Evolution of Trading Strategies in a Market with Heterogenously Informed Agents

Florian Hauser, Bob Kaempff

Innsbruck University, Department of Banking and Finance

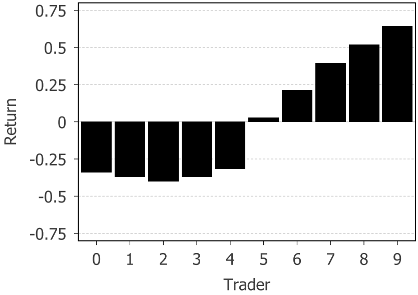
Outline

Introduction

- Existing Model (Schredelseker)
- Heterogenous and cost-free information

Key Results:

- average informed traders suffer the biggest loses
- these traders are better of by ignoring information and playing a random strategy



- Limited to exogenously defined trading strategies

Simulation Model

- One-period call market
- One security traded
- Agents are risk-neutral expected wealth maximizers
- 100 Agents $T \in \{0, 1, \ldots, 99\}$ supplied with heterogenous information
- Information is cost-free
- Intrinsic motivation to submit an order for buying/selling exactly one share of the security
- Trading strategies emerge endogenously with genetic programming

Fundamental Value

$$V = \sum_{i=1}^{10} \epsilon_i; \ \epsilon \in \{0, 1\}. \quad (1)$$

As ϵ_i can only take a value of 0 or 1, the true value of the security is characterized by a discrete distribution taking values between 0 and 10, e.g:

ϵ_1	ϵ_2	ϵ_3	ϵ_4	ϵ_5	ϵ_6	ϵ_7	ϵ_8	ϵ_9	ϵ_{10}	V
1	1	0	1	0	1	0	1	0	0	5

All results reported will be based on 1024 runs, each covering one unique combination of the signals ϵ_i.

Heterogenous Information

Agents are associated to 10 different information levels, each populated with 10 agents. According to his information level $I \in [0;9]$, an agent receives information on the realization of all signals $\epsilon_i; i \leq I$.

E.g., an agent in $I = 4$ knows the realization of the first 4 signals:

ϵ_1	ϵ_2	ϵ_3	ϵ_4	ϵ_5	ϵ_6	ϵ_7	ϵ_8	ϵ_9	ϵ_{10}	V
1	**1**	**0**	**1**	0	1	0	1	0	0	5

Fundamental Strategy

ϵ_1	ϵ_2	ϵ_3	ϵ_4	ϵ_5	ϵ_6	ϵ_7	ϵ_8	ϵ_9	ϵ_{10}	V
1	**1**	**0**	**1**	0	1	0	1	0	0	5

With the original fundamental strategy proposed in former studies, an agent in $I = 4$ will calculate his conditional expected value CV_I as

$$CV_I = \sum_{i=1}^{I} \epsilon_i + 0.5 \times (10 - I), so \tag{2}$$

$$CV_4 = 3 + 0.5 \times 6 = 6. \tag{3}$$

Matching and Returns

Every agent T is willing to buy the security at a market price $P < CV_T$ and he will sell the security if $P > CV_T$.

After all agents submitted their reservation prices, the market price P is set so that the trading volume is maximized.

After trading took place, all shares of the security will be liquidated according to its fundamental value. Hence, the net return for agent T is given by

$$R_T = (v - P) \times s_T, \tag{4}$$

with s_T being the net holdings of agent T.

Genetic Programming

Terminals:

- $\epsilon_i; i \in [1; I]$ provides all signals that an agent knows according to his information level I.
- $SUM_I = \sum_{i=1}^{I} \epsilon_i$.
- $R \sim N(\mu = 0, \sigma = 1)$
- $C \in \{0, 0.2, 0.5, 1, 2, \ldots, 10\}$ are constants.

Functions:

- Basic arithmetic operations (+ , - , * , /)
- If-greater-then-else function
- If-smaller-then-else function
- Maximum (max (arg1,arg2))
- Minimum (min (arg1,arg2))

GP Control Parameters

Parameter	Value
Population size	1000
Number of generations	10
Probability of crossover	90%
Probability of reproduction	10%
Probability of mutation	10%
Maximum tree-depth of initial population	5
Maximum tree-depth after crossover	17
Maximum number of nodes	300
Method for initial random population	ramped half-and-half
Basic selection method	Tournament selection

Optimization

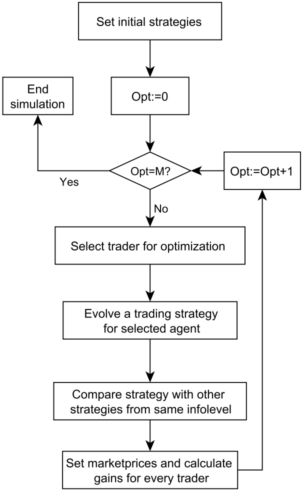


Figure: Simulation flowchart.

Returns with Fundamental Strategies

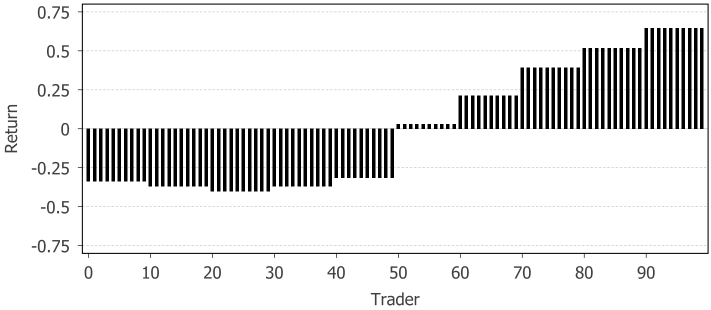


Figure: Distribution of returns for all 100 agents adopting a fundamental strategy.

Returns after Optimization

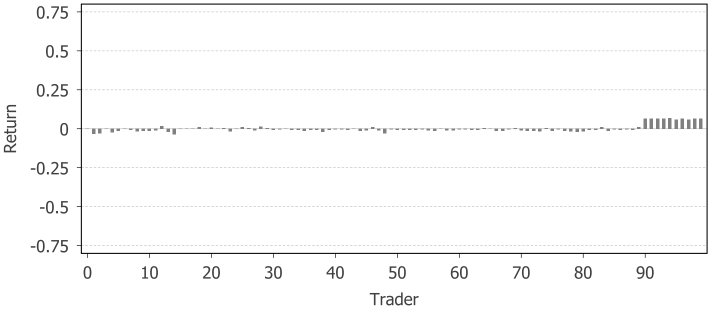


Figure: Distribution of returns for all 100 agents after 1500 optimization steps with genetic programming.

Market Inefficiency

Market Inefficiency:

$$\sigma_M^2 = \frac{\sum_{run=1}^{1024} (v - P)^2}{1024}. \quad (5)$$

Estimation error of an agent:

$$\sigma_I^2 = \frac{\sum_{run=1}^{1024} (v - CV_I)^2}{1024}. \quad (6)$$

I	0	1	2	3	4	5	6	7	8	9
σ_I^2	2.50	2.25	2.00	1.75	1.50	1.25	1.00	0.75	0.50	0.25

Market Inefficiency

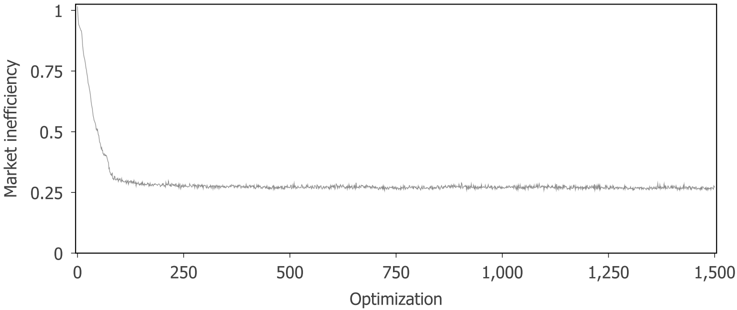


Figure: Development of market efficiency (σ_M^2) over 1500 optimization steps.

Estimation errors

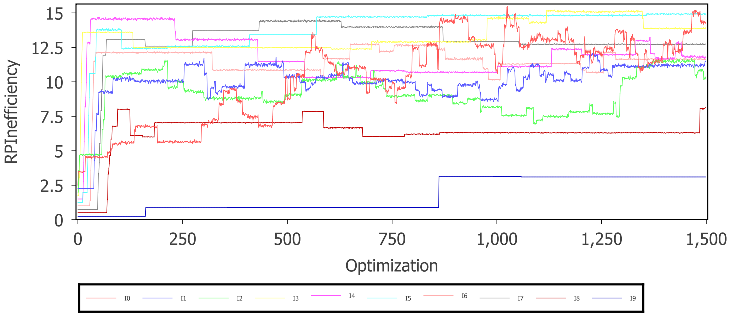


Figure: Development of agents' estimation errors σ_I^2 (mean values for all information levels) over 1500 optimization steps.

Diversity of Trading Strategies

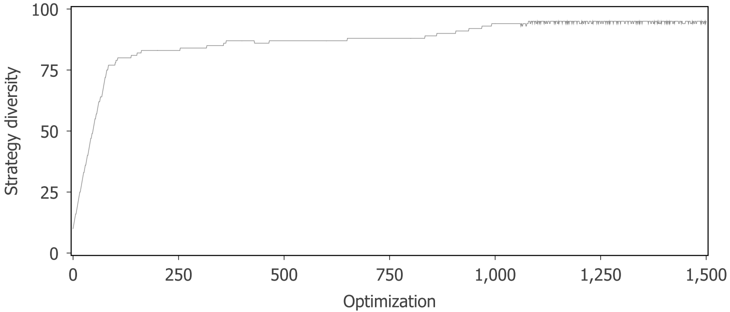


Figure: Diversity of trading strategies - number of different trading strategies for all 100 agents during 1500 optimizations.

Characterization of Trading Strategies

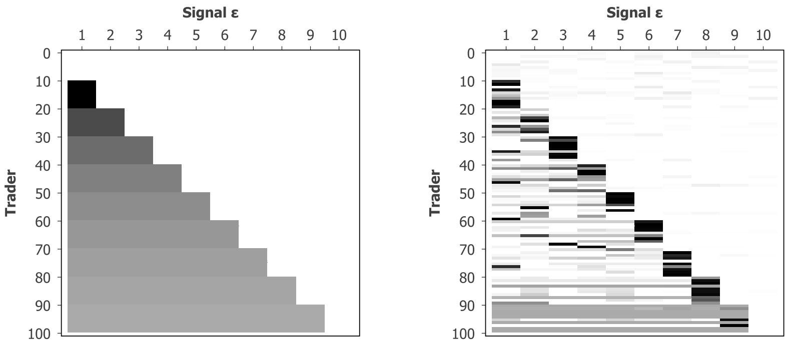


Figure: Correlations of the reservation prices of all agents with the individual signals ϵ_i when agents adopt a fundamental trading strategy (left panel) and in equilibrium (right panel).

Characterization of Trading Strategies

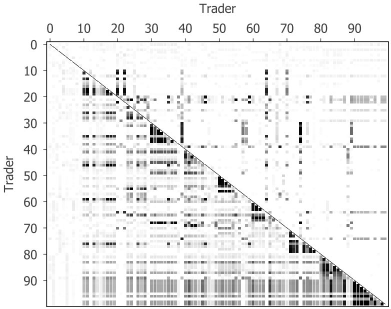


Figure: Correlations between the reservation prices of all agents in equilibrium. Positive (negative) correlations are plotted in the lower-left (upper-right) half of the graph.

Conclusions

- The original fundamental strategy as proposed by Schredelseker(2001) lets less informed agents make systematic mistakes due to biased information which in turn leaves them with systematic losses.
- Each individual trading strategy indeed exhibits a decreasing marginal utility. With a rich diversity of trading strategies, less informed agents can further reduce their price impact which maximizes their payoffs and also results in highly informationally efficient market prices.
- When informed agents ignore the signals that are also known to the less informed, they can reduce their losses by minimizing their price impact and protect themselves from being exploited by insiders.