Irrational Behaviour and Globalisation

Extended Abstract

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ABSTRACT

This paper seeks to predict globalisation using agent models and a combination of evolutionary game theory and irrational bias. In this paper, we use a new evolutionary process in the model, where we set several complex parameters and trade-offs to set the payoff matrix and its change in real-time. We define a new dynamic evolutionary process to ensure that each agent can choose its interests in the simulation of globalisation and also the model include irrational agents in the model to test the usefulness of the new dynamics against a control group without irrational agents.

KEYWORDS

Evolutionary Game Theory; Agent-Based Model; Irrationality.

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1 INTRODUCTION

Globalisation has been studied in several disciplines such as economics, politics, anthropology and religion. It is complex, as evidenced by Rodrik's triple paradox [8]; a country can only achieve two of the following three things: full economic integration, political democracy and full sovereignty. Relatively open economies grow faster than relatively closed ones [6]. However, with the increasing frequency of trade conflicts over the last decade, trade protectionism seems to have regained its place in the public eye.

In using computer science models to make predictions about globalisation, [3] uses agents as well as evolutionary game theory to make predictions about the process of globalisation through trade. For an evolutionary game theory model, the dynamic replication equation [9] is the most frequently used formulation to model the population dynamics to reach an evolutionary stable state [10]. However, with this formulation, individual agents are not free to choose whether to evolve at each step of the evolutionary process, a feature that can lead to inaccurate results. Therefore, we have designed a new dynamic evolutionary process to simulate individual states and analyse the impact of their strategies on globalisation.

Since the formalisation of prospect theory [11], irrational behaviour has been studied extensively, but not in computer science. In this paper, by combining evolutionary game theory with agent models and irrational behaviour, we conclude rather surprisingly that irrationality helps cooperation.

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2 EXPERIMENTAL SETUP

Agent-Based Model. Our globalisation model is rich and wide-ranging, inspired by work in geopolitics, economics and behavioural sciences including [2, 4, 5, 7]. Due to lack of space, we will here only give a very high-level overview, deferring the details to the full version of the paper.

We select 100 countries for the simulation, one agent per country. These countries cover a significant portion (85% ca) of international trade. Each agent plays a 2-player game against each of the other agents; in this sense, our globalisation game is a polymatrix game [1]. Each agent has a choice of five *types* defining one of three *strategies* to deal with other agents: (i) cooperation (*coop*) in which case the agent plays strategy c to cooperate; (ii) conditional betray (*cb*) (strategy betray, denoted b, with probability depending on agents' parameters); (iii) *hold* (strategy h); (iv) tit-for-tat (*tit*) (strategy b when the other agent betrayed at the last turn and c otherwise); (v) generous tit-for-tat (*gtit*) (strategy b with a certain probability as a response to a betray in the previous round, c otherwise).

The payoff functions, and in turns fitness function and our dynamics, will depend on the following agent parameters.

Structure (h). Structure of a country is a function of the percentage of GDP coming from the three sectors of the economy.

Trade (i). This measures the percentage of GDP coming from trade.

Culture (cl) and Confidence (c). These are defined following [2].

Agent's strength. The overall strength of the agent (called international effect and denoted *ee*) is made up of five items: (i) Economic strength (*es*); (ii) Military strength (*ms*); (iii) Labour force (*pn*); (iv) Technological strength (*ts*); (v) Natural resources (*ns*). Adding up the five dimensions above for some values b_1 to b_5, we get: $ee = b_1 \cdot es + b_2 \cdot ms + b_3 \cdot pn + b_4 \cdot ts + b_5 \cdot ns$.

Reputation (r) and Population mood (pm). The initial value of pm and r for all agents is 0. The range of pm and r is $(-1, 1)$.

$p's$	*Payoffs*	*Population mood*	*Reputation*
p_{cc}	$es_A \cdot a_5 \cdot (i_A \cdot l)$	$pm_A \cdot -a_5 \cdot l$	$r_A \cdot a_5 \cdot l.$
p_{bc}	$es_A \cdot a_9 \cdot (i_A \cdot l)$	$pm_A \cdot a_9 \cdot l$	$r_A \cdot -a_9 \cdot l$
p_{hc}	$es_A \cdot -a_4 \cdot (i_A \cdot l)$	$pm_A \cdot a_4 \cdot l$	$r_A \cdot -a_4 \cdot l.$
p_{cb}	$es_A \cdot -a_6 \cdot (i_A \cdot l)$	$pm_A \cdot -a_6 \cdot l$	$r_A \cdot a_6 \cdot l.$
p_{bb}	$es_A \cdot -a_7 \cdot (i_A \cdot l)$	$pm_A \cdot a_7 \cdot l$	$r_A \cdot -a_7 \cdot l.$
p_{hb}	$es_A \cdot -a_4 \cdot (i_A \cdot l)$	$pm_A \cdot a_4 \cdot l$	$r_A \cdot -a_4 \cdot l.$
p_{ch}	$es_A \cdot -a_4 \cdot (i_A \cdot l)$	$pm_A \cdot -a_4 \cdot l$	$r_A \cdot a_4 \cdot l.$
p_{bh}	$es_A \cdot -a_4 \cdot (i_A \cdot l)$	$pm_A \cdot a_4 \cdot l$	$r_A \cdot -a_4 \cdot l.$
p_{hh}	$es_A \cdot -a_4 \cdot (i_A \cdot l)$	$pm_A \cdot a_4 \cdot l$	$r_A \cdot -a_4 \cdot l.$

Table 1: Payoff, population mood and reputation of agent A

With these ingredients, we define (i) payoff for a game between agents A and B and dynamics of pm and r (see Table 1, where l is a shorthand for $\ln(es_A/es_B + 1)$); (ii) probability of betraying (defined as a certain function of $ee_A + ee_B$, $r_A - r_B$, $c_A - c_B$ and additional parameters to do with difference in culture of the agents, geographical positions, political systems, and industrial structures); and, (iii) fitness function and dynamics (details omitted).

Irrational Behaviours. Virtual payoff vp is used to define irrationality; vp will define the fitness function rather than the actual payoff. *Loss averse* agents will experience a loss vp equal to twice the actual payoff. For *risk seeking* agents, vp is equal to half the actual negative payoff. For an *overconfident* agent, after three consecutive rounds with a total gain greater than 0, the agent will continue its strategy and treat vp as 0 regardless of the loss.

3 RESULTS

The model is calibrated with the 2019 GDP data from the World bank, that is, the model is calibrated (by setting values for the a_i's in the payoff definition, etc.) to replicate historical data in terms of GDP. In each evolutionary process, we conducted 1, 200 periods of experiments. Each agent must evolve at each time step t, according to our new dynamic evolutionary approach. Our experiment starts with all the agents types being *coop*. According to the data analysis of the Bank of England, in 2020, global trade fell by 8.9%, as the Covid-19 pandemic has caused major disruptions to global trade. To simulate the effects of Covid-19 on globalisation, we introduce a shock at the 300th step of the evolutionary process. At the beginning of the shock, all agents would become *hold.*

Population of rational agents. We begin with perfectly rational agents (vp equal to actual payoff). In Figure 1, we plot the evolution of the agents' types over the evolutionary process, with the horizontal coordinate being the evolutionary period t and the vertical coordinate being the proportion of the five strategy types in the population We can see that before the shock, *coop* was the dominant

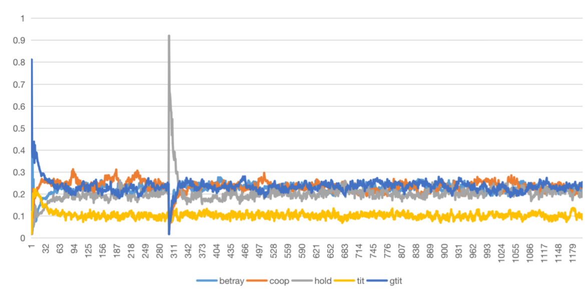

Figure 1: Agent types without irrational agents

strategy, while after the shock, the population did not reach a stable state, each type almost always around 25% of the total.

We also record the average *es* changes (that we call change-rate) to capture the evolution of world GDP. The *es* change rate is around 0.01% prior to the shock, and lower than that after.

Introducing irrational agents. In these experiments, the four types of irrationality are evenly distributed among irrational agents. 75% rational agents. The variation in agent types is shown in Figure 2 below. *Gtit* was already the dominant type in the population

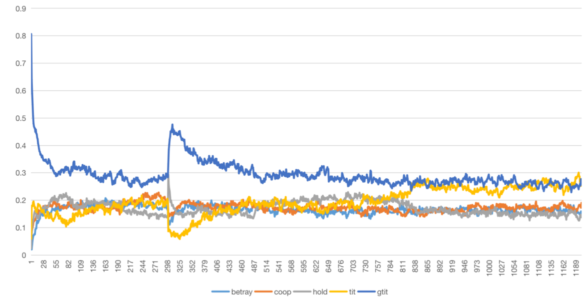

Figure 2: Agent types changes when 75 % agents are rational

before the shock. After the shock, more agents in the population choose the *gtit* type. However, after 800 steps, the number of *tit* agents increased to about the same share of *gtit* agents in the population. Moreover, at the time of shock, there were only approximately 30% of the agents with type *hold*, in contrast to Figure 1.

Risk-seekers have the highest payoffs in all periods, while overconfident agents have the lowest. However, overall the GDP grows more than in the case in which the population is perfectly rational.

50%, 10% and 0% rational agents. The ratio of *gtit* to *hold* before a shock occurred gets closer to 1 as the number of rational agents gets smaller. This demonstrates that as the number of irrational agents increases, more agents choose type *hold* to reduce the potential loss from trade. Also, as the number of irrational agents increases, more agents will become *hold* at the point of shock. After the shock, as the number of rational agents decreases, more agents choose the *gtit* type, from nearly 29% of agents in the 75% rational case to nearly 38% of agents in the 0% rational experiment.

We compare the payoffs of rational and irrational agents in the experiment. In the 50% environment, loss averse agents have the highest payoffs. In contrast, in 10% environment, both rational and loss averse are likely to be the most profitable agents. Risk-seeking agents become the most profitable agents in the 0% rational experiment. The overall GDP is higher in these environments than in the case of full rationality.

4 CONCLUSION

We define a novel agent-based model for globalisation. We simulate the effects of Covid-19 on globalisation and find that in the experiments with rational agents, the results are cyclic, with around 20% of the agents in the group using the same strategy, and not reaching an equilibrium through 1,200 time steps (accounting for 25 years of quarterly data). However, when irrational agents are introduced, we find that roughly 40% of the population of agents used the same strategy. This contrasts the results in [3], which suggest that globalisation is an endless cycle, since we seem to reach a relatively stable state with irrational behaviour. Moreover, the payoff of the agents after a shock tends to be higher than before. The result suggests that agents are more willing to cooperate after a shock, implying deeper globalisation. In the experiments with only rational agents, the overall payoff after the shocks is smaller than before, suggesting that globalisation has regressed and agents are more reluctant to cooperate.

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