Emergence of Money with Cognitive Computational Agents

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Partners:
1. SKEMA/GREDEG
2. I3S University of Nice
3. School of Math, Georgia Institute of Technology

Motivations

- The project builds on the two parallel streams of research developed in I3S and SKEMA.
- Using new methodology from computer science in order to find answers to important questions in social sciences: model the *emergence of money* in decentralized trading systems.

People Involved

- I3S: Celia Pereira and Andrea Tettamanzi

Two master students hired with the funds of the grant: Mattia di Russo and Eralda Frokku

- SKEMA/GREDEG: Maurizio Iacopetta and Zakaria Babutsidze
- Georgia Tech, USA: Federico Bonetto
- Osaka University, Japan: Nobuyuki Hanaki

Research Question

- In a classic work Kiyotaki and Wright (1989) established conditions for a stationary Nash equilibrium where money is accepted in trade.
- Laboratory experiments (e.g. Duffy, 2001), often fail to find situations in which this equilibrium actually emerges.
- This is a fundamental topic in economics: it involves trust, behavior, forward thinking, authority, quality of institutions. In capacity of an economic system to generate wealth hinges on the reliance of a good monetary system. The emergence of a monetary system based on fiat has been very recent – with the abandonment of the gold standard in 1970.

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- Some claim that you do not need a government authority for people to coordinate on a symbolic object to be accepted in trade. The success of cryptocurrencies is brought sometimes as an example, although there are serious issues in characterizing cryptocurrencies as means of transaction.

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Our approach

- We studies the issues from three perspectives:

1) Theory
2) Computer simulations
3) Laboratory Experiments

summary of results

1) Theory

The starting point is an economic environment developed by Kiyotaki and Wright (1989) where people randomly meet to trade goods against goods or goods against money. The existing literature had not described the dynamics of such a model. We did in the following article:

Federico Bonetto and Maurizio Iacopetta, **Journal of Mathematical Economics,** 2019, vol. 84, issue C, 207-224

summary of results

2) Computer Simulations

We extended and refined an early work by Marimon et al. 1990 who developed a classifier system to simulate the possible behavior of real people.

The Emergence of Money: Computational Approaches with Fully and Boundedly Rational Agents", **Computational Economics,** 58, pp. 3–26, 2021

Also presented at Eastern Economic Conference, 2019

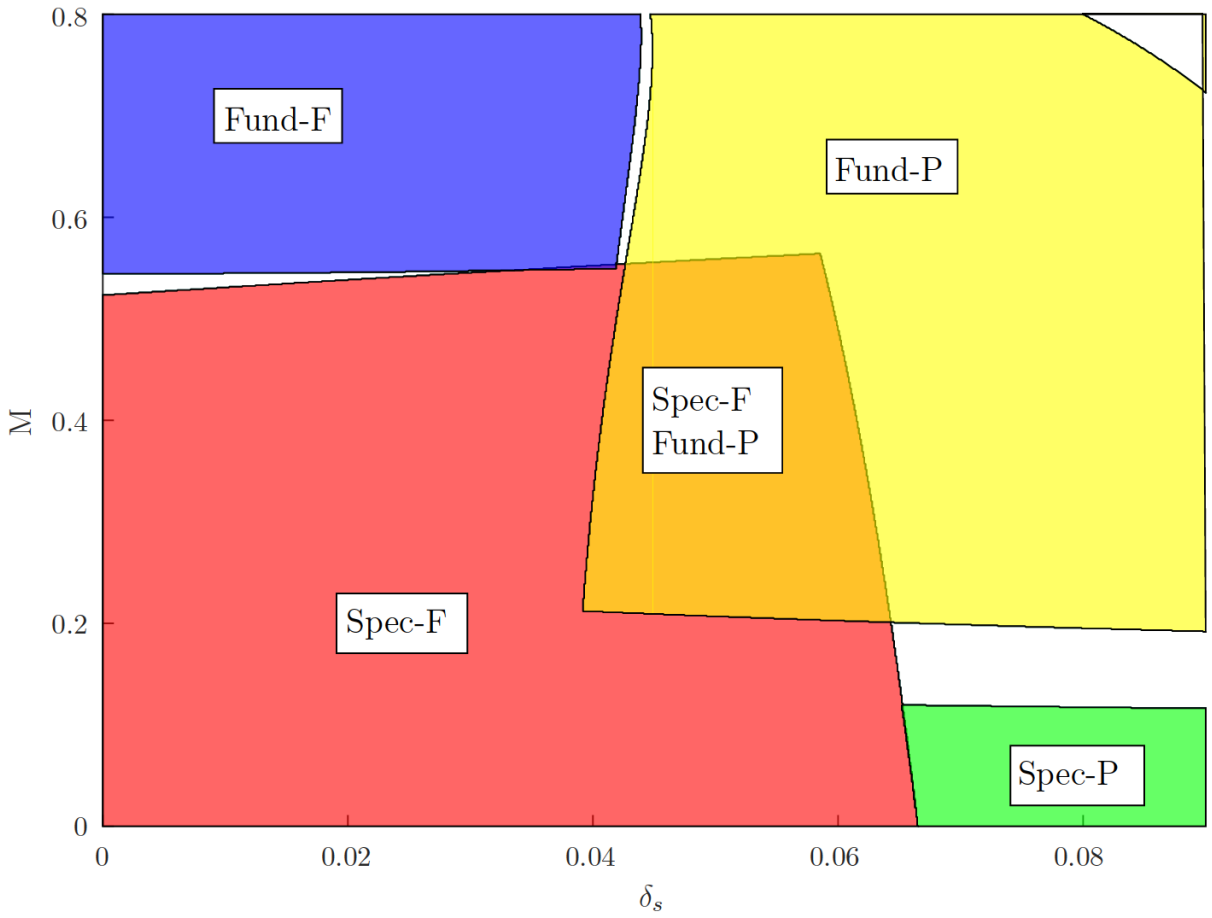
summary of results

3) Laboratory Experiments

We are currently working on the final draft of paper that puts together Theory, Computer Experiments, and Laboratory Experiments:

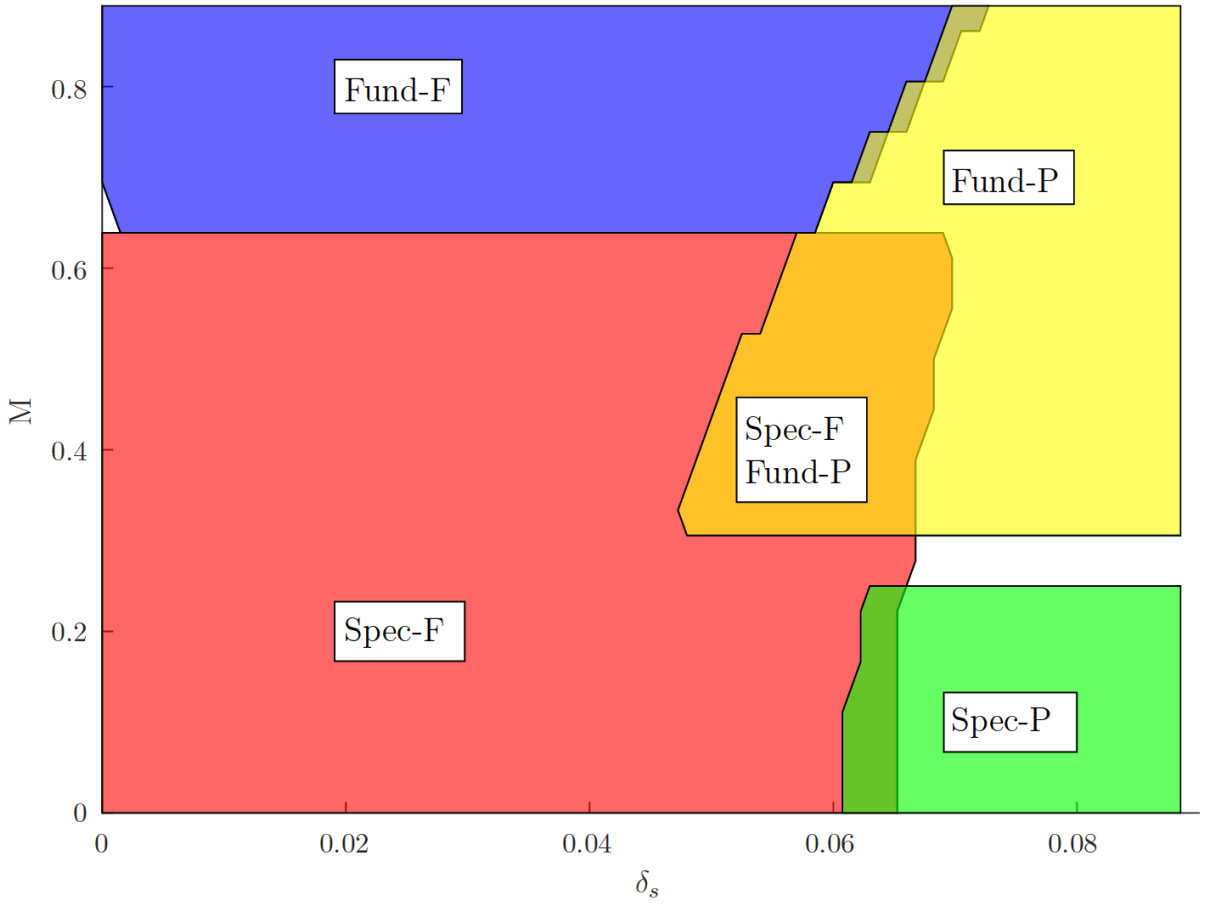
Title of the paper: Money and Inflation: From Search Theory to Laboratory Experiments

summary of results



(a) Infinite Economy

summary of results



(b) Finite Economy

summary of results

	c_1	c_2	c_3	c
Spec	-0.04	-0.13	0.28	0.04
Fund	0.20	-0.11	-0.17	-0.02

(a) Percentage changes in consumption with a 1% rise of δ_s.

	W_1	W_2	W_3	W
Spec	-0.77	-2.13	-0.36	-0.96
Fund	-0.74	-1.84	-1.81	-1.47

(b) Percentage changes in welfare with a 1% rise of δ_s.

summary of results

3) Laboratory Experiments

We split the individuals who participated in the experiments into groups of 18.

In every session, participants go through all the five treatments.

At the beginning of each round, participants are randomly assigned to one of the three types (1,2,3) with the condition that there are 6 participants of each type.

Every subject starts the round with an initial endowment 150 experimental points and a unit of fiat money, a ‘production’ good, or a ‘non-production’ good.

3) Laboratory Experiments

Main objective: To test how inflation and the stock of money affect:

a) Trading behavior (speculative vs. fundamental strategies)

b) Acceptance of money

We also wanted to study the welfare implications

3) Laboratory Experiments

We had a total of 75 rounds played.

42 terminated within first 10 time periods

22 terminated between 11th and 20th time periods

seven terminated between 21st and 30th

the remaining four terminated between 31st and 40th periods.

3) Laboratory Experiments

What we found:

1) Speculative behavior is not observed as often as predicted by the theory. Earlier studies by Duffy and Ochs had reached similar, but our experiments considered the presence of inflation.
2) Inflation has a significant effect on the decision to accept fiat money

Western Economic Society (2021) virtual

OFCE Sciences Po, (2021) virtual

Paper targeted for the International Economic Review

summary of results

Table 5

Laboratory Experiments: Frequencies of offers

		Panel I. Type 1 offers			**Panel II. Type 2 offers**			**Panel III. Type 3 offers**		
		Money for			*Money for*			*Money for*		
T	M	1	2	3	2	3	1	3	1	2
1	L_0	1.00	0.00	0.10	1.00	0.00	0.27	1.00	0.07	0.02
2	M_0	0.97	0.06	0.03	0.96	0.00	0.14	0.98	0.13	0.08
3	H_0	1.00	0.09	0.12	0.97	0.02	0.23	0.97	0.09	0.07
4	M_p	1.00	0.05	0.16	0.97	0.02	0.27	0.98	0.31	0.25
5	H_p	0.98	0.07	0.19	0.96	0.03	0.30	0.92	0.22	0.11

Laboratory Experiments

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5	H_p	0.98	0.07	0.19	0.96	0.03	0.30	0.92	0.22	0.11
		Good 2 for			*Good 3 for*			*Good 1 for*		
T	M	1	0	3	2	0	1	3	0	2
1	L_0	0.99	0.77	0.40	0.98	0.79	0.98	0.98	0.73	0.12
2	M_0	0.98	0.79	0.23	0.99	0.95	0.98	0.98	0.72	0.14
3	H_0	1.00	0.84	0.24	1.00	0.90	1.00	1.00	0.89	0.15
4	M_p	1.00	0.73	0.22	0.98	0.83	0.99	1.00	0.55	0.32
5	H_p	1.00	0.69	0.14	1.00	0.92	1.00	0.97	0.48	0.27
		Good 3 for			*Good 1 for*			*Good 2 for*		
T	M	1	0	2	2	0	3	3	0	1
1	L_0	0.97	0.67	0.29	0.99	0.54	0.11	1.00	0.64	0.64
2	M_0	1.00	0.75	0.69	1.00	0.62	0.02	1.00	0.53	0.48
3	H_0	1.00	0.83	0.50*	0.97	0.51	0.00	1.00*	0.31	0.38
4	M_p	1.00	0.50	0.44	0.98	0.42	0.04	1.00	0.38	0.58
5	H_p	1.00	0.63	1.00*	1.00	0.31	0.08	0.75*	0.56	0.67

Future Research

-- Going from an economic model to a laboratory experiments poses several issues: going from an environment from a continuum to a finite (and small) number of agents. Even the basic characterization of a Nash equilibrium is problemtic.