In-Class Discussion Exercise **Leigh Tesfatsion**
(lrnagent.pdf)

Constructing Computational Economic Agents Who Learn

STRATEGIC INTERACTION is said to arise between two agents A and B if the choices of agent B explicitly enter into the choice deliberations of agent A because A perceives or expects that B's choices can affect his own outcomes.

Specifically, A asks himself questions of the form: "Given B has done this, what should I do?, and "If I do this, what will B then do?"

As seen in previous lectures, no strategic interaction arises among agents in economic systems under the assumptions of competitive pricing theory. Agents are linked through prices and only through prices. All agents take these prices as given aspects of their decision environments, outside of their control. Consequently, they do not perceive any way in which the decisions of other agents impinge on their own decisions.

In contrast, strategic interaction naturally arises among agents in economic systems if they are permitted to set their own prices.

KEY DISCUSSION QUESTION FOR TODAY: If you had to construct a computational price-setting firm capable of surviving and prospering within a computational economic system, how would you go about it?

AN ILLUSTRATIVE ECONOMIC SYSTEM

Consider an economy that exists over time periods T=1, 2, ..., ∞.

The economy includes N_B bean-producing firms and N_H hash-producing firms (hash=fried potatoes!). Each firm initially has a positive wealth (net worth) level W.

Each bean firm has the capacity to produce at most Q_{BMax} pounds of beans per period. Beans are a perishable good and last at most one period. The cost of producing b pounds of beans is $C_B(b) = a_B \cdot b^2 + e_B \cdot b$, where a_B and e_B are nonnegative constants, and each bean firm has this same cost function.

If a bean firm sells b pounds of beans at unit price p_B, its profits are

$$p_B b \ - \ C_B(b) \ . \tag{1}$$

Each hash firm has the capacity to produce at most Q_{HMax} pounds of hash per period. Hash is a perishable good and lasts at most one period. The cost of producing h pounds of hash is $C_H(h) = a_H \cdot h^2 + e_B \cdot h$, where a_H and e_H are nonnegative numbers, and each hash firm has this same cost function.

If a hash firm sells h pounds of hash at unit price p_H, its profits are

$$p_H h \ - \ C_H(h) \ . \tag{2}$$

Explicit collusion among firms is prohibited by antitrust laws.

The economy also includes M price-taking consumers who derive utility (happiness) from the consumption of beans and hash.

Each consumer has a fixed positive income I in each period T.

Each consumer must consume some minimal positive amounts $\bar{b}$ and $\bar{h}$ of beans and hash in each period T to survive.

Given unit prices p_B and p_H for beans and hash in any period T, each consumer demands (buys) nonnegative amounts b^d and h^d of beans and hash to maximize her utility $U(b^d - \bar{b}, h^d - \bar{h})$ subject to her budget constraint, i.e., subject to the constraint that her expenditures on beans and hash do not exceed her current income:

$$p_B b^d + p_H h^d \quad \leq \quad I \quad . \tag{3}$$

For example, suppose that the utility obtained by a consumer from consumption of beans and hash is measured by a utility function of the form

$$U(b-\bar{b},h-\bar{h}) \;=\; log(b-\bar{b})+\theta\cdot log(h-\bar{h}) \ , \qquad (4)$$

where θ measures the consumer's relative preference for hash versus beans in any given time period.

Suppose, also, that the LOWEST unit price for beans currently known to the consumer is p_B^L and the LOWEST unit price of hash currently known to the consumer is p_H^L

Suppose, also, that the firms offering these low prices have ample supplies of goods on hands so that the consumer does not have to take into account the possibility of stock-outs (inability to meet her demands).

The utility maximization problem faced by the price-taking consumer then takes the following form: Taking p_B^L and p_H^L as given prices, maximize

$$log(b-\bar{b})+\theta\cdot log(h-\bar{h}) \qquad (5)$$

with respect to the choice of b and h subject to the budget and feasibility constraints

$$p_B^L b \ + \ p_H^L h \ \leq \ I \ ; \qquad (6)$$

$$b,h\geq 0 \ . \qquad (7)$$

Suppose that $p_B^L\bar{b} + p_H^L\bar{h} < I$. (This guarantees there exist feasible choices of b and h yielding finite utility levels.) It can then be shown that the solution to the consumer's utility maximization problem yields demands $b^d > \bar{b}$ and $h^d > \bar{h}$ for beans and hash satisfying the following *demand functions*:

$$\begin{aligned} b^d &= \bar{b}\theta/[1+\theta] + [I - \bar{h}p_H^L]/p_B^L[1+\theta] &=& \; D_B(p_B^L, p_H^L) \;\; ; \quad (8) \\ h^d &= \bar{h}/[1+\theta] + [I - \bar{b}p_B^L]\theta/p_H^L[1+\theta] &=& \; D_H(p_B^L, p_H^L) \;\; , \quad (9) \end{aligned}$$

where dependence of the demand functions on the exogenous variables $\bar{b}$, $\bar{h}$, θ, and I has been supressed for expositional simplicity.

IMPORTANT NOTE: If the firms currently offering the lowest prices for beans and hash do not have sufficient goods on hand to meet consumer demands for beans and hash at these prices, then the utility maximization problems faced by the consumers become much more complicated. The consumers would presumably then have to take into account the "rationing rule" used by firms when their demands exceed their supplies, as well as the likelihood of being rationed and hence forced to move on to more expensive firms to satisfy any residual (unsatisfied) demands.

BOTTOM LINE: When firms with imperfect information choose their own prices and quantities, these choices can be WRONG in the sense that markets fail to clear. In this case, even price-taking consumers can be forced into strategic interaction as they compete with other consumers for limited supplies!

At the beginning of period T=1, each firm knows the number of bean firms, hash firms, and consumers in the economy. However, firms do not know the consumers' income levels, their utility functions, or the technology of firms not of their own type (e.g., bean firms do not know the capacities or cost functions of hash firms).

At the beginning of each period T, starting with period T=1: (1) each bean firm produces a supply of beans and publicly offers this amount for sale at a unit price of its own choosing; and (2) each hash firm produces a supply of hash and publicly offers this amount for sale at a unit price of its own choosing.

These publicly posted quantity and price offers are made simultaneously by each firm, so that no firm has a strategic advantage through asymmetric information.

All firms and consumers costlessly acquire complete information about these quantity and price postings as soon as they are made.

At the end of each period T, each firm can costless acquire information about the actual sales of other firms. Thus, each firm can costlessly calculate actual profit outcomes of firms of its own type, because it knows all firms of the same type (e.g., all bean firms) have the same cost function.

At the end of each period T, if a firm's sales revenues are less than its production costs, it must pay the remaining portion of its production costs out of its current wealth.

If a firm's wealth level ever becomes negative (i.e. if the firm becomes insolvent), it must immediately exit the economy.

PROBLEM:

Suppose you are an economic consultant to one of the bean-producing firms, hereafter referred to as the CLIENT bean firm.

The objective of this client bean firm is to stay in business over the long haul, making as much profit as possible.

How would you direct this client bean firm to make its price and quantity decisions in each period T, starting with period T=1?

That is, what STRATEGY would you recommend to your client bean firm for choosing its price and quantity decisions over T=1, 2, ...?