Making a market for Miscanthus: can new contract designs solve the biofuel investment hold-up problem?

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Abstract

We present designs for optimal contracts to solve the investment hold-up problem for perennial crops for the biofuel industry. A fixed-price contract is ex-ante efficient but renegotiation-proof for a limited range of discount parameters. A perfectly-indexed contract is both renegotiation-proof and ex-post efficient. Provided long-run land prices are stationary, the expected cost for both contracts converges to the long-run expected price of land for a risk-neutral farmer.

Motivation

- Biofuels, such as ethanol or biodiesel, have traditionally been manufactured from annual crops such as corn or sugar. The environmental benefits of these crop sources is questionable (Schlarlemann & Laurance 2008) and diverting food crops from human consumption can have real impacts on domestic food prices (Abbott et al. 2008)
- The technology exists to manufacture biofuels from perennial crops such as switchgrass, Miscanthus, or willow. None of these crops are presently grown at commercial scale, however, and the investment cost of a plant to process these feedstocks is much greater than for a conventional corn-fueled plant. This leads to an investment hold-up problem: firms are unwilling to commit resources to build a refinery to process perennial crops without first insuring an adequate supply of feedstocks.
- Long-term contracts between farmers and processors are one possible solution to the investment hold-up problem. In the absence of a traded market, these contracts would establish (1) a price for the contracted good and (2) a method of adjusting that price (if need be) to long-run changes in either farmers' or processors' valuation functions.
- Farmers' long-run valuation function for a biofuel feedstock is likely to be related to long-run land values. We assume corn prices approximate movements in land rental rates, as evidenced by Du and co-author's work in Iowa (Du et al. 2009).
- A risk-neutral processor's valuation function will minimize cost subject to a target quantity of feedstock. This target quantity will be specified by exogenously determined factors (such as transport costs of the feedstock from the farm to the processing facility).
- Both parties will agree to contract as long as each party is either made better-off (increased surplus) or indifferent (no change in surplus). This may be *ex-ante* expected surplus or *ex-post* realized surplus, but there is no contract specification which can simultaneously maximize both types of surplus.

References

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Principal's Problem

- For a two period contract:

$$\min_{s,\, b,\, q} \; \left[s_1 q + bP_1 q + \delta * (s_2 q + bP_2 q)\right] * \sum_{q=1}^{n} q \qquad s.t.$$

$$\sum_{q=1}^{n} q \geq Q$$

$$s_1 q + bP_1 q - C(q) - \frac{r_A}{2} b^2 \sigma^2 q^2 + \delta * \left[s_2 q + bP_2 q - \frac{r_A}{2} b^2 \sigma^2 q^2\right]$$

$$\geq P_1 y - C(y) - \frac{r_A}{2} \sigma^2 y^2 + \delta * \left[P_2 y - \frac{r_A}{2} \sigma^2 y\right]$$

- Where:
  - s is a per-period fixed payment
  - b is an incentive bonus defined on the interval [0,1]
  - q is a per-acre yield of the biofuel crop
  - Y is a per-acre yield of the index crop (assumed to be corn)
  - P is the price of corn in each period
  - C() is an increasing, convex cost function
  - r_A is the Arrow-Pratt measure of risk aversion
  - δ is the discount rate
  - σ is the standard deviation of the distribution of corn prices (assumed to be stationary)

Ex-Ante Efficient Contract

- For risk averse agents, the contract price which maximizes *ex-ante* expected surplus is a fixed price contract.

$$S = \frac{E(P)y - \frac{r_A}{2}\sigma^2 y^2}{q} + \frac{C(q) - C(y)}{(1 + \delta) * q}$$

$$\delta \geq \frac{P_1 y - s_1 q + C(q) - C(y) - \frac{r_A}{2}\sigma^2 y}{s_2 q - P_2 y + \frac{r_A}{2}\sigma^2 y}$$

Ex-Post Efficient Contract

- Since there is no existing market for these crops, one strategy that is likely to be agreeable to both contracting parties is to construct an index from familiar commodities (such as corn, wheat, hay, oil, diesel, etc). The indexed contract uses a consistent relationship between changes in the index price and changes in the contract price over the full contract period such that the contract price always reflects the value of the contracted good contingent on the realized state of the world.
- A perfect index - where changes in the index price are completely reflected in the contract price without attenuation or amplification - maximizes *ex-post* realized surplus.

$$s_1 + \delta s_2 = \frac{(P_1 + \delta P_2)y}{q} + \frac{C(q) - C(y)}{q}$$

- There is are no limits on the discount rate for this type of contract.

Conclusions

- A fixed-price contract is ex-ante efficient but renegotiation-proof for a limited range of discount parameters. A perfectly-indexed contract is both renegotiation-proof and ex-post efficient. Provided long-run land prices are stationary, the expected cost for both contracts converges to the long-run expected price of land for a risk-neutral farmer.
- The fixed price contract provides complete insurance against absolute earnings losses, but no insurance against relative earnings losses. Relative earnings losses are instances where profit under the fixed price contract is less than the realized profit for the outside option. Fixed price contracts also protect the agent against the risk of principal bankruptcy, as the principal's future liabilities are well-specified *ex-ante*. On the other hand, the perfect index completely insures the agent against relative earnings losses, but does not protect against principal bankruptcy or absolute earnings losses.
- An agent is indifferent between these two contracts if and only if the realized index price exactly equals expected index price less the idiosyncratic risk premium. With heterogeneous agents, there will be some set of agents who are not indifferent between these contracts for any given ex-post index price, depending on the frequency of agent types in the population.

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