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Exploring Narrative Economics: Integrating (Near-)Zero-Intelligence Trader-Agents with Opinion Dynamics Models

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In his influential 2017 paper (Shiller, 2017), later expanded into the 2019 book *Narrative Economics: How Stories Go Viral and Drive Major Economic Events* (Shiller, 2019), Nobel laureate Robert Shiller introduced the concept of *narrative economics* as an overlooked factor in understanding market trends. In brief, Shiller argues that in many markets the movement and maintenance of prices are driven to a significant extent by the stories, the narratives, that market participants tell each other. Shiller draws comparisons between the spread of narratives and the transmission of infectious diseases, and argues that bubbles and crashes (most notably in cryptocurrency markets) can plausibly be accounted for as primarily down to the narratives that cryptocurrency traders tell each other, even when those narratives make little sense to outside observers.

The narratives told in and about a market are externalisations, verbalisations, of the participant's interior beliefs or opinions. In this paper, we present the first results from a novel combination of two previously separate fields that both rely on agent-based modelling: our work synthesizes practices from minimal-intelligence agent-based computational economics with ideas developed separately in the research field known as *opinion dynamics.* We show here for the first time how zero-intelligence (ZI) and minimal-intelligence (MI) traders can be extended so that each trader also holds its own independent *opinion*, which is a minimal approximation model of Shiller's notion that real traders are influenced by the narratives that they hear, read, and tell. In our work, an individual trader's opinion may be influenced to varying degrees by the opinions of other traders that it interacts with; and the trader's opinion also directly influences its trading activity, i.e. the sequence of bids and/or offers that it quotes into a continuous double auction (CDA) market operating with a limit order book (LOB).

In keeping with the spirit of minimalism that motivates ZI/MI trader research, in our work each trader's opinion is represented as a signed scalar real value, e.g. as a number in the continuous range [-1.0, +1.0]. This approach is long-established in opinion dynamics research, a field that over a multi-decade history has seen developed a succession of models introduced to explore and/or account for observable patterns of opinion dynamics in human societies. In our work we have explored the integration of ZI/MI traders with the following previously-established opinion dynamics models: the *Bounded Confidence* model (Krause, 2000; Hegselmann & Krause, 2002); *the Relative Agreement* model (Deffuant, Neau, & Amblard, 2002; Meadows & Cliff, 2012); and the *Relative Disagreement* model (Meadows & Cliff, 2013). We refer to these three opinion dynamics models as the BC, RA, and RD models respectively.

The trader-agents that we extend by addition of these opinion dynamics models are ZI-C (Gode & Sunder, 1993), and Duffy & Unver's (2006) near-zero-intelligence (NZI) trader agents which minimally extends Gode & Sunder's ZI approach in such a way that markets populated by NZI traders can exhibit asset price-bubbles. We refer to the extended agent designs as *opinionated* agents: we name our opinionated version of ZI-C as *OZIC*, and our opinionated version of NZI as *ONZI*. For both OZIC and ONZI agents, the bounds of the probability distribution used to randomly generate a trader's bid or offer prices is dependent at least in part on the current value of that agent's opinion-variable; and that opinion variable can change over time as a consequence of interactions with other traders in the market, thereby modelling Shiller's notion of narrative economics: in our system opinions can drive prices, and prices can alter opinions.

We evaluate and test the performance of these trading agents, contrasting and comparing the BC, RA, and RD opinion dynamics models, using as our financial-market simulator the *Bristol Stock Exchange* (BSE), an open-source simulator of a LOB-based financial exchange for a single asset, written in Python, and freely available in the public domain since 2012 (Cliff, 2012; Cliff, 2018). When this paper is presented at Yale in October, Python source-code for the models described in this paper will be made publicly available on an appropriate open-source repository such as GitHub. This paper summarises Lomas's Computer Science Master's thesis, submitted in early May 2020 (Lomas, 2020), which contains extensive visualization and discussion of additional results that, for reasons of brevity, will not be included in the full version of this paper.

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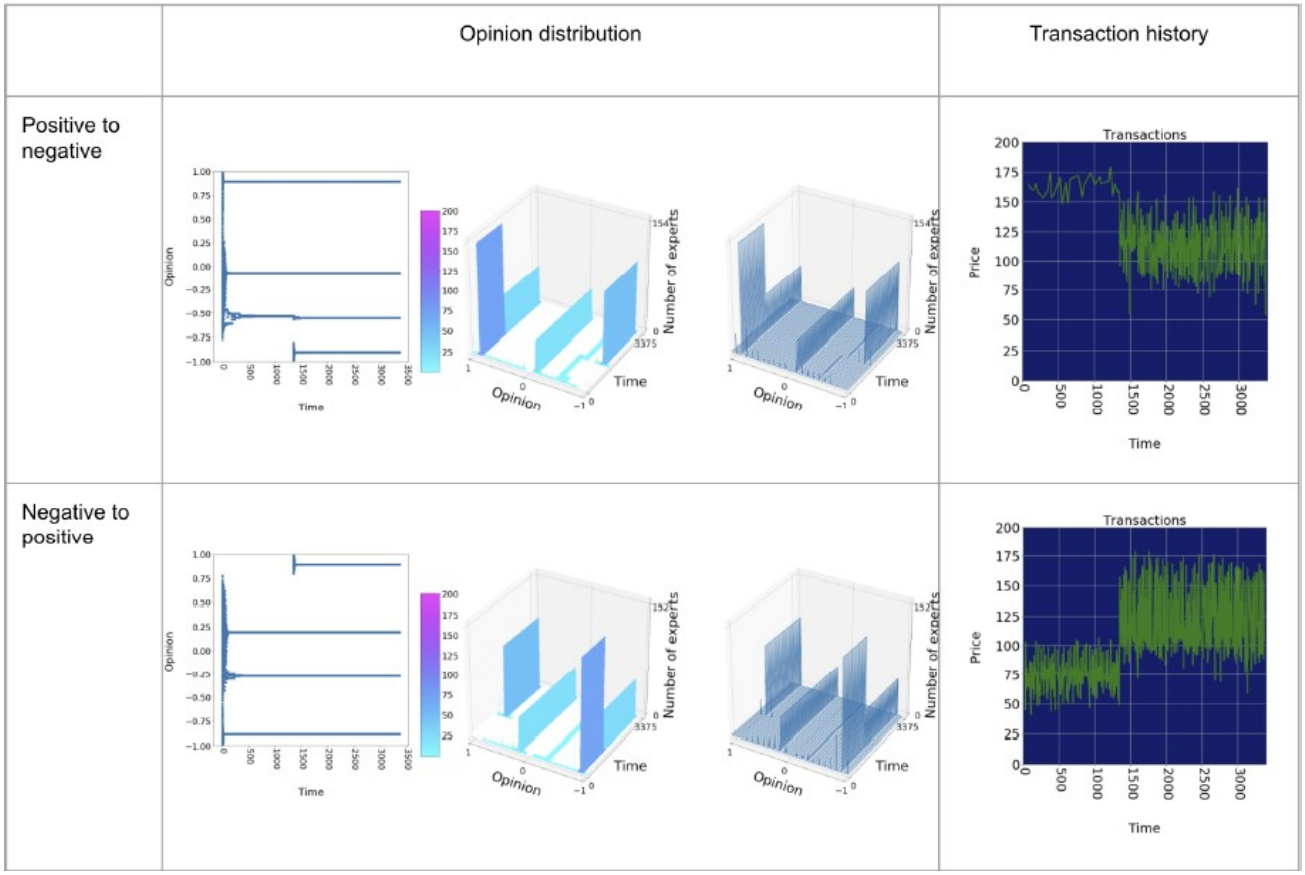
For the purposes of this extended abstract, we show here illustrative results from two experiments, in which a market populated only by OZIC traders is subjected to a sudden "shock" change in the opinions held by those traders, and the change in opinions has an obvious effect on prices. Our figure shows one experiment (on the upper row) in which positive sentiment is shock-changed to negative sentiment, and transaction prices fall in consequence; and a second experiment (on the lower row of the figure) in which the change in sentiment is from negative to positive, and where prices rise in consequence. For both experiments, the left-hand panel shows how opinion changes over the course of the experiment, and the right-hand panel shows the time-series of transaction prices in the OZIC market over the same time-period.



The results we have generated thus far indicate that the system is robust, and that it provides a solid platform on which further research can be conducted to explore issues in narrative economics. This agent-based approach complements the empirical approach proposed by Shiller, who advocated the automated analysis of online texts (social media discussions, news articles, etc) to track the effects of narratives; our work is an alternative, constructivist approach which can be used to experimentally evaluate hypotheses.

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