



# The effects of intelligence on price discovery and market efficiency

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## ABSTRACT

The influence of speculation on market performance has long been discussed. Under the framework of bounded rationality in which traders are endowed with different intelligence levels in terms of different learning styles or different representations of intelligence, we examine the effects of traders' intelligence on price discovery based on "intraday" data, and market efficiency. We find that intelligence does help improve market performance. However, the influence of different intelligence levels on the market crucially depends on the characteristics of learning styles or the representation of intelligence.

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## 1. Introduction

What is speculation? As mentioned in Kaldor (1939, p. 1):

Speculation, for the purpose of this article, may be defined as the purchase (or sale) of goods with a view to re-sale (re-purchase) at a later date, where the motive behind such action is the expectation of a change in the relevant prices relatively to the ruling price and not a gain accruing through their use, or any kind of transformation effected in them or their transfer between different markets.

The impacts of speculation on the market have bothered economists for a long time, and in general, a consensus in terms of opinion has so far not been reached. Some people may argue that speculation has a negative effect on the economy as a whole because it introduces uncertainty into the market. By contrast, many economists have shown that speculation is a source of stability because speculators can correctly predict the underlying price dynamics so as to stabilize the price fluctuations. The main reason behind the controversy is that the essence of speculation as well as its conduits of influence in the economy are not well understood. In addition, different characteristics of traders in the various environments may cause speculation to exhibit quite different features.

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Basically, in the literature, three different aspects of the effects of speculation are examined. One of them focuses on the impacts of rational speculation in an environment populated by rational speculators and non-speculators. The conditions for supporting the stabilizing or destabilizing feature of rational speculation are provided. Another related area of research emphasizes the importance of irrational speculation. Traders' irrational behavior has been shown to generate substantial influences that rational traders are unable to eliminate, perhaps further destabilizing the market. The third area is concerned with the role of market structure. Under different market environments, intelligence could be irrelevant to or else give rise to significant effects on the market phenomena.

We argue that the effects of speculation crucially depend on the characteristics of learning styles (i.e., the representation of intelligence). Traders with different learning methods may constitute different characteristics of speculation that result in different impacts on the market. In this paper, different levels of traders' intelligence are modeled by means of zero intelligence (ZI), the simple adaptive learning method, and the genetic programming (GP) learning algorithm. The differences between these modelings consist of the learning styles, or the complexity or representations of the GP functions that traders can use to form their beliefs. Therefore, our framework will serve to enrich our understanding of how the representation of intelligence as well as its consequent characteristics in the microstructure exert their strength on the market properties.

In Section 2, the literature regarding speculation and intelligence are briefly discussed. The methodology employed in this paper is described in Section 3. Section 4 presents the framework of the artificial stock market. Sections 5 and 6 summarize the experimental design and the simulation results, respectively, and Section 7 concludes.

## 2. Literature

One of the most famous arguments that underpin the positive effects of rational speculation can be found in Friedman (1953, p. 175): "People who argue that speculation is generally destabilizing seldom realize that this is largely equivalent to saying that speculators lose money, since speculation can be destabilizing in general only if speculators on the average sell when the currency is low in price and buy when it is high." Irrational traders who exert the destabilizing force will sooner or later disappear. Therefore, the traders who remain in the market, the rational traders, should help to stabilize the price fluctuations. Since this proposition was put forward by Friedman, a series of theoretical models have been proposed to examine this contention, for example, Baumol (1957), Telser (1959), Kemp (1963), Farrell (1966), and Schimmler (1973). In a more general environment in which speculators are aware only of the current non-speculative excess demand, Jesse and Radcliffe (1981) have shown that the linearity of the non-speculative excess demand function is both a sufficient and a necessary condition for supporting Friedman's proposition when transaction costs are not considered.

Hart and Kreps (1986) expressed a view that was a little different from that of Friedman. They asserted that speculators buy when the chances of a price increase are high and sell when the chances of such an increase are low. They also criticized a series of papers regarding Friedman's proposition (e.g., Baumol, 1957; Telser, 1959; Farrell, 1966), in which the results were questionable because they either depended on a small number of imperfectly competitive speculators or on non-speculators with irrational expectations. Under the situation where speculators have perfect foresight regarding the distribution of non-speculators' demand up to a limited future, Hart and Kreps found that speculation can be destabilizing. In sum, the literature described above drew attention to the situation where rational speculators stabilize or destabilize the market in an environment where both rational speculators and non-speculators coexist.

This line of research regarding the impacts of rational speculation on the market seems to overlook the importance of irrational speculation because it implicitly presumes that the "noise" resulting from irrational traders will, sooner or later, be eliminated by rational traders (e.g., Friedman, 1953; Fama, 1965). "Noise traders", according to the definition by Black (1986), are those who have no access to inside information and act on noise irrationally as if it were information. A series of studies regarding noise traders conducted by De Long et al. (1990a, b, 1991) and Shleifer and Summers (1990) have demonstrated that the presence of noise traders can generate substantial effects that are quite different from those observed in a market populated by rational traders alone. In De Long et al. (1990a), the destabilizing feature of rational speculation manifests itself in such a way that rational traders trigger the trading behavior of positive feedback traders. Under the situation where rational traders characterized by risk aversion will not take unlimited positions against noise traders, De Long et al. (1990b) showed that the unpredictability of noise traders' beliefs creates a risk that rational traders are unable to eliminate. As a result, prices can deviate significantly and persistently from fundamental values even when there is no fundamental risk. De Long et al. (1991) investigated the survivability of noise traders in the long run. They found that as long as noise traders' misperceptions lead them to suffer the greater risk, noise traders as a group can not only earn higher expected returns, but they can also survive and dominate rational traders in wealth terms in the long run.

Rather than emphasizing the traders' rationality, several studies have stressed the importance of market structure. Researchers who believe that market structure is the main cause of market properties have suggested that appropriate market rules will help to improve market performance and that individual motivations are secondary. One of the most famous papers favoring this proposition is that of Gode and Sunder (1993), who attempted to figure out the relationship between individual irrationality and allocative efficiency. They introduced ZI traders whose behavior was approached using random bids or offers proposed by computer programs in the market. They claimed that the aggregate behavior of ZI traders was able to generate an efficient market. The allocative efficiency of a double auction (DA) was mainly determined by the market structure. Therefore, learning, intelligence, and profit motivation were not necessary. The studies such as Jamal and Sunder (1996), Gode and Sunder (1997), and Bosch and Sunder (2000) support this argument. However, Cliff and Bruten

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