**Project Overview**

This paper uses an analytical approach to determine necessary and sufficient conditions for the formation of asset bubbles in low-information populations. By using simulated agents, we can create very precise specifications of various pricing methods and completely determine population demographics. Different agent and population characteristics will be examined to determine what factors lead to the formation of price bubbles in a specific, homogeneous asset. Asset bubbles have two very distinctive features: a gradual or sudden increase in prices and then a precipitous decline of value.

Much public knowledge of these bubbles comes from relatively recent memory—the tech bubble of the early 2000s and the real estate bubble that led into the great recession. Stories of these events usually feature lengthy discussion of “irrational exuberance” and traders, investors, and homeowners who were caught up in the mania of the latest new thing. Although behavioral explanations certainly inform valuation of assets and contribute to the “group think” that can cause these bubbles, this paper seeks to determine more fundamental causes for pricing bubbles by simulating populations of low-information actors. Using unsophisticated agents will allow us to approach disentangling potentially interacting forces in a much more sophisticated manner.

**Asset Description**

We use a simple asset that allows us to examine agents that differ on these three different dimensions. The asset is a multi-period dividend-paying stock. The “intrinsic value” of each share is $100, and does not change throughout the trading period. This is designed to simulate the formation of a bubble in stocks for companies for which, over the given time period, fundamentals have not drastically changed.

**Agent Description**

The actors in these experiments are designed after the zero-information agents first introduced by Sunder and Gode (1993). Agents generate random bids and offers (depending on whether they are designated a buyer or a seller) that adhere to their perceived budget constraints. Agents value their held assets and use their valuations as well as public market data about past transactions in order to buy more. Agents differ on three axes that influence their pricing of assets, (1) price level, (2) induction, and (3) thought level. Each of these is referred to as a “brain,” i.e. agents have three brains. We will discuss each of these in turn:

1. Price Level Brain: some agents are very concerned with absolute price levels, but others are more captivated by the “momentum” of a stock, focusing more on price changes. Agents will have one of these two types of brains:
   1. Absolute Price Level Brain: all else equal, agents only use market data to determine whether the absolute price at which assets are being transacted is above or below their perceived “fundamental value.”
   2. Changes Price Level Brain: these agents are captivated by rapid changes in prices by virtue of seeking to move quickly on price changes seen in the market.
2. Induction Brain: some agents calculate the value of an asset through discounted cash-flow analysis of future expected cash flows, while others are more sensitive to market information about an asset’s worth. This is characterized into two types of brains:
   1. Forward Induction Brain: agents using forward valuation techniques will calculate the net present value of the asset by considering its future cash flows. The number of future dividend payments considered is specified by the Thought Level Brain.
   2. Backwards Induction Brain: other agents prefer to us market information to calculate their perceived fundamental value.
3. Thought Level Brain: agents can work entirely with their own information, or they can assume any number of "levels of thought" with regards to their competitors. Particularly, agents can choose whether or not to anticipate the responses of their peers in the markets. We will examine three forms of this brain:
   1. Personal Thought Level Brain: agents will only consider the upcoming dividend period.
   2. Secondary Thought Level Brain: meant to test the marginal influence of agent foresight, these actors will consider two dividend periods when valuing the asset.
   3. Optimal Thought Level Brain: finally, some agents will assume the rational conclusion of the game, that being common knowledge. These agents will use all future dividend payments to value the stock as a perpetuity.

[I’m a bit confused as to why levels of foresight = levels of thought]

Since agents possess one of each type of brain, the above categories leave use with 12 different types of agents. For each specific model simulation, the number of each of these types is determined. Since some brains require additional parameters, it might also be the case that heterogeneity within a single agent type will be introduced. Specific model configurations will be discussed below.

**Market Overview**

Agents compete to buy and sell assets in a double auction marketplace. Different tests use different, fixed agent populations (described at length below) competing to buy and sell common assets. The assets represent dividend-paying stocks of a company and are thus identical, but are valued differently by different agents, perhaps as a result of their own structure (exogenous parameters) or their own ownership states (endogenous parameters).

Each dividend period, each agent has ten opportunities to participate in the market. Agents are called upon in a fixed order that was randomly determined at the start of the simulation. Each agent in turn is randomly designated a buyer or a seller and thus uses his various valuation brains to generate a fair value. This decision is an independent 50-50 coin flip. Then, he randomly generates a bid or ask below or above that calculated fair value, respectively. [Figure out what kind of decay function agents should use, if any]

If the given quote narrows the active spread in the market, the agent then holds the active bid or offer. If the spread is crossed, the two active agents transact at mid and all other bids and offers are forgotten. The market restarts with the next agent. Agents are endowed with five assets and $1,000 and are short-sale constricted. Since offers are specific to specific shares of the company, only one share may be bought or sold at a time. Previous transaction prices are public knowledge, but not all agents choose to use the information.