An Evolutionary Trust Game for the Sharing Economy

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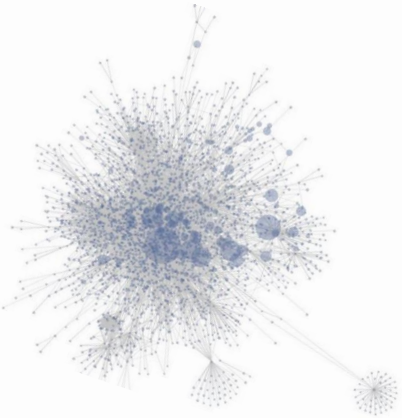


What is the sharing economy?

Rapid proliferation of new C2C platforms (sharing economy) where consumers share access to their private resources.

Transactions do not involve transfer of ownership.

Private individuals act as providers. Consumers get access to resources at lower prices than conventional model.

High level of exposure (in contrast to traditional e-commerce): providers risk damage or theft.

Trust is fundamental in the sharing economy

There is a transaction if there is a bidirectional trust process:
Both providers and consumers' belief is they will behave untrustworthily.

Goal: to study the dynamics of cooperation in the sharing economy using evolutionary game theory

The outline of our work is:

1. To present an evolutionary game theory model to represent and study trust within the sharing economy.

2. Use a social network and evolutionary update strategy for the consumers and providers of the game.

3. Experimentation and analysis of different scenarios to see under which circumstances, trust and global net wealth are maximized

4. Conclusions and next steps

Game definition

Our sharing economy model consists of a finite set of players occupying the nodes of a social network.

4 types of strategies to be played:

TP: a **trustworthy provider** who offers an asset as promised.

UP: an **untrustworthy provider** who offers an asset with lower quality than promised.

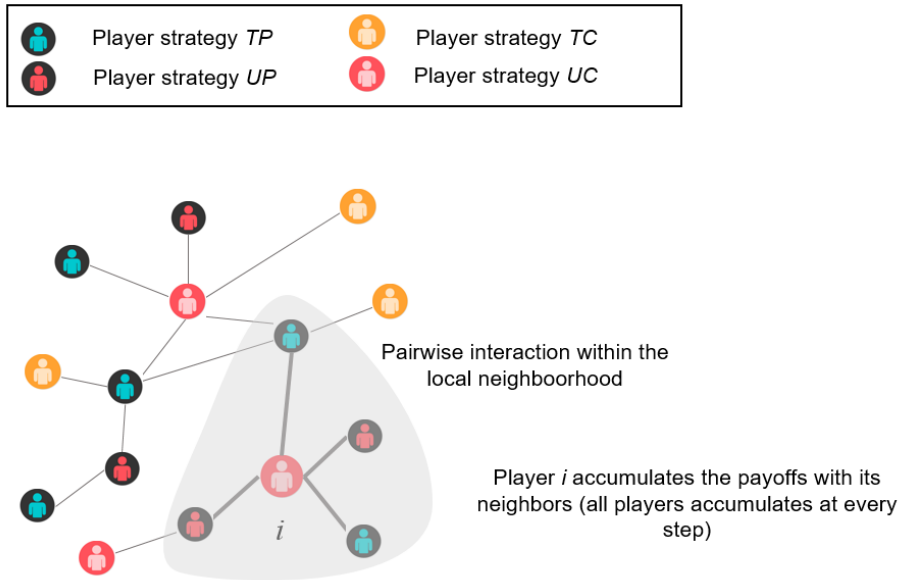
TC: a **trustworthy consumer** who uses the asset in a socially and economically appropriate manner.

UC: an **untrustworthy consumer** who uses the asset in an excessive and inappropriate manner.

Players within a social network

Population is formed by 4 groups of players, connected through a social network. Edges denote interactions or transactions between the nodes.

Pairwise interactions: a player interacts with direct neighbors in the social network during all the steps of the simulation:



Payoffs (fitness) for the trust game

The players play the game within its neighborhood and obtain a payoff (fitness) depending on her strategy and the ones of the local players.

Providers	Consumers TC	UC
TP	R, R	$-S, Temp$
UP	$X, -X$	$X, -X$

$$2 \cdot R > Temp > R > S > X.$$

Temp: the temptation for a consumer to be untrustworthy.
R: is the reward when both provider and consumer are untrustworthy.
S: is the sucker punishment for a trustworthy provider when consumer is untrustworthy.
X: the value a provider keeps and a consumer pays after the transaction is done

Evolutionary update rule

After playing the game in the time-step, players can reconsider their current strategies by comparing them within local neighborhood (bounded rationality).

Our model uses an evolutionary update rule called **proportional imitation.**

At player *i* selects one of her neighbors at random *j* and only if its payoff or fitness is better, selects its strategy with a probability:

$$prob_i^t j = \frac{\max\{0, w_j^{t-1} - w_i^{t-1}\}}{\phi},$$

$\phi = max_w - min_w$ is the maximum payoff distance

Experimentation

1,133 players (nodes of the real social network of emails sent at the URV, Spain)
50 Monte Carlo simulations during 5,000 steps
Collect global net wealth (sum of all players' payoffs) by averaging last 25% steps

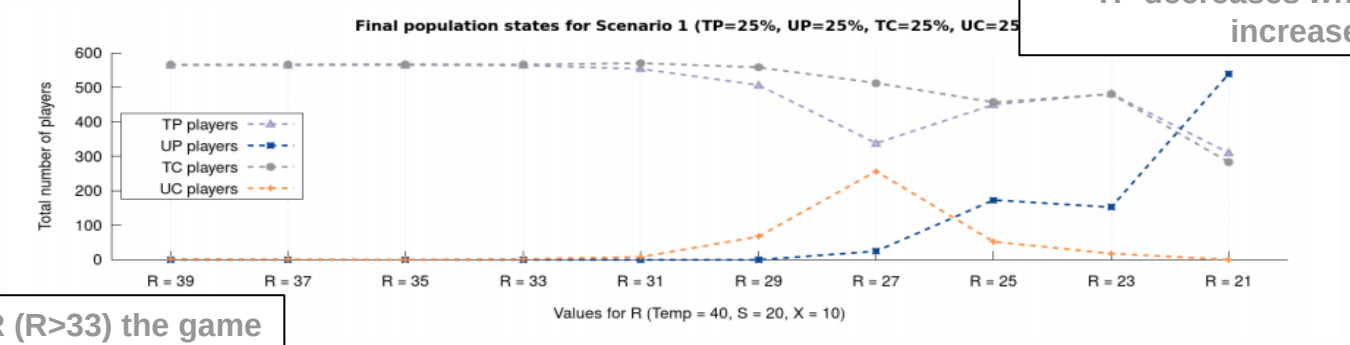
Study dynamics and compare 5 scenarios for the initial population conditions:

- **Scenario 1:** TP = UP = TC = UC = 25%
- **Scenario 2**: Providers (TP+UP) = 10% Consumers (TC+UC) = 90%
- **Scenario 3**: Providers (TP+UP) = 90% Consumers (TC+UC) = 10%
- **Scenario 4**: Trustworthy (TP+TC) = 10% Untrustworthy (UP+UC) = 90%
- **Scenario 5**: Trustworthy (TP+TC) = 90% Untrustworthy (UP+UC) = 10%

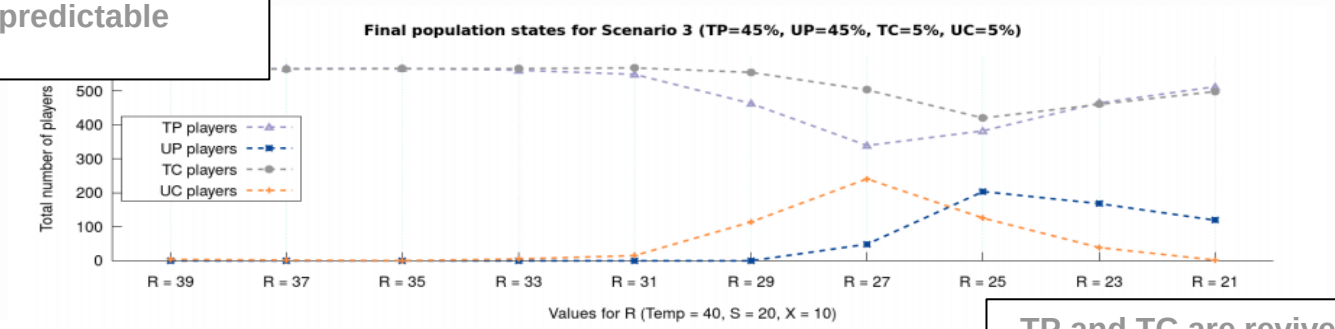
Different reward parameter R values (from easier to difficult game):
R = {21, …, 39} Temp = 40, S = 20, X = 10

Results for scenarios 1, 3, and 5

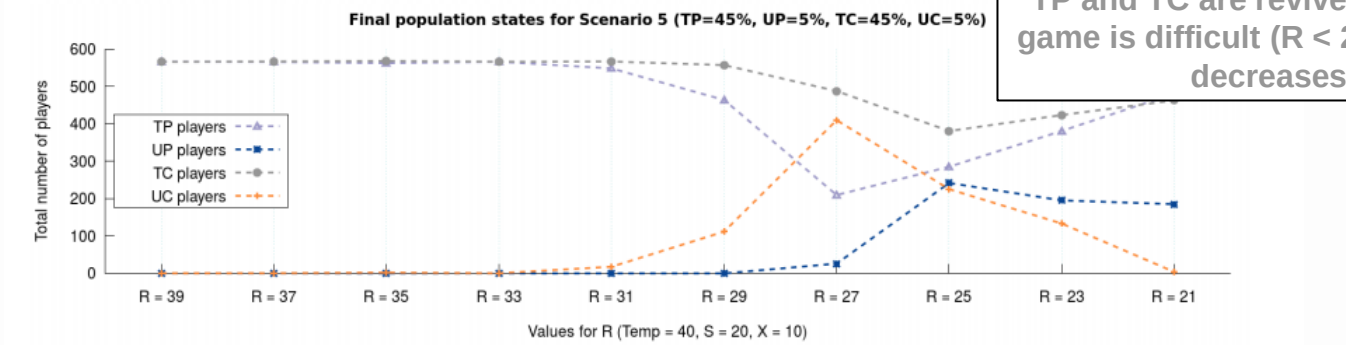
If game is moderate (27<R<33), TP decreases while UP/UC increase



High values of R (R>33) the game is easy and predictable

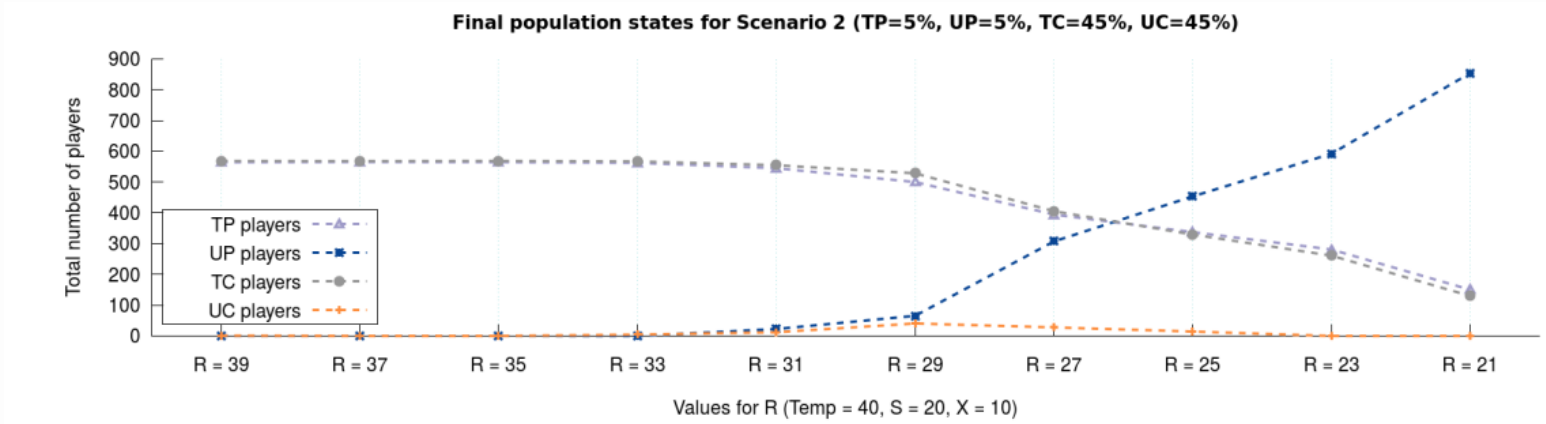


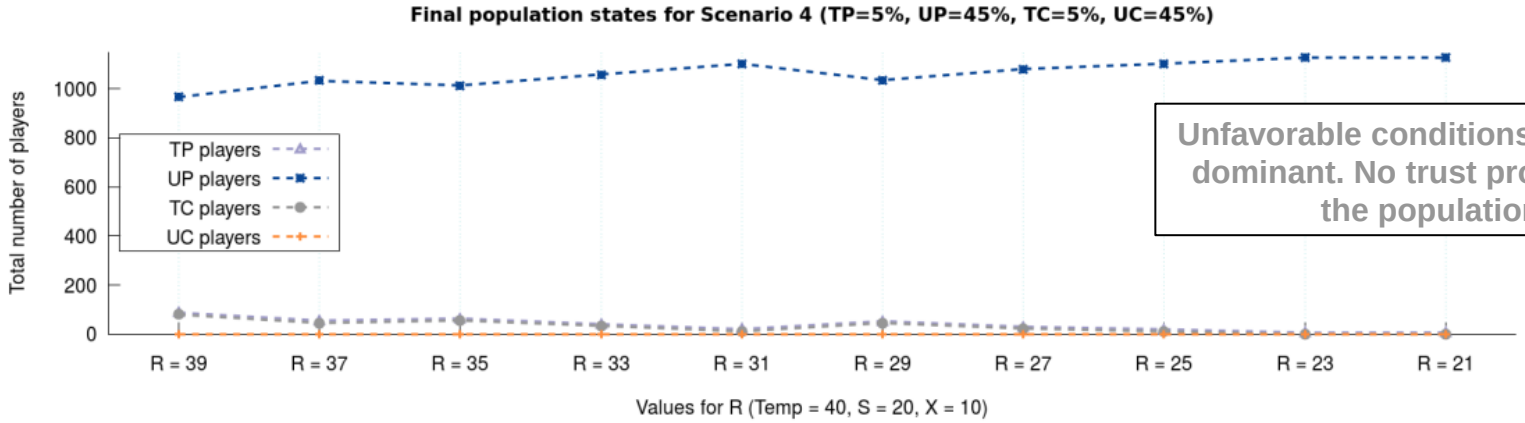
TP and TC are revived when the game is difficult (R < 27) while UP decreases.



Results for scenarios 2 and 4

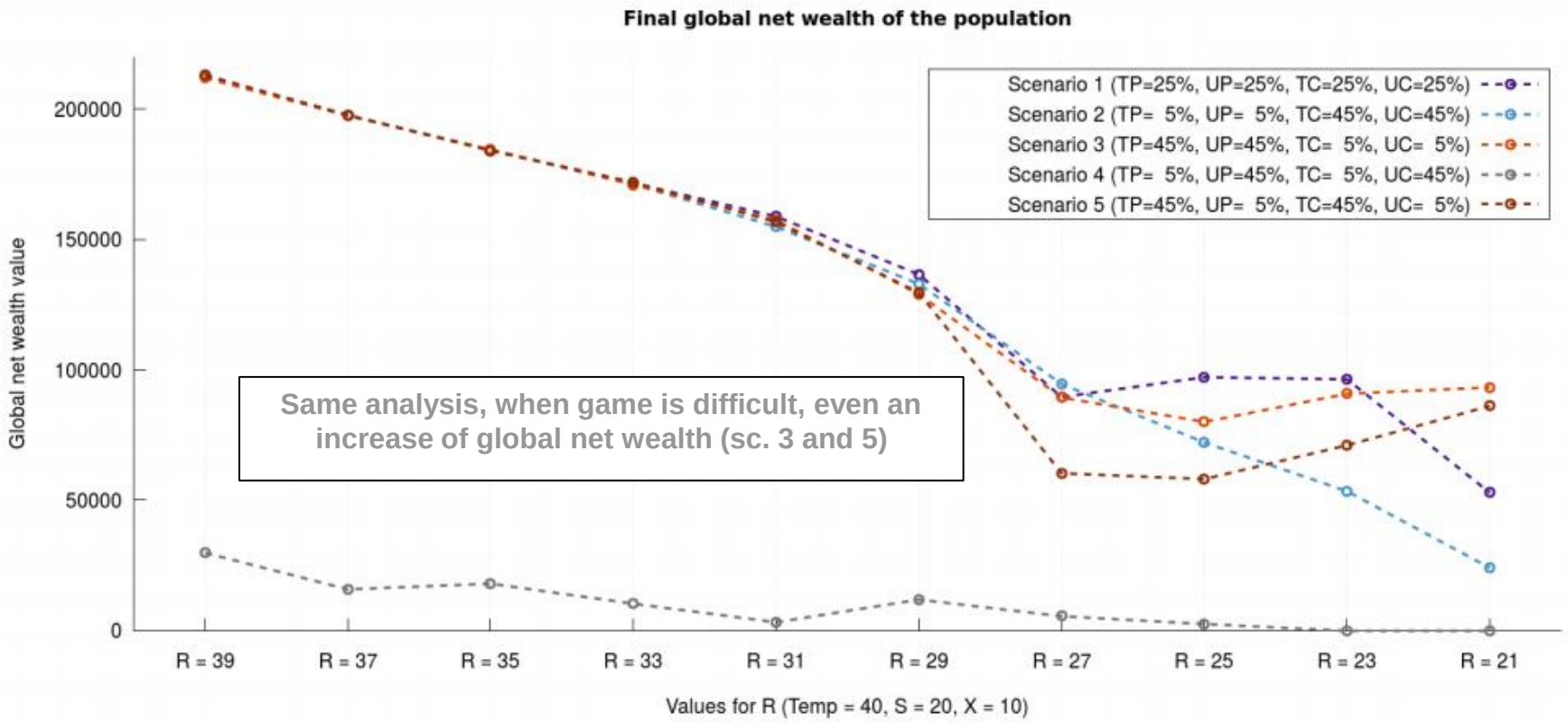
Majority of consumers → Trustworthy when R > 25
UP are dominant when R <= 25





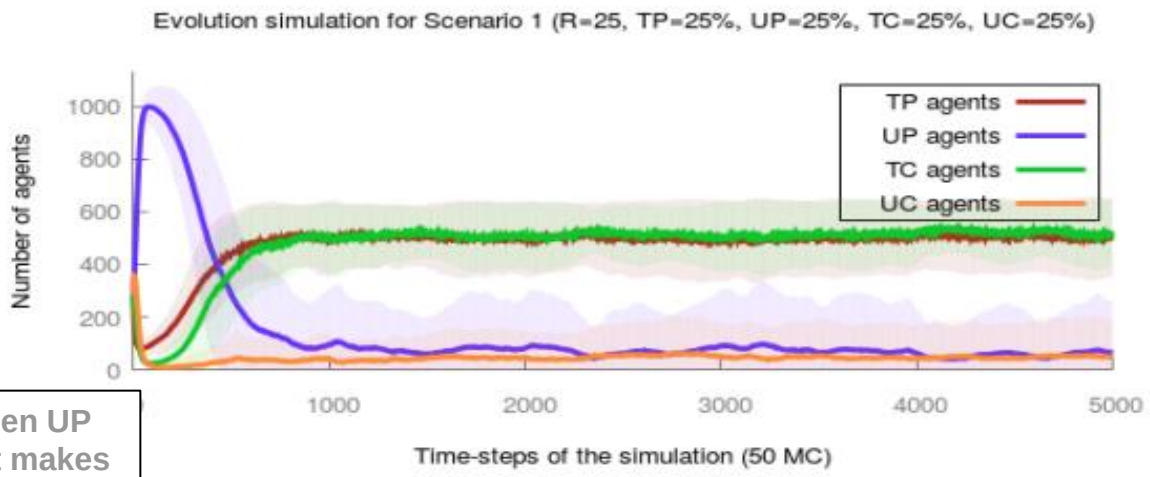
Unfavorable conditions → UP are dominant. No trust promoted in the population

Results for all the scenarios (global net wealth)

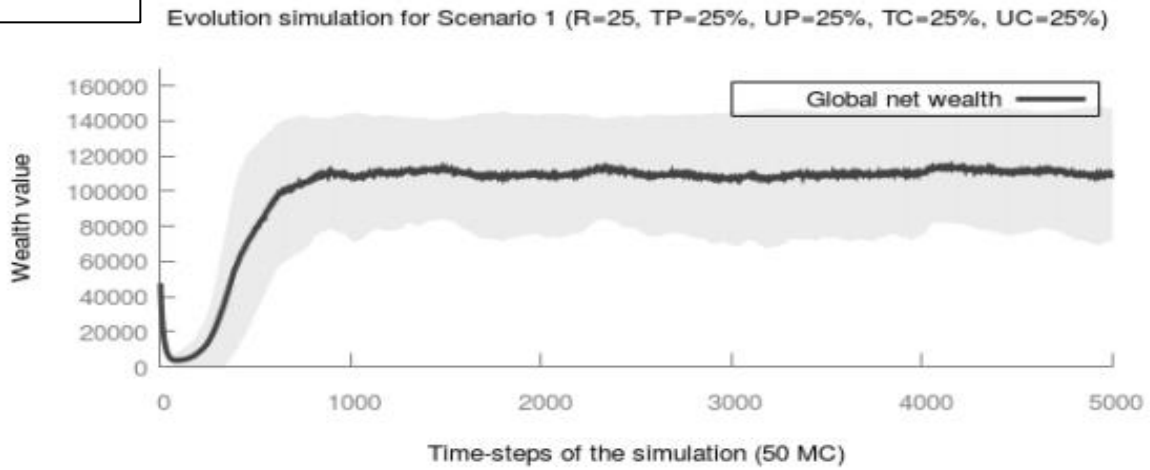


Same analysis, when game is difficult, even an increase of global net wealth (sc. 3 and 5)

Time-series evolution (scenario 1, R = 25)



Recovery of TP when UP and UC increases. It makes trustworthy players to rise.



Conclusions

First use of an evolutionary game theory model to study trust dynamics for the sharing economy.

4 playing strategies within a social network. Payoff function with 4 parameters to model the difficulty of the game (players to be untrustworthy).

We found that trust can be easily promoted when reward values are high (R) except if the initial population has limited trustworthy players (10%).

Untrustworthy consumers are never dominant. They can exploit TP but they are 'punished' by UP.

Untrustworthiness of consumers is reciprocated by untrustworthy providers → driving consumers to behave trustworthy (balancing effect).

Next steps and future work

Use real data from sharing economy platforms to empirically validate the results.

Make the payoffs matrix more realistic for the sharing economy:

- deposit for consumers in case a provider is untrustworthy (X + b).
- directly penalize providers when they are untrustworthy (X - a).
- reputation and opinion about providers and consumers.

Studying different evolutionary update rules (UI, …) and values for Temp, S, X.

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Code: https://bitbucket.org/mchserrano/trust4sharingeconomy

THANKS