Principles of Contract Design for Perennial Energy Crops

Steve Wu
Purdue University

December 1, 2009

Motivation

- Challenge: Develop commercially viable dedicated energy crops.

- Will require optimization along the entire supply chain to minimize costs.

- One way to reduce costs is to design "optimal" contracts that maximize productivity at minimum cost.

Outline

Contract theory is a large field with many nuances. Therefore will focus on broad principles of optimal contract design:

- Screening for matching and risk sharing
- Performance incentives
- Incentive conflicts
- Technology advances and contract restructuring

Principle 1: Use a menu of contracts to match growers to the right contract

- Example: growers may have heterogeneous risk tolerances. Some may be willing to tolerate more contract payment fluctuation for increased avg returns. Others might trade lower avg returns for stability.

⇒**Application**: should contract payments be tied to a price index?

⇒**Problem:** level of risk tolerance largely unobservable. How do we know whether a specific grower wants an index?

⇒**Solution**: Should not have one-size-fits all level of indexing. Offer a menu of contracts with tiered indexing to induce growers to self-select into the right contracts. Examples:

Contract 1: 1% change in diesel price ⇒ 1% in contract payment.

Contract 2: 1% change in diesel price ⇒ ½% in contract payment.

Contract 3: Fixed payment.

Why do menus work?

- Plant's Total Cost of Contracting = Opportunity cost + Production/delivery cost + Risk premium.
- Strength of indexing allows contractor to control risk premium.
- Growers with different risk tolerances will require different "risk premiums" to accept contracts with indexing.
- Customizing strength of index to grower allows contractor to avoid over- or under-paying risk premiums.
- Matching maximizes number of trades (avoid under-paying RP) while minimizing costs (avoid over-paying RP)

Features of a good menu

- Example: Suppose grower A is risk averse. Grower B is risk tolerant. Index on diesel price.
- The index for grower A should be weaker to reduce risk premium paid to the grower.
- Grower B is more risk tolerant and can handle a strong index w/o increasing risk premium substantially.
- Must ensure grower B doesn't want the contract meant for grower A **(incentive compatible).** That is,

$$\text{Profit}_B(\text{Contract B}) > \text{Profit}_B(\text{Contract A})$$

Can also construct menus around:

- Production costs differences.
- Division of responsibility.
- Input cost sharing.
- Input price indexing.

Principle 2: Balance Risk Against Incentives

Suppose:

Performance = grower actions + random factors

E.g. yield is a function of good practices, temperature and precipitation.

Providing performance incentives for yield also increases grower risk. Need to weigh the tradeoff.

Note: here I am referring to production risk not price or index risk.

Risk vs. Incentives

- Performance pay ⇒ high pay for good performance and low pay for bad performance. Incentives imply payment variability.
- Higher powered incentives (pay very sensitive to performance) motivates better but also introduce more income risk!
  - ⇒ Must pay contractee a "risk premium" (raise avg pay)
  - ⇒ Risk premium is "cost" of providing incentives.

- Find the balance:
  - ⇒ Weak incentives mean less performance but lower risk premium to induce grower to participate
  - ⇒ Strong incentives means more performance but must pay more to get grower to participate.

Lessons

- Growers who are very risk averse should be offered contracts with weaker incentives (cost of incentives is very high).
- Growers who are more risk tolerant can be given strong incentives.
- If incentives are provided, then pay a risk premium or growers will either reject contract or quit.
- In risky environments, it is more costly to provide performance incentives (risk premiums naturally high).
- In risky environments, may want to go with production contracts, input control and monitoring rather than pay-for-performance.

Application: Contract on yield or acres?

- Yields:

  Pro: Better incentives to induce yield maximizing practices.

  Con: Grower bears more income risk via yield fluctuation**.**

- Acres:

  Pro: Farmer income fluctuates less with yield variation.

  Con: Weaker incentives to maximize yield.

Key Question: Are the incremental gains from contracting on yields worth the extra risk premium needed to compensate grower to accept contract?

Principle 3: Do Not Ignore Incentive Conflicts

- Example: Plant may want to maximize yield and control carbon footprint.

- Handling incentive conflicts:
  1. Determine if tasks are complements or substitutes.
  2. If complements, no problem. Rewarding one performance factor will indirectly incentivize a complementary performance factor (e.g. yield incentives indirectly incentivize proper harvesting techniques).
  3. If substitutes, then must either:
     a) Balance incentives for both tasks (make sure one is not rewarded significantly more than another task).
     b) Weaken incentives for both tasks (this also has the added benefits of reducing risk premiums).

Example: Yield vs Environmental Concerns

- Contracting on yield may increase farming intensity and conflict with regulatory requirement to minimize greenhouse gas emissions or control carbon footprint.
- Solution: Weaken incentives for yield . Some options:

  a) Contract on acres

  b) Contract on acres and have yield bonus that only kicks in when output prices are low.

  c) Contract on acres and have a penalty if some yield minimum is breached.

Related Issues

- Big problem for typical plant is securing steady local supply of biomass to run through the plant. What are the key issues?

  ⇒ Will need to contract with many growers and coordinate their deliveries. Numerous growers will also allow the plant to diversify away idiosyncratic risks (risk of any one grower failing to deliver).

  ⇒ If can't sign large number of growers, then will need to have high powered incentives to ensure that the growers under contract deliver as promised. But….

  ⇒ Providing high powered incentives will raise supply chain costs (e.g. higher risk premium, incentive conflicts, contract for more than necessary as a safeguard).

  ⇒ Beneficial to contract with more growers, all else equal. (may not hold with scale effects).

Taking Advantage of Technology Shifts

- There are often external constraints on contract design (e.g. limits to pay-for-performance).
- New varieties can have two major effects: increases yield and/or reduce yield variance.
- An increase in yield allows for:

  ⇒ Reduction in number of acres contracted. Reduces contracting costs.
- A reduction in variance allows for:

  ⇒ Movement away from input control and monitoring to pay-for-performance.

  ⇒ Higher powered pay-for-performance.

  ⇒ Easier to contract for yield w/o significantly increasing risk premium.

Conclusion

- Minimizing supply chain cost should also include smart contract design.
- The following principles can be a guide to structuring efficient contracts:
  - Screening and risk sharing (smart and tiered indexing)
  - Performance incentives (balance incentives and risk)
  - Incentive conflicts (balance conflicting incentives)
  - Take advantage of technology shifts to improve contract design.

Extra slides
Our Analytical model: preliminary insights

- Risk premiums are functions of:
  1) Degree to which contract payment correlates with index (e.g. strength of index).
  2) Volatility of the index.
  3) Output (yield or acres) under contract.

- Can also reduce risk premium by reducing strength of index and/or quantity under contract (acres or yield)

- Want risk averse growers to select contract with less payment variability and lower quantity, and risk tolerant growers to select contracts with high payment variability and high quantity.

Implication: If environment becomes more risky, contracting becomes less viable (must lower amount under contract).