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<td>57.36</td>
<td>60.83</td>
<td>71.26</td>
<td>-0.53</td>
<td>0.84</td>
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<td>13.90</td>
<td>0.41</td>
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<tr>
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<td>56.39</td>
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<td>41.26</td>
<td>32.29</td>
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<tr>
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<td>47.20</td>
<td>43.55</td>
<td>-0.71</td>
<td>0.34</td>
<td>0.24</td>
<td>0.85</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Notes: $p_t$ is the simulated price; $p_{\alpha,t}^e$ is the expected price of the fundamentalists; $p_{\beta,t}^e$ is the expected price of the chartists; $m_t$ is the market fraction index; $\pi_{\alpha,t}^r$ is the realized profit of the fundamentalists; $\pi_{\alpha,t}$ is the expected profit of the fundamentalists; $\pi_{\beta,t}^r$ is the realized profit of the chartists; $\pi_{\beta,t}$ is the expected profit of the chartists.