WRITTEN PRELIMINARY Ph.D. EXAMINATION

Department of Applied Economics
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2004 Summer

PRODUCTION AND MARKETING ECONOMICS

Instructions:

-- Identify yourself by your code letter, not your name, on each question.

-- Start each question's answer at the top of a new page.

-- Answer the first question.

-- Answer three of the remaining five questions.

-- You have four hours to complete this examination.
1. Some observers of the global agricultural biotechnology sector identify three anticipated “waves” of biotechnology innovation: (1) agronomic improvements, (2) quality traits, and (3) “biofactory” plants and animals that will produce high valued products such as drugs. Most believe we are still in the midst of the first “wave” – current biotechnology products offer features such as resistance to insects or to chemical herbicides that improve agronomic performance. During this first wave, firms like Monsanto (which was originally a chemical company) have expanded their boundaries by acquiring seed companies. Prior to the advent of biotechnology, chemical companies such as Monsanto held patents on insecticides and herbicides and had strong sales networks that reached farm input suppliers. Seed companies had expertise in traditional plant breeding and had strong sales and distribution networks that were especially effective in building direct relationships with farmers.

The theory of property rights and incomplete contracts developed by Oliver Hart should provide some insights on (i) why an expansion of firm boundaries was needed to develop this first wave of biotechnology innovations and (ii) why we have observed chemical companies acquiring seed companies rather than seed companies acquiring chemical companies.

a. Briefly summarize the key features (assumptions, unit of analysis, general predictions) of Hart’s theory. Then use it to develop explanations for the questions of: (i) why firm boundaries expanded and (ii) why chemical companies rather than seed companies expanded their boundaries. (Your knowledge of these industries may be limited, but you should be able to apply the theory with the information provided in this question.)

b. In the second wave of biotechnology innovation, there will be increased emphasis on developing plant varieties that deliver very specific quality traits that can make it less costly to produce existing food and fiber products or can make it possible to produced improved products. For example, one such innovation is colored cotton that does not need to be dyed before being made into cloth. There are likely to be similar innovations in a wide range of products. Use incomplete contract theory to make some initial predictions about changes in firm boundaries during this second wave. Your discussion and explanation should address the following questions.

(i) Will chemical/seed companies like Monsanto continue to expand their boundaries by acquiring downstream firms that produce consumer products, or will they use markets to exploit “second wave” innovations?

(ii) Might firms like Monsanto be acquired by a downstream firm that transforms their biotechnology innovations into consumer products?

(iii) Why are your predictions similar to or different from patterns observed in the first wave?
2. You are advising an investor group that has raised a fund of F dollars for investment in a wind farm sometime in the next five years. The wind farm will be in a state that has instituted a percentage tax credit for wind energy investments, TCₜ, will decline linearly from ten percent (0.10) in the current year (t = 0) to zero in year five (t = 5) – i.e.:

\[ TC_t = 0.10 - 0.02t \quad t \in \{0, 1, \ldots, 5\}. \]

Wind turbine technology is improving, but productivity is fixed once an investment is made. The following stochastic difference equation describes the evolution of annual kilowatt hour production, KWₜ, for the investment being considered:

\[ KW_{t+1} = KW_t + (1 - (I_t + X_t))\varepsilon_t. \]

\( I_t \) is a binary variable equal to zero if the wind farm has not been built and equal to one if it has been built. \( X_t \) is a binary variable equal to zero if the group does not invest in the current period and one if the group does invest in the current period, and \( \varepsilon_t \) is a non-negative random variable. The evolution of \( I_t \) is described by the following expression:

\[ I_{t+1} = I_t + X_t, \]

The group can only invest once. Therefore, \( I_t X_t = 0 \) for all \( t \).

The wind farm comes online in the year when an investment is made. For simplicity, assume that the price received per kilowatt hour of wind energy, \( P \), and the annual cost of operating the wind farm, \( OC \), will be constant over the planning horizon, \( t \in \{0, 1, \ldots, 5\} \). Also assume that the investment pool can earn a risk-free annual return of \( \rho \) prior to investment. Therefore cash flow in period \( t \), \( \pi_t \), is:

\[ \pi_t = (1 - (I_t + X_t))\rho F + (I_t + X_t)((P)KW_t - OC) - (1 - TC_t)(F)(X_t) \]

The value of the fund for \( t = 6 \), the year after the end of the planning horizon is:

\[ V(KW_6, I_6, 6) = F(1 - I_6) + \alpha(KW_6)(I_6), \]

where \( \alpha \) is a positive constant representing the value of future wind farm returns.

a. Formulate a dynamic programming problem that will identify an optimal investment policy over the planning horizon. The group’s objective is to maximize the net present value of net cash flows, with a constant annual discount factor of \( \delta \). Your formulation should include: the objective function, the state equations, any relevant constraints on states or controls, boundary conditions, and the recurrence relation.

b. Assuming that the wind farm investment has a positive net present value at the start of the planning horizon, discuss the factors that affect the timing of this investment. Under what conditions would it be optimal to delay investment?
3. Equilibrium asset pricing models usually assume perfect, frictionless asset markets. Yet, studies of actual asset price behavior point out that various trading frictions or portfolio restrictions may exist. These frictions and restrictions may include short sale constraints, borrowing constraints, and transactions costs.

a. Define and differentiate between these frictions and restrictions, giving financial examples where appropriate.

b. Assume a utility-based asset pricing model (which presumes state-independent and time-separable utility functions, \(u(c)\), and no trading frictions or restrictions). The market equilibrium condition is

\[
u'(c_t) P_t = \beta E_t [u'(c_{t+1}) P_{t+1}] \tag{1}
\]

where \(c_t\) is current consumption, \(P_t\) is the current price of the asset, \(\beta\) is the discount factor \((0 < \beta < 1)\), and \(E_t[\cdot]\) is the expectation conditional on information at time \(t\). Provide an economic interpretation of (1).

c. Reformulate the model as a dynamic programming problem where the investor maximizes expected lifetime discounted utility,

\[
\text{max } E_t \{ \sum_{j=0}^{\infty} \beta^j u(c_{t+j}) \} \tag{2}
\]

subject to a dynamic budget constraint of the form,

\[
W_{t+1} = (W_t - c_t) [\omega R_{t+1} + (1 - \omega) I] R_f + y_{t+1} \tag{3}
\]

where \(W_t\) is the amount of current financial wealth \((W \geq 0)\), \(\omega\) is an \(N\)-vector of portfolio weights, \(I\) is an \(N\)-vector of ones, \(R\) is an \(N\)-vector of returns (including capital gains and dividends), \(R_f\) is the return to the riskless asset, and \(y\) is the investor's endowed stream of labor income \((y \geq 0)\). Write the investor's problem using the indirect utility function \(J(W_t, t)\), then provide answers for each of the cases that follow.

**Case 1.** Derive and interpret the first-order, equilibrium conditions that hold for \(R_{t+1}\) and \(R_f\) assuming no market frictions or restrictions (i.e., perfect asset markets).

**Case 2.** Derive and interpret the first-order, equilibrium conditions that hold for \(R_{t+1}\) and \(R_f\) assuming just a borrowing constraint \((c \leq W)\).

**Case 3.** Derive and interpret the first-order, equilibrium condition that holds for \(R_{t+1}\) and \(R_f\) assuming that transactions costs on buying and selling assets are proportions \((p_b\) and \(p_s\), respectively) of the amount traded and no other restrictions or frictions apply.
d. Now assume that you want to apply a version of the model in part c to farmland market prices. Carefully describe the analysis and tests you would perform in order to determine if the historical returns to farmland provide evidence of a frictionless market or one with transaction costs. Does the assumed length of holding period affect your analysis? Why or why not?

4. The concepts of competitive spatial equilibrium and market integration are interrelated and of interest to economists. The test of spatial equilibrium examines whether trade exhausts all rents to arbitrage, while the test of market integration has to do with the extent to which shocks are transmitted among spatially separate markets. Depending on the relationship among prices, transactions costs, and trade volumes, markets can be classified into one of four possible regimes demarcated by the above two spatial concepts.

Recent studies on issues related to market integration and spatial equilibrium can be classified into three groups: (i) price correlation models, allowing for short-run and long-run market integrations; (ii) switching regime models, accounting for the multiple regimes that may result from transactions costs; and (iii) threshold autoregression models, recognizing that, shocks must exceed a certain threshold, due to the presence of transactions costs, before market adjustments are provoked.

a. Discuss the normative implications of market integration and spatial equilibrium, and possible reasons for their failures.

b. Pick one out of the three listed approaches of testing for market integration and/or spatial equilibrium. Discuss the model, state the hypothesis and outline the general procedure, as well as comments on its strengths, limitations and possible remedies.

c. Pick one out of the two remaining approaches of testing for market integration and/or spatial equilibrium. Discuss the model, state the hypothesis and outline the general procedure, as well as comments on its strengths, limitations and possible remedies.

5. Suppose a farmer’s corn crop can either be free of European Corn Borer (ECB) with probability $q$ or heavily infested with ECB with probability $1 - q$. Average yields without an ECB infestation are $Y$ bu/acre. Yield with a heavy infestation are lower: $Y(1 - \delta)$ bu/acre where $1 > \delta > 0$. The price of corn is $P$ $/bu and the opportunity cost of planting $L$ acres of farmland is $aL^2$. If $\pi_G$ represents corn crop revenues in the good state without an ECB infestation and $\pi_B$ represents corn crop revenues in the bad state with a heavy ECB infestation, the farmers utility of corn production is assumed to be

$$W(\pi_G, \pi_B) = q U(\pi_G) + (1 - q) U(\pi_B)$$

where \( \frac{\partial U}{\partial \pi} > 0 \), and \( \frac{\partial^2 U}{\partial \pi^2} < 0 \).
a. Analytically and graphically characterize the set of feasible net revenue combinations with and without an ECB infestation.

b. Analytically and graphically characterize the farmer’s optimal level of corn production.

c. Suppose a farmer can mitigate ECB losses by buying insurance coverage, $I$ such that $PY \delta L \geq I \geq 0$, for a price $\delta r$ per $1$ of coverage. Illustrate how this changes the feasible set of net revenues. Characterize the conditions under which the farmer should fully ($I = PY \delta L$), partially ($PY \delta L \geq I \geq 0$), or not insure ($I = 0$).

d. Intuitively, how is the availability of this crop insurance likely to affect the optimal level of corn production? Can we be assured that net revenues from corn production will be less varied, one of the goals of this type of insurance (Note: Your argument can be heuristic)?

6. You have been given farm level data from farm/household units in one hundred villages in Andra Pradesh, India. On average you have data on 50 households in each village. For each farm, the major inputs were fertilizer, fuel, labor, land, seed, and irrigation water. You have price and level data for each of the input categories. The major outputs were rice, chickpeas, spinach, and tea. You have price and level data for each of the outputs. For simplicity, assume a well functioning market exists for the farming region and that all farms face the same input and output prices. You have been asked to examine whether any villages appear to be more efficient than others in producing the major outputs described above.

a. Give a brief description of how you would conduct such a study using non-parametric methods. Your discussion should include at least the following points: (i) your representation of the underlying technology, its properties regarding returns to scale and disposability, and the specific functional form you would use, (ii) the restrictions you would place on the parameters of the functional form, and what the restrictions mean, and (iii) the efficiency measure (e.g., Nerlovian efficiency, distance function, etc).

b. Give a graphical representation of the efficiency measure you discussed in part (a) of this question. In other words, if you used a distance function approach, show on the graph an efficient and inefficient firm. For your graph, be sure to specify the technology’s properties regarding returns-to-scale and input or output disposability.

c. Describe a simple procedure for decomposing the efficiency measures into a technical efficiency component and an allocative efficiency component.