

BACKGROUND AND MOTIVATION

How are prices formed in markets? Decentralized markets are an important area to study, occurring frequently in the real world. In a decentralized market, agents trade with other agents, making a sequence of trades with a series of partners. When there is uncertainty, agents may learn from the actions of their trading partners.

An Example:

1. You move to a new area and need to find a contractor for home improvements
2. Not knowing the going rate of service in the new area, you search for bids
3. Either:
 - Receive and accept a low price offer
 - See only higher prices and settle on a high price
4. After seeing a large number of prices and trades, you will learn market conditions

The goal of this work is to characterize efficiency and understand information percolation in a decentralized market. To do this, I use empirical game theoretic analysis from computer science and traditional equilibrium techniques from economics.

MODEL SUMMARY

The model I study is an exchange economy with two goods (x_1, x_2), comprised of three main components: a state of uncertainty with a binary realization, a set of agents, and a bargaining process. These components are heavily intertwined.

MODEL FEATURES: UNCERTAINTY AND AGENTS

- A state of nature
 - Realizations: High (H) or Low (L)
- Nature corresponds to relative good values
 - In high state good 1 yields relatively more utility (this is the state definition)
- Common state dependent utility functions $U^H(x_1, x_2)$ and $U^L(x_1, x_2)$
 - Agents want more of each good
 - Agents want a balanced portfolio
- Subset of sellers observe the signal and are 'informed'
- All other agents are 'uninformed'
- N sellers
 - have relatively more of good 1
 - trade good 1 for good 2
 - select prices
- N buyers
 - have relatively more of good 2
 - trade good 2 for good 1
 - accept or reject prices

For demonstration, I present a few games with one informed seller, one uninformed seller, and two uninformed buyers. The agents are depicted as follows:



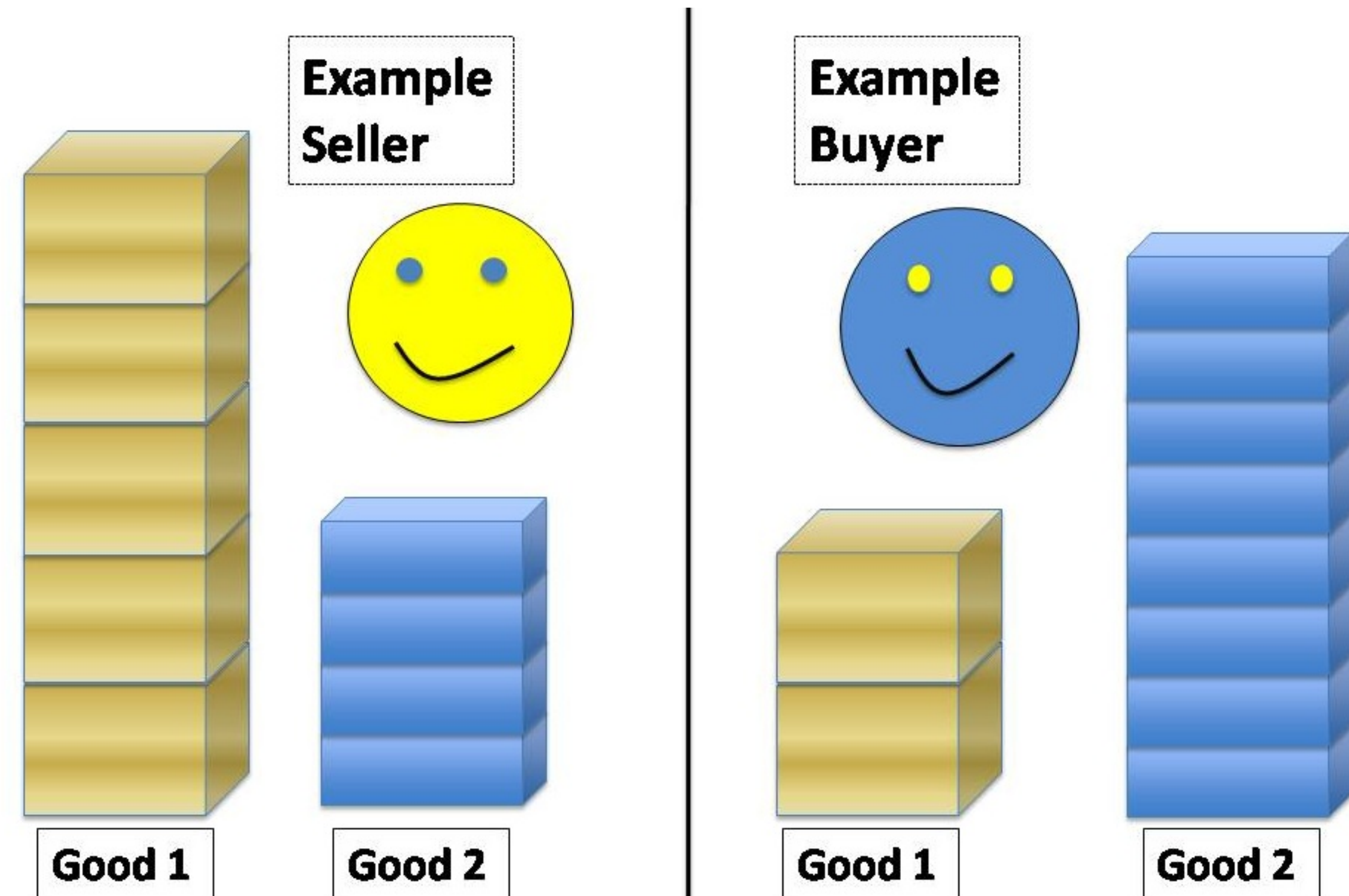
Agents maintain beliefs regarding the uncertainty. These are represented by the following color scale, where darker means a stronger belief in the high state:

State is Low Likely Low Fifty/Fifty Low/High Likely High Probably High Very Likely High

MODEL FEATURES: BARGAINING PROCESS

- Every period, each seller is matched with one buyer
- Seller chooses a price
 - Either high (p^H) or low (p^L)
- A seller knows:
 - Setup of the game
 - Own initial belief and endowment
 - Own past offers and responses received
- Agents do not know names, beliefs, or holdings of their trading partners
- Buyer sees price
 - Accepts (Yes) or rejects (No) the offer
- A buyer knows:
 - Setup of the game
 - Own initial beliefs and endowment
 - Past offers made and own responses

ALLOCATION EVOLUTION: AN EXAMPLE



- Seller begins with 5 units of good 1, and 4 units of good 2
- Buyer begins with 2 units of good 1, and 8 units of good 2

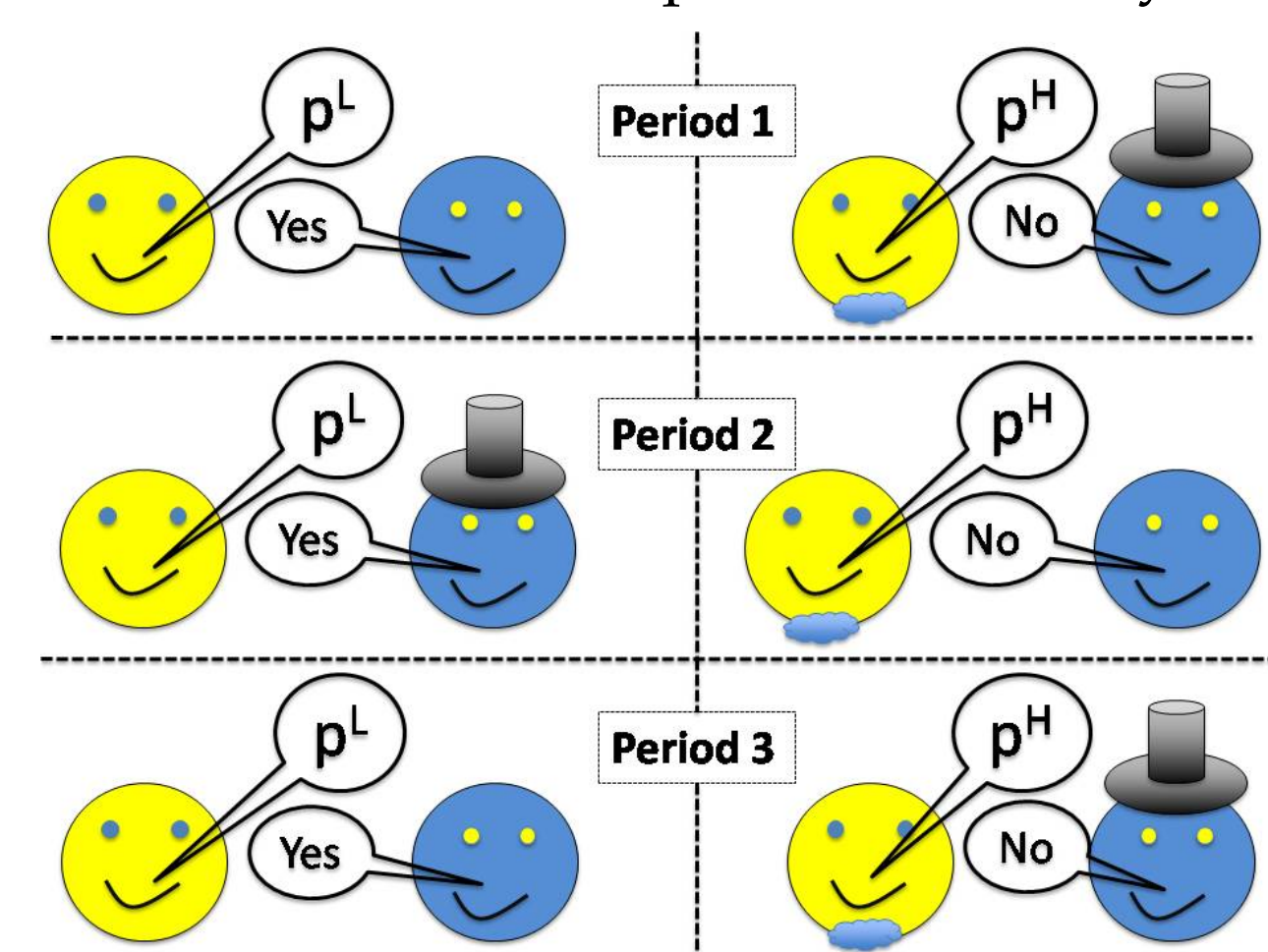
In each period seller offers one good 1 for $p^L = 1$ or $p^H = 2$ units of good 2

Agents do not want to transact at an unfavorable price in a favorable state:

- In the high state a seller would not want to trade one for one
- In the low state a buyer would not want to trade two for one

A SIMPLE MARKET

To illustrate the model, below is an example series of negotiations (low state). Note, the endowments and price choices may differ from the above example.



Strategy overview:

- The informed seller offers a low price in the low state for three periods
- Buyers refuse high prices in the first two periods, taking time to discover if the state is low

Beliefs' evolution after observing the match partner's action:

Pd	Seller 1	Seller 2	Buyer 1	Buyer 2
1				
2				
3				

In a counterfactual high state:

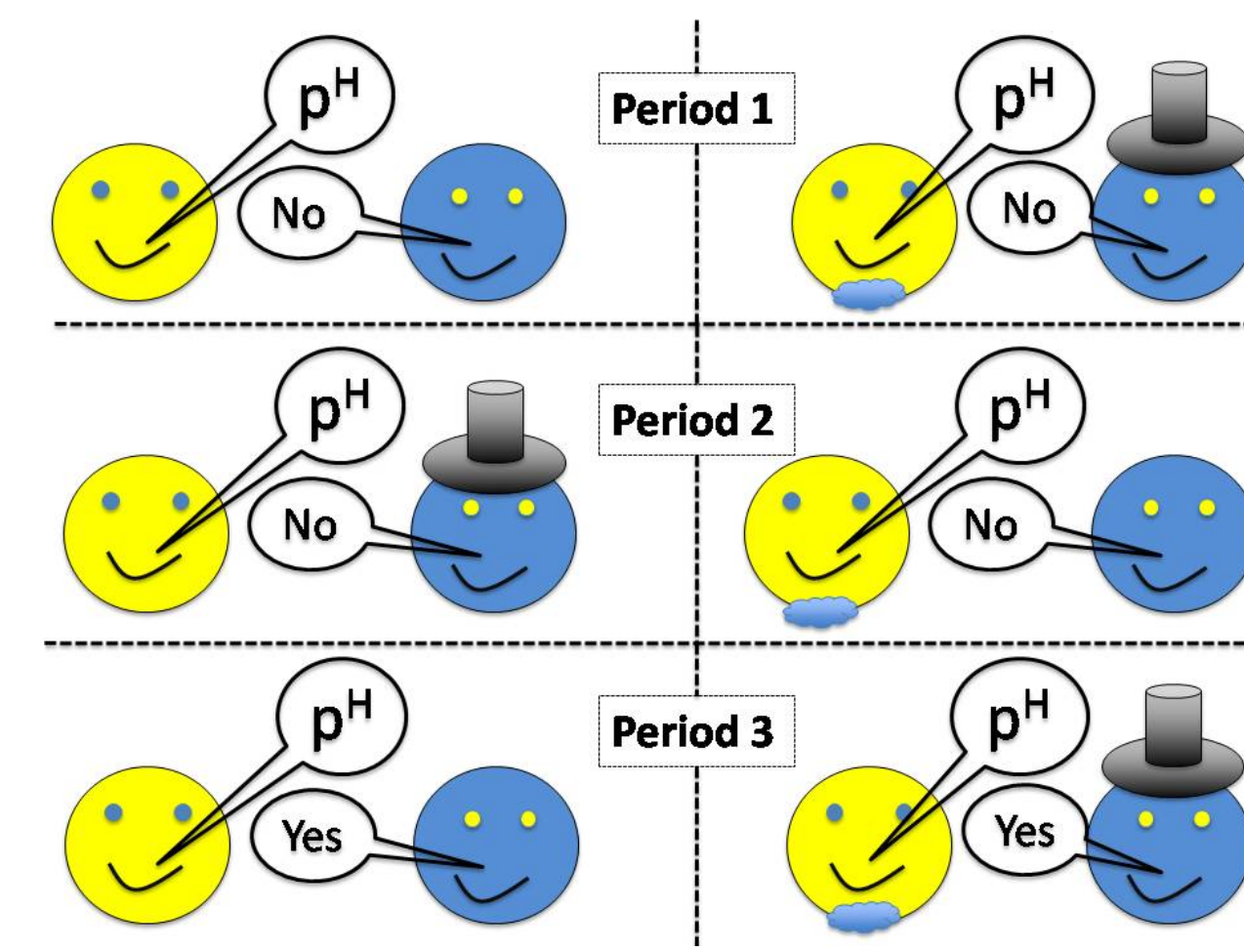
- Both the informed and uninformed seller request a high price in the first two periods
 - Buyers reject these prices
- In the third period both sellers again ask a high price, buyers accept believing (correctly) the state is very likely high

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SIGNAL MISREPRESENTATION

Under signal misrepresentation, an agent chooses actions inconsistent with her beliefs to signal a more favorable state. This places restrictions on the existence of equilibria, as agents' beliefs must be consistent with strategies. Signal misrepresentation is demonstrated below, when an informed seller in the low state signals a high state (with a high price) for three periods.



Strategy overview:

- The informed seller offers a high price
- Buyers refuse high prices in the first two periods, hoping to discover if the state is low

Beliefs' evolution:

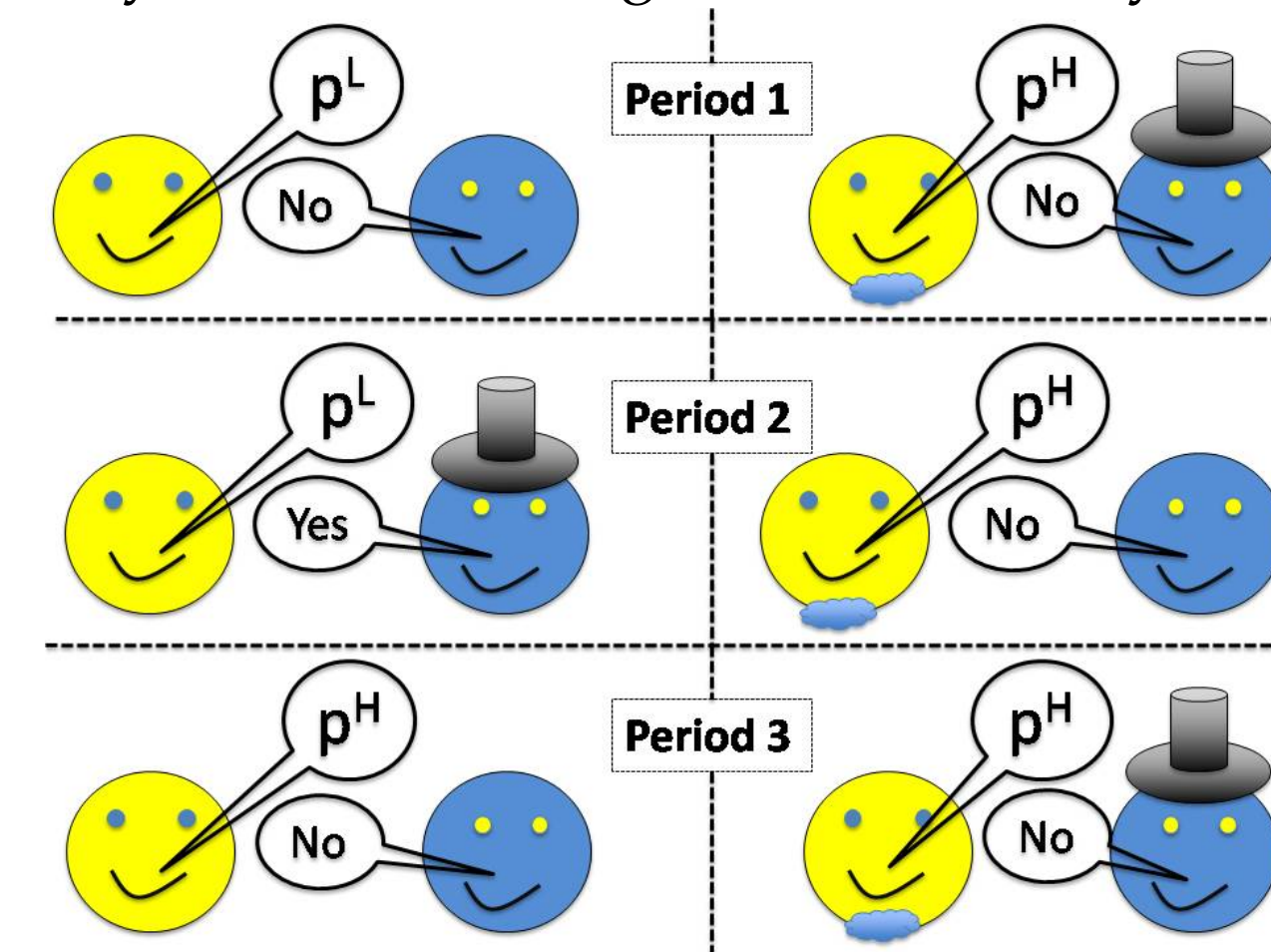
Pd	Seller 1	Seller 2	Buyer 1	Buyer 2
1				
2				
3				

RESULTS SUMMARY

I identify two types of behavior: **signal misrepresentation** and **forced diffusion**, which do not exist in models with infinite agents. **Signal misrepresentation** breaks many of the naive equilibria which exist in other models. **Forced diffusion** is a behavior which may exist in some equilibria here, but is not found in other models.

FORCED DIFFUSION

Forced diffusion can exist in an equilibrium in which a buyer learns the state is low, and wants other buyers to learn the low state. For example, if there is a single informed seller who wishes to sell for the low price only once, the only way for both buyers to see that signal is for one buyer to refuse the low price.



Strategy overview:

- In the low state, informed seller offers low price until it's accepted
- Buyers refuse all offers in the first period
- The buyer who sees a low price in the first period
 - Sacrifices a short term gain
 - Realizes a long term benefit as the uninformed seller learns the low state faster

Beliefs' evolution:

Pd	Seller 1	Seller 2	Buyer 1	Buyer 2
1				
2				
3				

In the counterfactual where buyer 1 accepts the first low price:

- Buyer 2 sees only high prices
 - Buyer 2 buys at p^H from the uninformed seller
 - Telling that seller the state is likely high
 - The uninformed seller will not sell at a low price to Buyer 1

DISCUSSION

By allowing for signal misrepresentation and forced diffusion, I improve on earlier models to better characterize behavior affecting decentralized markets. Continuing research will identify the conditions under which information percolates to all agents, and when markets will always converge to efficient outcomes. This research can help better understand behavior in increasingly realistic markets.