

# An Evolutionary Framework for Studying Behaviors of Economic Agents

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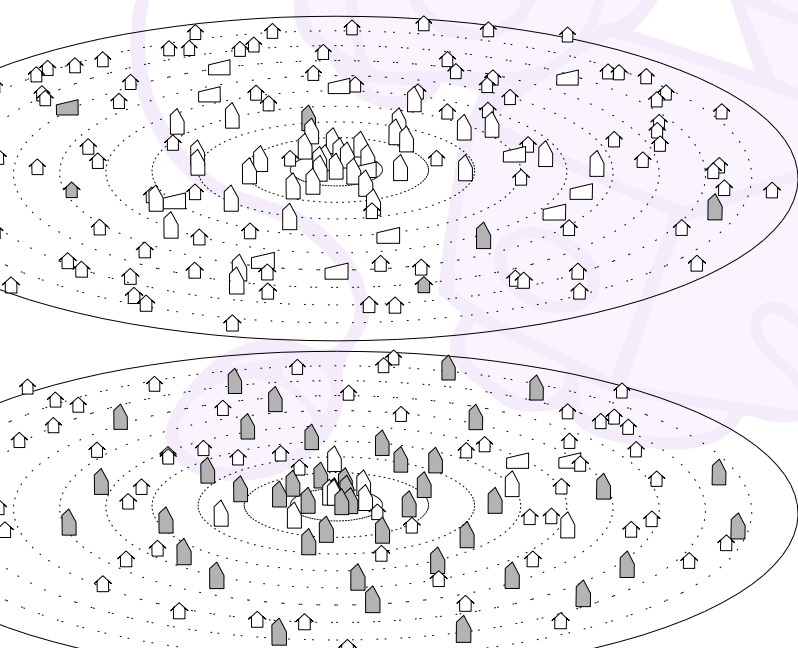
Study performance of agents' strategies in systems using an evolutionary framework.

What agent strategies are good for which conditions.

Comprehensive testing of electronic market implementations.

**Evolutionary Framework?** Evolutionary methods for studying complex societies, where the society changes during the simulation, and strategies change as well in an effort to adapt to the environment. Evolutionary frameworks allow studies through controlled experiments.

**Simulation Model:** Simulation of a society of suppliers and their customers. The agents live in a circular city. The simulation is based on a supply and demand model, where multiple providers compete for customers, and where the criterion to stay in business.



## Customer Agent:

- Anonymous customers come to the market with a fixed frequency, for a single transaction.
- Density of customers is inversely proportional to the distance from the city center.
- A customer minimizes its net cost:  

$$\text{netcost} = \text{price} + \text{distance} \times c^{\text{mile}} + \text{delay} \times c^{\text{hour}}$$
- Customers do not change their properties during the simulation.

## Supplier Agent:

- Suppliers are characterized by their pricing strategy, and the number of customers they can serve concurrently (size).
- Each supplier is audited at regular time periods and removed from the market if its profit becomes negative.
- The society of suppliers evolves to meet the demands of the customers.

## Structure of the City:

In the two figures to the left we show the structure of the city at milestone 110 (top) and 290 (bottom). Price seeker suppliers are denoted by white houses, market samplers are gray.

At milestone 110 only a few market samplers exist in the city. At milestone 290 the market is dominated by size 3 market samplers and size 1 price seekers.

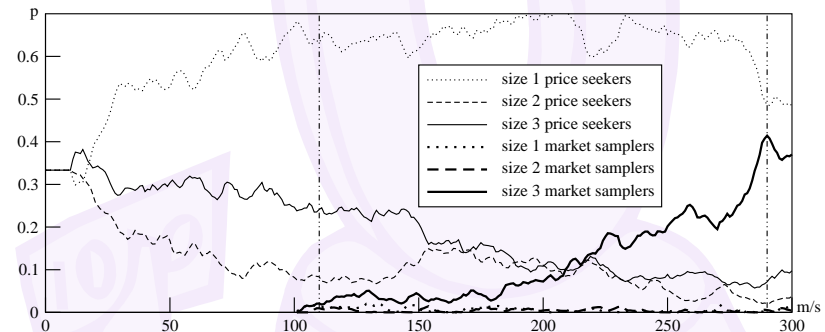
The market structure is more regular at milestone 290 due to market samplers' ability to pick advantageous deployment locations.

## Sample Simulation with Two Different Strategies:

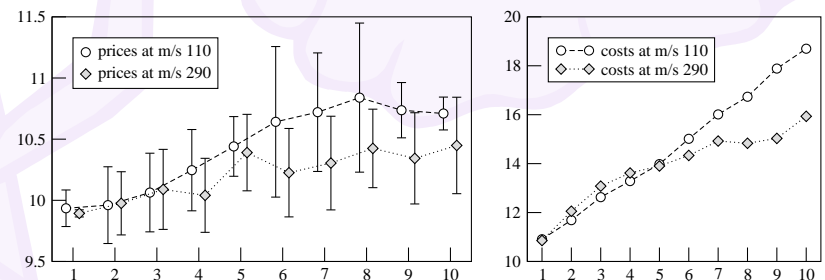
**Market Sampler** samples the city in several locations to maximize a potential revenue flow given the state of the market. The price and the number of samples it takes are assumed to be distributed normally.

**Price Seeker** assumes that the "right" price and density of the suppliers depend solely on the distance from the center of a city.

**Simulation Time-Line:** in the next figure we can see the probabilities of a new supplier entry for different supplier types as a function of milestone numbers. Market sampler suppliers are introduced at milestone 100.



**Price Distribution:** The next figure shows the average supplier prices with standard deviations (left) and 25 hour half-life decaying averages of customer costs (right) for 10 concentric city zones at milestones 110 and 290.



## Why another Evolutionary Framework?

- Heterogeneous strategies can co-exist and evolve. New agents are created by choosing the type of the new agents and general initial parameters using statistical information on the number of existing agents of the same type.
- Agents with different strategies can enter the market at any time.
- Strategies never disappear. Even when no agents using a specific strategy are left in the market, the probability of creating new agents using that strategy never becomes zero.

## Future Work:

- Build evolutionary framework on top of an existing system, e.g., TAC03.
- Introduce individual agent learning.